Version 52

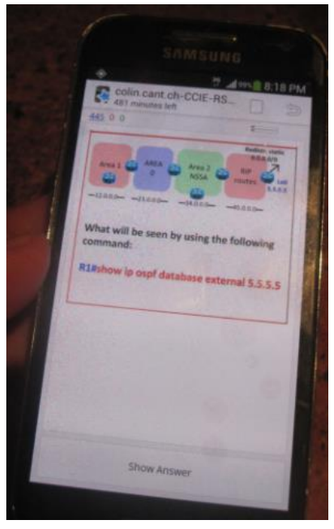
http://www.flashcardguy.ch

1600+ Cisco CCIE RS ver 4 / 5 / CCNP RS study flashcards

Best viewed with an iPad or similar!

As I was going through the entire CCIE training material and had found that I tend to forget some of the many details I had studied month earlier and had to come up with a solution on how to remember all the nibbly details and keep the learned fresh. This file contains over 1600 designs, config snippets, explanations of command output, and handy debug commands to keep in mind. Based on the "APP Free study cards" I have created the ANKI version, so people can go through the flashcards on their mobile phones etc while commuting to work and back again, utilizing that time as study time. I am still working on my CCIE number, therefore this document is subject to change without notice, I keep adding things I think one could easily forget etc or is just generally good to know. Keep an eye on the "revision number" on the top left to see if I had made any changes since you last visited the file. If my "APP Free" card deck had a great impact on your CCIE trail, please feel free to let me know and post me your CCIE number!

Have fun studying!



ANKI version for mobile devices:

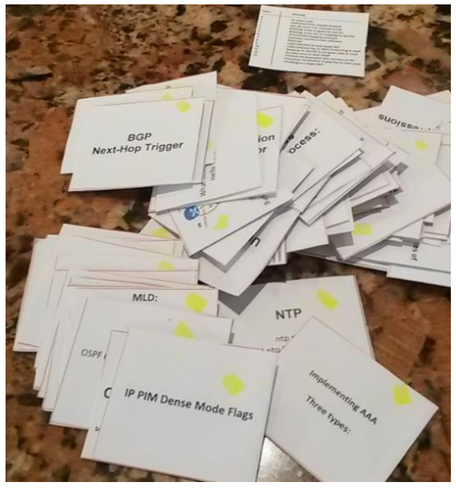
For all the folks who rather use the "APP Free" study flashcards on a mobile device, please download the ANKI version of the cards
Found here:

http://www.flashcardguy.ch

There are two versions, one with all the 1600 cards in one deck, and another ZIP version where I have separated each technology into a separate ANKI file which might be easier, better to use initially.

ANKI for mobile devices found here: http://ankisrs.net/

Please use ankisrs support / forums if you are facing problems running ANKI on your mobile devices. Thanks



"APP Free", the classic way:

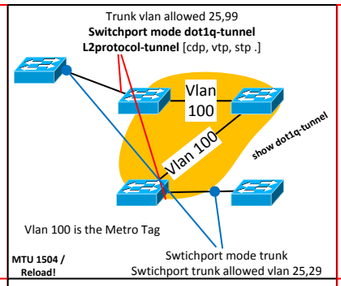
Instructions "APP Free" study flashcards

***Print them A3** colored, cut them in rows, pre-fold them in rows, glue them together, cut the single cards from the row.*
Mark the question side with a highlighter/marker to make it easier for you to sort.

or simply use the PDF to search for a command etc. Lets say you forgot how to do OSPF authentication, then go to the first page of OSPF, CTRL-F, "authentication" and hopefully you will find something within minutes that can help you.

Switch / Bridge

802.1q Tunneling



`show interface fa0/x pruning`

Show interface fa0/x pruning

Port Vlans pruned for lack of request by neighbor
Fa0/16 7-8,10,22,58,67,146

Port Vlan traffic requested of neighbor
Fa0/16 1,5,7-10,22,43,58,67,79,146

Show interface fa0/x trunk -> offers easier output

`show interface trunk`

```
Swi#sh int trunk
Port        Mode             Encapsulation  Status        Native vlan
Fa0/13      on               isl            trunking      1

Port        Vlans allowed on trunk
Fa0/13      1-4094

Port        Vlans allowed and active in management domain
Fa0/13      1,5,7-10,22,35,43,58,67,79,100,146,200,300,500,600,1000

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/13      1,5,7-10,22,35,43,58,67,79,100,146,200,300,500,600,1000
Swi#
```

What is a important pre-requisit for Dot1Q Tunnel setups ?

Set the MTU to 1504 and reload the switch.

VTP Prune-Eligible List

Vlans **not** specified in the list will NOT be pruned, vlans within the list could be pruned:

interface FastEthernet0/X
switchport trunk pruning vlan 2-6, 8-10

2-6, 8-10 are prune-eligible!

Vlan 7 will never be pruned!

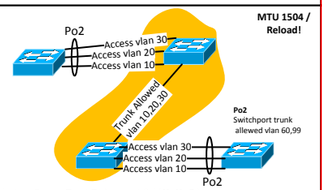
Show spanning-tree uplinkfast

```
VLAN0010
  Spanning tree enabled protocol ieee
  Root ID     Priority    10
              Address     001b.d490.7c00
              Cost        4000
              Port        15 (FastEthernet0/13)
              Hello Time   3 sec  Max Age 10 sec  Forward Delay 10 sec

  Bridge ID   Priority    49162  (priority 49152 sys-id-ext 10)
              Address     001b.d4df.ec80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time 300
  Uplinkfast enabled

Interface        Role Sta Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/6            Desg FWD 3019      128.8    P2p
Fa0/13           Root FWD 4000      128.15   P2p
Fa0/14           Altn BLK 4000      128.16   P2p
Fa0/15           Altn BLK 4000      128.17   P2p
```

EtherChannel over 802.1q Tunneling




```
interface FastEthernet0/[X,Y,Z]
switchport access vlan [10,20,30]
switchport mode dot1q-tunnel
l2protocol-tunnel cdp
l2protocol-tunnel stp
l2protocol-tunnel point-to-point [Pagp,Lacp]
```

Spanning-tree global vs Interface commands

Global command over-rules the interface command:

Spanning-tree vlan 1 – x port-prio 16

Interface Fa0/x
Spanning-tree port-priority 16

`debug spanning-tree backbonefast`

```
Rack1SW2#debug spanning-tree backbonefast
Spanning Tree backbonefast general debugging is on
Rack1SW2#
STP FAST: received inferior BPDU on VLAN0001 FastEthernet0/19.
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/13 Vlan1
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/14 Vlan1
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/15 Vlan1
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/20 Vlan1
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/21 Vlan1
STP FAST: received inferior BPDU on VLAN0001 FastEthernet0/20.
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/13 Vlan1
STP FAST: sending RLQ request PDU on VLAN0001(1) Fa0/14 Vlan1
```

Switchports types

```
Interface Fa0/x
```

Switchport mode dynamic auto

Switchport mode dynamic desirable

Switchport mode trunk

Switchport mode access

switchport mode dot1q-tunnel

switchport mode private-vlan host

switchport mode private-vlan promiscuous

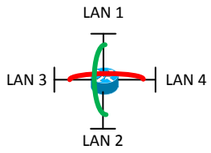
no switchport

Change Spanning-tree listening / learning timers

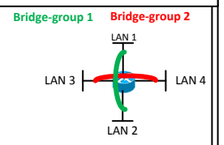
Spanning-tree vlan x-y forward-delay [seconds]

Default is 15, command impacts LISTENING and LEARNING
There is no separate command for the two states, only one for both.

Bridge-group 1
Bridge-group 2



Bridge-group 1 **Bridge-group 2**



Bridge 1 protocol ieee

int fa0/x
bridge-group X

int ser0/x
bridge-group X

switchport mode dynamic desirable **switchport mode dynamic desirable**

switchport mode dynamic desirable **switchport mode dynamic auto**

switchport mode dynamic desirable **switchport mode dynamic desirable**

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    n-isl          trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    n-isl          trunking      1
```

switchport mode dynamic desirable **switchport mode dynamic auto**

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    n-isl          trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      auto         n-isl          trunking      1
```

How to identify STP portfast ports in the debug output

Debug spanning-tree events

Port fast enabled ports will have a log entry such as:

JUMP TO FORWARDING FROM BLOCKING

What types of bridging over Frame relay are there?

Bridging over Frame-Relay -non multicast

Bridging over Frame-Relay with multicast

Bridging over Frame-Relay via SubInterfaces

Remote Transparent bridging with Circuit-groups (MFR like)

switchport mode dynamic desirable
Switchport trunk encapsulation dot1q **switchport mode dynamic desirable**

switchport mode dynamic desirable
Switchport trunk encapsulation isl **switchport mode dynamic desirable**

switchport mode dynamic desirable
Switchport trunk encapsulation dot1q

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    802.1q         trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    n-802.1q       trunking      1
```

switchport mode dynamic desirable
Switchport trunk encapsulation isl

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    isl            trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      desirable    n-isl          trunking      1
```

switchport trunk encapsulation dot1q **switchport trunk encapsulation dot1q**
switchport mode trunk **switchport mode trunk**

switchport trunk encapsulation isl **switchport trunk encapsulation isl**
switchport mode trunk **switchport mode trunk**

switchport trunk encapsulation dot1q **switchport trunk encapsulation dot1q**
switchport mode trunk **switchport mode trunk**

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      on           802.1q         trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      on           802.1q         trunking      1
```

switchport trunk encapsulation isl **switchport trunk encapsulation isl**
switchport mode trunk **switchport mode trunk**

```
Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      on           isl            trunking      1

Port        Mode         Encapsulation  Status        Native vlan
Fa0/13      on           isl            trunking      1
```

Handy set of Spanning tree debug commands:

Debug spanning-tree events

Debug spanning-tree backbone fast

Debug spanning-tree pvst+

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Switch / Bridge

UDLD port modes

Int fa0/x
Udld port aggressive

UDLD well-known MAC 0100.0ccc.cccc
Device ID + Originator Port + Timeout Echo Value

Normal Mode: Undetermind – continues to operate/ does not prevent loops

Agressive Mode: 8 UDLD frames / second
No response for 1 second -> Port is error-disabled

Reset all UDLD error disabled ports via:

UDLD RESET

Storm control setup

```
SW1:
interface FastEthernet0/1
 storm-control unicast level pps 100

SW2:
interface FastEthernet0/6
 storm-control broadcast level bps 10m

SW4:
interface FastEthernet0/4
 storm-control broadcast level 10.0
```

Interface bandwith 10 %

SW1(config-if)#storm-control action [trap, shutdown]

IP Phone Trust and CoS Extend

```
interface FastEthernet0/2
 mls qos trust cos
 mls qos trust device cisco-phone
 switchport priority extend cos 1
!
interface FastEthernet0/4
 mls qos trust cos
 mls qos trust device cisco-phone
 switchport priority extend cos 1
!
interface FastEthernet0/6
 mls qos trust cos
 mls qos trust device cisco-phone
 switchport priority extend cos 1
```

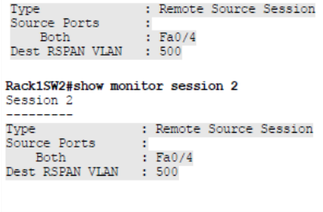
Spanning-tree MST config

```
spanning-tree mst configuration
  name MST1
  revision 1
  instance 1 vlan 1-100
  instance 2 vlan 101-200
  instance 3 vlan 201-4094

spanning-tree mst 1 priority 0
spanning-tree mst 2 priority 4096
spanning-tree mst 2 priority 8192

spanning-tree mode mst
```

Show spanning-tree mst X detail

SPAN sessions

Monitor session [X] source [vlan x, int y]
Monitor session [X] destination fa0/x ingress vlan [YY]



Smartport Macros

Default interface fa0/x

macro name MACRO-NAME
switchport mode access
switchport access vlan 146
spanning-tree bpdufilter enable
@

Interface fa0/x
macro apply MACRO-NAME

```
show parser macro
```

Spanning-tree MST port priority and cost

Interface fa0/x
Spanning-tree mst X cost [COST]

Interface fa0/x
Spanning-tree mst X priority [16]

RSPAN sessions:

SW1:

Vlan [500]
remote-span

show vlan remote-span

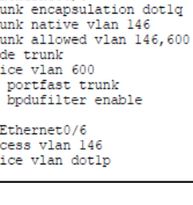
monitor session [X] source interface [fa0/x]
monitor session [X] destination vlan [500]

SW2:

Vlan [500]
remote-span

SW3:

Vlan [500]
remote-span



monitor session [X] source vlan [500]
monitor session [X] destination fa0/x ingress vlan [YY]

Applying dynamic macros

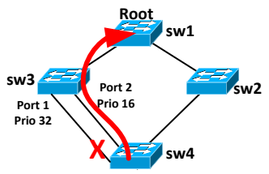
Standard / existing macros can be verified by:

Show parser macro

And applied with dynamic parameters:

Interface fa0/10
Macro apply cisco-desktop $access_vlan 10

Spanning-tree **port priority** and its influence?



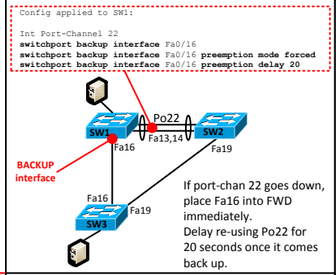
Spanning-tree port-priority influences only the direct attached SW4, but is configured on SW3!

Span session show output

```
Rack1SW1#show monitor session 1
Session 1
---------
Type                : Local Session
Source VLANs        :
    Both            : 146
Destination Ports   : Fa0/24
    Encapsulation   : Native
          Ingress   : Disabled

Rack1SW4#show monitor session 1
Session 1
---------
Type                : Local Session
Source Ports        :
    Both            : Fa0/4
Destination Ports   : Fa0/24
    Encapsulation   : Native
          Ingress   : Enabled, default VLAN = 146
```

Flex Links

Alternative to spanning-tree



If port-chan 22 goes down, place Fa16 into FWD immediately.
Delay re-using Po22 for 20 seconds once it comes back up.

Spanning-tree **port cost** and its influence?

Spanning-tree port cost affects SW4 and also other switches possible down stream switches to use port 2

RSPAN session show output:

```
Rack1SW2#show monitor session 2
Session 2
---------
Type                : Remote Source Session
Source Ports        :
    Both            : Fa0/4
Dest RSPAN VLAN     : 500

Rack1SW2#show monitor session 2
Session 2
---------
Type                : Remote Source Session
Source Ports        :
    Both            : Fa0/4
Dest RSPAN VLAN     : 500
```

Flex Links

Show outputs

```
Primary link is UP/UP                    debug backup all

show interfaces po1 switchport backup

Switch Backup Interface Pairs:

Active Interface        Backup Interface        State
------------------------------------------------------------------------
Port-channel1           FastEthernet0/16        Active Up/Backup Standby


Primary link is DOWN

show interfaces po1 switchport backup

Switch Backup Interface Pairs:

Active Interface        Backup Interface        State
------------------------------------------------------------------------
Port-channel1           FastEthernet0/16        Active Down/Backup Up
```

Protected Ports setup:

Int fa1
Switchport access vlan 20

Int fa2
Switchport protected
Switchport access vlan 20

Int fa3
Switchport protected
Switchport access vlan 20

Int fa4
Switchport access vlan 20

Fa2 and Fa3 can't communicate even being in the same Vlan

What are the three different configuration methods for Voice ports?

```
interface FastEthernet0/2
 switchport access vlan 146
 switchport voice vlan 600
 spanning-tree portfast
!
interface FastEthernet0/4
 switchport trunk encapsulation dot1q
 switchport trunk native vlan 146
 switchport trunk allowed vlan 146,600
 switchport mode trunk
 switchport voice vlan 600
 spanning-tree portfast trunk
 spanning-tree bpdufilter enable
!
interface FastEthernet0/6
 switchport access vlan 146
 switchport voice vlan dot1p
```

Fallback Bridging

SW1:
IP routing

bridge 1 protocol vlan-bridge

Int fa0/4
bridge-group [1]

Int fa0/6
bridge-group [1]

IPv4 is routed while IPv6 packets are bridged

show bridge [1] group

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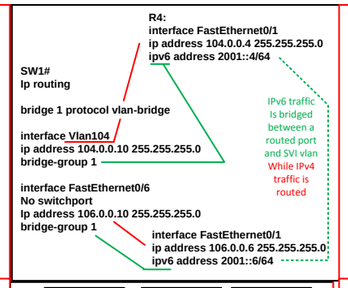
Switch / Bridge

Fallback Bridging



PPP
Bi-directional
CHAP Authentication

```
R4#

username USER-R4 pass cisco

interface Serial 0/1
encapsulation ppp
ppp authentication chap
ppp chap hostname USER-R5
```

CHAP auth

```
R5#

username USER-R5 pass cisco

interface Serial 0/1
encapsulation ppp
ppp authentication chap
ppp chap hostname USER-R4
```

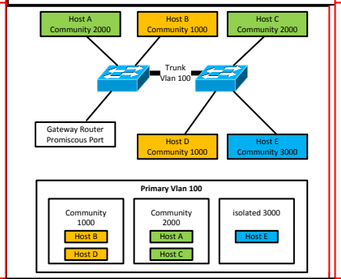
PPP AAA Authentication
(Radius)


```
R4#
( User admin password 0 cisco ! Don't get locket out )

aaa new-model
aaa authentication login CONSOLE none
aaa authentication ppp PPP-AUTH-LIST group GRP-RADIUS local
!
aaa group server radius GRP-RADIUS
server-private 155.1.146.100 key CISCO
!
interface Serial 0/1/0
ppp authentication pap chap PPP-AUTH-LIST
!
line console 0
login authentication CONSOLE

(Auth via Radius, if not available fallback to local database)
```

Private VLANs
Design



PPP
Useful PPP debug commands

Debug ppp negotiations

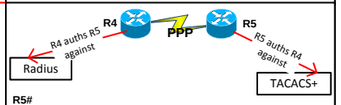
Debug ppp authentication

Debug ppp packet

Debug ppp error

(**debug aaa authentication**)

PPP AAA Authentication
(TACACS+)




```
R5#

( User admin password 0 cisco ! Don't get locket out )

aaa new-model
aaa authentication login CONSOLE none
aaa authentication ppp default group tacacs local
!
tacacs-server host 155.1.146.200 key CISCO
!
line console 0
login authentication CONSOLE

(Auth via TACACS+, if not available fallback to local database)
```

Private VLANs
config

```
vtp domain CCIE
vtp mode transparent

vlan 1000
private-vlan community

vlan 3000
private-vlan isolated

vlan 100
private-vlan primary
private-vlan association 1000,2000,3000

interface FastEthernet0/1
switchport private-vlan mapping 100 add 1000,2000,3000
switchport mode private-vlan promiscuous

interface FastEthernet0/3
switchport private-vlan host-association 100 1000
switchport mode private-vlan host

interface FastEthernet0/5
switchport private-vlan host-association 100 2000
switchport mode private-vlan host

interface FastEthernet0/13
switchport trunk encapsulation dot1q
switchport mode trunk
```

check "cfg phase 1"
show vlan private-vlan

"Config phase 1"

(Associate Prim / Sec as last part in cfg phase 1)

Gateway

Community 1000

Community 2000

between switches

How do you filter out Vlan IDs out of SPAN sessions for Trunks ?

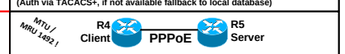
monitor session 2 source interface fa0/2 rx

monitor session 2 **filter vlan 5-10**

monitor session 2 destination interface fa0/1

(SPAN session will only SPAN traffic within Vlan 5-10)

PPPoE
Client / Server



R4 Client:

```
interface Dialer1
ip address dhcp
encapsulation ppp
dialer pool 1
ppp chap hostname USER-1
ppp chap password CISCO
!
interface FastEthernet0/1
no ip address
no shutdown
pppoe enable
pppoe-client dial-pool-number 1
```

```
aaa authentication ppp PPPOE-LIST local
username USER-1 password CISCO

ip dhcp pool POOL-PPPoE
network 155.1.35.0 255.255.255.0

interface FastEthernet 0/1
no shutdown

interface FastEthernet0/1.35
encapsulation dot1Q 35
pppoe enable group PPPOE

bba-group pppoe PPPOE
virtual-template 1
sessions per-mac throttle 10 60 300

interface Virtual-Template 1
encapsulation ppp
ip address 155.1.35.1 255.255.255.0
ppp authentication chap PPPOE-LIST
```

Private VLANs
Show commands

show vlan private-vlan

Primary	Secondary	Type	Ports
100	1000	community	Fa0/1, Fa0/3
100	2000	community	Fa0/1, Fa0/5
100	3000	isolated	Fa0/1

check after configuring "phase 1"

Whats the purpose of

vlan dot1q tag native

In dot1q tunneling ?

enables tagging of native VLAN frames on all IEEE 802.1Q trunk ports in dot1q tunnels.

show vlan dot1q tag native

-> Service-provider network mis-direction issue

PPPoE
Debugs / Show CMDs

```
debug pppoe packets
debug pppoe events
debug ppp negotiation
clear pppoe all
show pppoe session
```

PPP
Uni-directional
PAP Authentication

```
R4#
interface Serial 0/1
encapsulation ppp
ppp pap sent-username USER-1 pass cisco
```

R4 will have to authenticate towards R5 (sending credentials)

```
R5#

username USER-1 pass cisco

interface Serial 0/1
encapsulation ppp
ppp authentication pap
Clock rate [64000]
```

How can one SPAN CDP, STP and other control protocols to the destination port ?

monitor session [1] destination interface Fa0/x encapsulation replicate

```
C3750#sh monitor session 1
Session 1
---------
Type                   : Local Session
Source Ports           :
    Both               : Gi1/0/9
Destination Ports      : Gi1/0/24
    Encapsulation      : Replicate
          Ingress      : Disabled
```

PPPoe Client status views:

Session on Client is UP

```
R3#sh pppoe sess
     1 client session

Uniq ID  PPPoE  RemMAC          Port              Source   VA       State
         SID    LocMAC                                     VA-st
   N/A    19     0021.a09a.f4c1  Fa0/1             Di1      Vt2      UP
                 000c.cec7.05c1                             UP
```

Transit to PPPoe SRV has just been disrupted

```
R3#sh pppoe sess
     1 client session

Uniq ID  PPPoE  RemMAC          Port              Source   VA       State
         SID    LocMAC                                     VA-st
   N/A    20     0021.a09a.f4c1  Fa0/1             Di1      N/A      SHUTDOWN
                 000c.cec7.05c1
```

Transit disrupted, attempting connection to SRV

```
R3#sh pppoe sess
     1 client session

Uniq ID  PPPoE  RemMAC          Port              Source   VA       State
         SID    LocMAC                                     VA-st
   N/A    20     0021.a09a.f4c1  Fa0/1             Di1      N/A      PADISNT
                 000c.cec7.05c1
```

PPP
Uni-directional
CHAP Authentication

```
R4#

username USER-R4 pass cisco

interface Serial 0/1
encapsulation ppp
ppp authentication chap callin
ppp chap hostname USER-R5
```

R4 sends credentials to R5

R4 does not expect R5 to auth back (callin)

```
R5#

username USER-R5 pass cisco

interface Serial 0/1
encapsulation ppp
ppp authentication chap
```

How to configure dot1Q tunnel on a routers subInterface

Interface Fa0/1
MTU 1504

Interface Fa0/1.41
encapsulation dot1Q 99 second-dot1q 200,300

PPPoE Server's status views:

Connection from PPPoe SRV to Client established

```
R5#sh pppoe sess
     1 session  in LOCALLY_TERMINATED (PTA) State
     1 session  total

Uniq ID  PPPoE  RemMAC          Port              Source   VA       State
         SID    LocMAC                                     VA-st
   518    21     000c.cec7.05c1  Gi0/1.35          Vt1      Vt1.1    PTA
                 0021.a09a.f4c1  VLAN :35                   UP
```

Connection from PPPoe SRV to Client was lost due to problem on transit from client to server

```
R5#sh pppoe sess

Uniq ID  PPPoE  RemMAC          Port              Source   VA       State
         SID    LocMAC                                     VA-st
```

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Switch / Bridge

Advanced LACP / PAGP troublehsooting commands:

Show int trunk
Show etherchannel summary

Rack1SW1#**show pagp ?**
<1-48> Channel group number
counters Traffic information
internal Internal information
neighbor Neighbor information

Rack1SW1#**show lacp ?**
<1-48> Channel group number
counters Traffic information
internal Internal information
neighbor Neighbor information
sys-id LACP System ID

spanning-tree extend system-id

explained

IF "**spanning-tree extend system-id**" is **NOT ENABLED**:

one MAC address per VLAN to make the bridge ID unique for each VLAN, using a lot of MAC addresses
-> (chassis with only 64 MAC addresses!)

extended system ID enabled:

One MAC address used in all STP Vlans. In order to uniquely identify the root the VLAN-ID value is added to the STP priority value, with the same MAC address in all VLANs.

What does:

define interface-range

Do?

```
conf t
```

define interface-range VPORTS FastEthernet 0/7-8

Used for macro's

VTP Version 3

And MST

- **MST domain** = **domain name** and **revision number**
(64 instances max)
- MST domain configuration can be distributed via VTP Version 3 instance. (Instead of error prone manual config)

- MST config changes only allowed on primary server.

SWITCH# **show spanning-tree mst configuration**
% Switch is not in mst mode
Name [MST]
Revision **1 Instances configured 3**
Instance Vlans mapped
-------- ---
0 2-400,406-4000,4006-4094
-------- ---
config changes of MST only allowed on VTP 3 primary server.

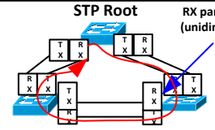
Spanning-tree loopguard

Mainly

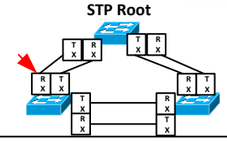
(mainly used on fiber links, can be reproduced with bpdufilter on ethernet)

STP Root

RX part breaks (unidirectional)



STP Root



VTP Version 3

facts:

- **only the vtp primary server, is allowed to update other devices**
- **Two instances in VTP version 3, VLAN and MST instance**
- **Instances can be on the same or separate switches.**
- **If there is more than one primary server a warning message will indicate conflicting devices.**
- **Reserved VlanIDs 1000-1017, (show vlan intern usage)**
- **VTPVer 2 compatible to Version 3, where as Ver 1 is not.**
- **VTP 2 device will never update a Version 3 device.**
- **After reload a primary server will take the secondary server role**

VTP Version 3

With routed interfaces and

Default VLAN-IDs:

int fa1/24
no switchport
ip address 1.2.3.4 255.255.255.0

SWITCH# **show vlan internal usage**
VLAN Usage
---- --------------------
<SNIP>
1018 FastEthernet1/24 VlanID 1018 for Fa1/24 !

default allocation policy the switch starts to allocate beginning at 1018! In order to use Vlan 1018, default interface fa1/24, shutdown the port, force a VTP revision number change, by changing vlan 1018's name to flood the change from an Internal Vlan to a regular vlan to other switches.

Global:
Spanning-tree loopguard default

Per interface:
Spanning-tree guard loop

VTP Version 3

Configuration:

spanning-tree extend system-id **<- required**

vtp version 3

vtp domain DOMAIN-X

vtp primary-server vlan [force]

vtp primary-server mst [force]

service password-encryption

SW1# show vtp password
VTP Encrypted Password: 02270A5F19030E32

Display of the password is encrypted, **vlan.dat IS CLEAR TEXT**

VTP Version 3

modes

- vtp mode server
- vtp mode client
- vtp mode transparent
- vtp OFF

Disable vtp per port (VTP off)

int fa0/24
no vtp

SDM Prefer on Catalyst

Access
Used for QoS classification and security

Routing
Used for routing

Vlan
Disables routing and sets the switch to be a layer 2 switch

Extended-match
Reformats routing memory space to allow 144-bit layer 3 TCAM support needed for WCCP and/or multple VRF instances

show sdm prefer

conf t
sdm prefer [Access | Routing | Vlan | Extended-match]

VTP Version 3

Difference between

vtp password X **hidden**

And

vtp password / service password-encryption

service password-encryption
vtp password CISCO

SWITCH# show vtp password
VTP Encrypted Password: 02270A5F19030E32

Within **vlan.dat** password is still in **clear text.**

---

vtp password CISCO hidden

SW1# show vtp password
VTP Password: CF94C2FF1CDCEB8DC795CEB21E305F10

vlan.dat is encrypted

VTP Version 3

Cisco 3750 **Stack** Master is the

vtp primary-server

The Stack Master **announces** its **own MAC Address** as vtp version 3 primary-server.

-> THE CURRENT STACK **MASTER FAILS**!

With the following command, the **newly assigned Stack Master** will send a VTP Version 3 **take-over message** after 5 minutes down time of the previous Stack Master. Announcing the new Stack Masters MAC address as primary-server

stack-mac persistent timer <5>

Catalyst VMPS config:

SW1#show vmps

VQP Client Status:

VMPS VQP Version: 1
Reconfirm Interval: 60 min
Server Retry Count: 3
VMPS domain server:

Reconfirmation status:

VMPS Action: No Dynamic Port

vmps reconfirm 30
vmps retry 5
vmps server 1.1.1.1 primary
vmps server 2.2.2.2

int fa0/x
switchport mode access
switchport access vlan dynamic

VTP Version 3

Show commands:

show vtp **status enhanced**

show vtp **devices conflicts**

show vtp **devices feature**

show **vtp interface**

show vtp counters
(can discover configs from different primary servers)

show vlan internal usage (Vlan ID 1000-1018 issue)

VTP Version 3

show vtp devices

Output:

SWITCH# **show vtp devices**
Gathering information from the domain, please wait.
VTP Database Conf switch ID Primary Server Revision System Name
---------- ---- --------------- ------ ---------- ----------
VLAN No 000c.0012.3456=000c.0012.3456 1001 SWITCH
MST No 000c.0012.3456=000c.0012.3456 42 SWITCH

(**Neighbor with two instances** shown, VLAN and MST instance)

Spanning-tree selection rules

STP rules:

1. Lower root BID
2. Lower path cost to the root bridge
3. lower sending BID
4. lower Sending Port-ID (Priority).Port-iD

Home Lab tip:

If you have a lab on which the Lines keep miss-behaving, Clear all lines instead of individually:

alias exec line-clear event manager run CLEAR-LINES

```
event manager applet CLEAR-LINES
 event none sync yes
 action 1.0 cli command "clear line 65"
 action 1.1 cli command "clear line 66"
 action 1.2 cli command "clear line 67"
 action 1.3 cli command "clear line 68"
 action 1.4 cli command "clear line 69"
 action 1.5 cli command "clear line 70"
 action 1.6 cli command "clear line 71"
 action 1.7 cli command "clear line 72"
 action 1.8 cli command "clear line 73"
 action 1.9 cli command "clear line 74"
 action 2.0 cli command "clear line 75"
 action 2.1 cli command "clear line 76"
 action 2.2 cli command "clear line 77"
 action 2.3 cli command "clear line 78"
 action 2.4 cli command "clear line 79"
 action 2.5 syslog msg "All lines cleared"

R3#line-clear
%HA_EM-6-LOG: CLEAR-LINES: All lines cleared
```

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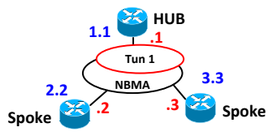
DMVPN

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x



DMVPN Phase 1
Static config

```
HUB
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.2 192.1.2.2
 ip nhrp map 10.1.1.3 192.1.3.3
 ip nhrp map 10.1.1.4 192.1.4.4
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R1#show ip nhrp
10.1.1.2/32 via 10.1.1.2
  Tunnel1 created 00:11:18, neve
  Type: static, Flags:
  NBMA address: 192.1.2.2
10.1.1.3/32 via 10.1.1.3
  Tunnel1 created 00:11:18, neve
  Type: static, Flags:
  NBMA address: 192.1.3.3
10.1.1.4/32 via 10.1.1.4
  Tunnel1 created 00:11:18, neve
  Type: static, Flags: used
  NBMA address: 192.1.4.4
```

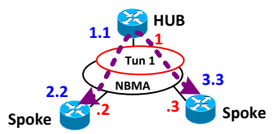
DMVPN Phase 1, static

```
Spoke
interface Tunnel1
 ip address 10.1.1.2 255.255.255.0
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 192.1.1.1
```

```
R2#show ip nhrp
10.1.1.1/32 via 10.1.1.1
  Tunnel1 created 00:11:49, nev
  Type: static, Flags:
  NBMA address: 192.1.1.1
```

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x

Trace from Spoke 2 to Spoke 3



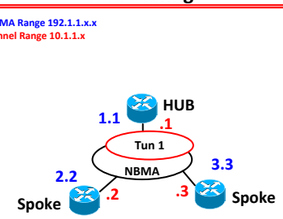
DMVPN Phase 1
Static config

R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.1** 13 msec 6 msec 5 msec
 2 **10.1.1.3** 3 msec * 2 msec

2nd traceroute:

R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.1** 13 msec 6 msec 5 msec
 2 **10.1.1.3** 3 msec * 2 msec

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x



DMVPN Phase 2
Static config

```
HUB
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.2 192.1.2.2
 ip nhrp map 10.1.1.3 192.1.3.3
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R1#show ip nhrp
10.1.1.2/32 via 10.1.1.2
  Tunnel1 created 00:03:41, neve
  Type: static, Flags: used
  NBMA address: 192.1.2.2
10.1.1.3/32 via 10.1.1.3
  Tunnel1 created 00:03:41, neve
  Type: static, Flags: used
  NBMA address: 192.1.3.3
```

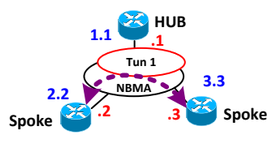
DMVPN Phase 2, static mapping

```
Spoke
interface Tunnel1
 ip address 10.1.1.2 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp map 10.1.1.3 192.1.3.3
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R2#show ip nhrp
10.1.1.1/32 via 10.1.1.1
  Tunnel1 created 00:02:41, neve
  Type: static, Flags: used
  NBMA address: 192.1.1.1
10.1.1.3/32 via 10.1.1.3
  Tunnel1 created 00:02:41, neve
  Type: static, Flags: used
  NBMA address: 192.1.3.3
```

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x

Trace from Spoke 4 to Spoke 2



DMVPN Phase 2
static config

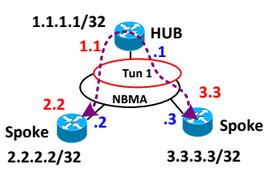
R4#traceroute 10.1.1.2 numeric
Type escape sequence to abort.
Tracing the route to 10.1.1.2
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.2** 7 msec * 1 msec

2nd traceroute:

R4#traceroute 10.1.1.2 numeric
Type escape sequence to abort.
Tracing the route to 10.1.1.2
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.2** 7 msec * 1 msec

Direct access due to static mapping and Tunnel mode gre multipoint

DMVPN Phase 1 setup
Using EIGRP



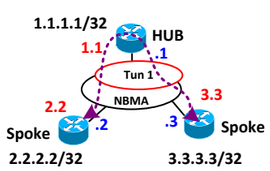

```
HUB
interface Tunnel123
 ip address 123.1.1.1
255.255.255.0
 no ip redirects
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 no ip split-horizon eigrp 10
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB:
router eigrp 10
 network 123.0.0.0
 network 1.1.1.1
```

```
Spoke:
 router eigrp 10
 network 123.0.0.0
 network 2.2.2.2
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

DMVPN Phase 1 setup
Using RIP
do not use "no ip split-horizon"




```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 ip summary-address rip 0.0.0.0 0.0.0.0
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip rip advertise 2
 no ip split-horizon
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB:
router rip
 version 2
 network 1.0.0.0
 network 123.0.0.0
 no auto-summary
```

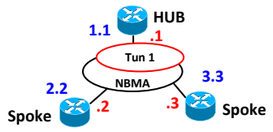
Sending a default route via summarization (NBMA must be specifically routed /32 or higher AD)

```
Spoke:
 router rip
 version 2
 network 2.0.0.0
 network 123.0.0.0
 no auto-summary
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x

DMVPN Phase 1
Dynamic mapping config




```
HUB
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R1#show ip nhrp
10.1.1.2/32 via 10.1.1.2
  Tunnel1 created 00:07:29, expire 0
  Type: dynamic, Flags: unique regist
  NBMA address: 192.1.2.2
10.1.1.3/32 via 10.1.1.3
  Tunnel1 created 00:07:24, expire 0
  Type: dynamic, Flags: unique regist
  NBMA address: 192.1.3.3
```

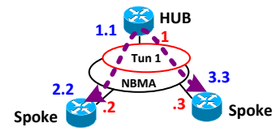
DMVPN Phase 1, Dynamic

```
SPOKE
interface Tunnel1
 ip address 10.1.1.2 255.255.255.0
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 10.1.1.1
 tunnel source Ethernet0/0
 tunnel destination 192.1.1.1
```

```
R2#show ip nhrp
10.1.1.1/32 via 10.1.1.1
  Tunnel1 created 00:11:39, never ex
  Type: static, Flags:
  NBMA address: 192.1.1.1
```

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x

Trace from Spoke 2 to Spoke 3



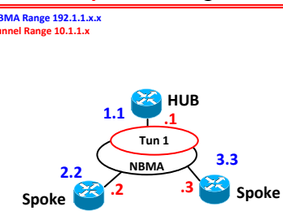
DMVPN Phase 1
Dynamic config

R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.1** 12 msec 1 msec 6 msec
 2 **10.1.1.3** 6 msec * 2 msec

2nd traceroute:

R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 **10.1.1.1** 12 msec 1 msec 6 msec
 2 **10.1.1.3** 6 msec * 2 msec

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x



DMVPN Phase 2
Dynamic config

```
HUB
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R1#show ip nhrp
10.1.1.2/32 via 10.1.1.2
  Tunnel1 created 00:15:59, expire
  Type: dynamic, Flags: unique regi
  NBMA address: 192.1.2.2
10.1.1.3/32 via 10.1.1.3
  Tunnel1 created 00:15:51, expire
  Type: dynamic, Flags: unique regi
  NBMA address: 192.1.3.3
```

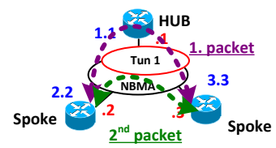
DMVPN Phase 2, dynamic

```
Spoke
interface Tunnel1
 ip address 10.1.1.2 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 10.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
R2#show ip nhrp
10.1.1.1/32 via 10.1.1.1
  Tunnel1 created 00:04:29, never
  Type: static, Flags: used
  NBMA address: 192.1.1.1
10.1.1.4/32 via 10.1.1.4
  Tunnel1 created 00:02:31, expire
  Type: dynamic, Flags: router
  NBMA address: 192.1.4.4
```

NBMA Range 192.1.1.x.x
Tunnel Range 10.1.1.x

Trace from Spoke 4 to Spoke 2



DMVPN Phase 2
dynamic config

R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 10.1.1.1 11 msec 1 msec 6 msec
 2 10.1.1.3 1 msec * 1 msec

2nd traceroute:

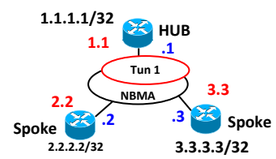
R2#**traceroute 10.1.1.3 numeric**
Type escape sequence to abort.
Tracing the route to 10.1.1.3
VRF info: (vrf in name/id, vrf out name/id)
 1 10.1.1.1 1 msec * 2 msec

You have issued

clear ip nhrp on the HUB and discover that you no longer have reachability from and to your spokes!

How do you solve this in the lab?

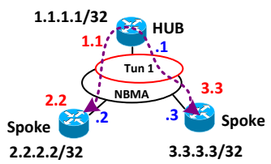
Force the spokes to re-register



On Spokes:
int tun x
ip nhrp registration timeout <1 sec>

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

DMVPN Phase 1 setup
Using RIP




```
HUB
interface Tunnel123
 ip address 123.1.1.1
255.255.255.0
 no ip redirects
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip rip advertise 2
 no ip split-horizon
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB:
router rip
 version 2
 network 1.0.0.0
 network 123.0.0.0
 no auto-summary
```

```
Spoke:
 router rip
 version 2
 network 2.0.0.0
 network 123.0.0.0
 no auto-summary
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

What is the difference between the two DMVPN flavors?

What are main configuration **differences between**

DMVPN Phase 1

Static and dynamic

Config?

What are main configuration **differences between**

DMVPN Phase 2

Static and dynamic

Config?

Hub:

```
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

Spoke:

```
interface Tunnel1
 ip address 10.1.1.4 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 10.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

On Hub: **debug nhrp cache:**

Hub:

```
interface Tunnel1
 ip address 10.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

Spoke:

```
interface Tunnel1
 ip address 10.1.1.4 255.255.255.0
 no ip redirects
 ip nhrp map 10.1.1.1 192.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 10.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

On Hub: **debug nhrp packet:**

GRE

int tun 1
tunnel source x.x.x.x
tunnel destination y.y.y.y

---

mGRE

int tun 1
tunnel source x.x.x.x
tunnel mode gre multipoint

debug nhrp cache:

```
NHRP: Tunnel1: Cache add for target 10.1.1.4/32 next-hop 10.1.1.4
192.1.4.4
NHRP: Inserted subblock node for cache: Target Inserted subblock
node for cache: Target 10.1.1.4/32nhop 10.1.1.4
NHRP: Converted internal dynamic cache entry for 10.1.1.4/32
interface Tunnel1 to external
NHRP: Updating our cache with NBMA: 192.1.1.1, NBMA_ALT:
192.1.1.1
NHRP: Setting 'used' flag on cache entry with nhop: 10.1.1.4
NHRP: NHRP successfully mapped '10.1.1.4' to NBMA 192.1.4.4
NHRP: Tunnel1: Cache update for target 10.1.1.4/32 next-hop 10.1.1.4
192.1.4.4
NHRP: Updating our cache with NBMA: 192.1.1.1, NBMA_ALT:
192.1.1.1
NHRP: Setting 'used' flag on cache entry with nhop: 10.1.1.4
NHRP: NHRP successfully mapped '10.1.1.4' to NBMA 192.1.4.4
```

```
NHRP: Receive Registration Request via Tunnel1 vrf 0, packet size: 92
src NBMA: 192.1.4.4
src protocol: 10.1.1.4, dst protocol: 10.1.1.1

NHRP: Send Registration Reply via Tunnel1 vrf 0, packet size: 112
src: 10.1.1.1, dst: 10.1.1.4
(M) flags: "unique nat ", reqid: 65544
src NBMA: 192.1.4.4
 src protocol: 10.1.1.4, dst protocol: 10.1.1.1

NHRP: Receive Registration Request via Tunnel1 vrf 0, packet size: 92
src NBMA: 192.1.4.4
src protocol: 10.1.1.4, dst protocol: 10.1.1.1

NHRP: Send Registration Reply via Tunnel1 vrf 0, packet size: 112
src: 10.1.1.1, dst: 10.1.1.4
```

Phase 1 static
Hub:
ip nhrp map SPOKE-TUNNEL-IP SPOKE-NBMA-IP
tunnel mode gre multipoint

Spoke:
ip nhrp map HUB-TUNNEL-IP HUB-NBMA-IP
tunnel destination HUB-NBMA-IP

Phase 1 dynamic
Hub:
ip nhrp map SPOKE-TUN-IP SPOKE-NBMA-IP
tunnel mode gre multipoint

Spoke:
ip nhrp map HUB-TUNNEL-IP HUB-NBMA-IP
tunnel destination HUB-NBMA-IP
ip nhrp nhs HUB-NBMA-IP

Phase 2 static
Hub:
ip nhrp map SPOKE-TUNNEL-IP SPOKE-NBMA-IP
tunnel mode gre multipoint

Spoke:
ip nhrp map HUB-TUNNEL-IP HUB-NBMA-IP
ip nhrp map SPOKE-x-TUNNEL-IP SPOKE-x-NBMA-IP
tunnel mode gre multipoint

Phase 2 dynamic
Hub:
ip nhrp map SPOKE-TUNNEL-IP SPOKE-NBMA-IP
tunnel mode gre multipoint

Spoke:
ip nhrp map HUB-TUNNEL-IP HUB-NBMA-IP
ip nhrp nhs HUB-TUNNEL-IP
tunnel mode gre multipoint

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Colin

http://www.flashcardguy.ch

DMVPN

What three solutions are there in regards to

DMVPN Phase 1 and OSPF?

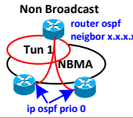
Phase 1 – OSPF
Point-to-point

Error messages!
EXCHANGE to DOWN ....

Phase 1 – OSPF
Broadcast

ip ospf prio 0

Phase 1 – OSPF
Non Broadcast



ip ospf prio 0

Phase 1 – OSPF
Point-to-Multipoint

DMVPN Phase 2 and RIPv2

(direct Spoke to Spoke)

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 no ip redirects
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 no ip split-horizon
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router rip
 version 2
 network 1.0.0.0
 network 123.0.0.0
 no auto-summary
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp map multicast 200.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 123.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router rip
 version 2
 network 2.0.0.0
 network 123.0.0.0
 no auto-summary
```

```
R2#show ip route | i 3.3.3.3
R    3.3.3.3 [120/2] via 123.1.1.3, 00:00:16, Tunnel123

R2#traceroute 3.3.3.3 source 2.2.2.2 numeric
VRF info: (vrf in name/id, vrf out name/id)
  1 123.1.1.3 2 msec *  6 msec
```

DMVPN Phase 3 and EIGRP

(direct Spoke to Spoke)

Not using:
no ip next-hop-self eigrp 10

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1    /24
 no ip redirects
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 ip nhrp redirect
 no ip split-horizon eigrp 10
 tunnel source FastEthernet0/0
 tunnel mode gre multipoint

router eigrp 10
 network 1.1.1.1 0.0.0.0
 network 123.1.1.1 0.0.0.0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2    /24
 ip nhrp map multicast 200.1.1.1
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 222
 ip nhrp nhs 123.1.1.1
 ip nhrp shortcut
 tunnel source FastEthernet0/0
 tunnel mode gre multipoint

router eigrp 10
 network 2.2.2.2 0.0.0.0
 network 123.1.1.2 0.0.0.0
```

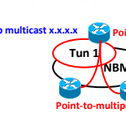
Notice the route pointing to .1, traffic flowing to .3 directly as of the 2nd packet!

```
R2#show ip route | i 3.3.3
D     3.3.3.3 [90/28288000] via 123.1.1.1, 00:00:16, Tunnel123

R2#traceroute 3.3.3.3 sou 2.2.2.2 numeric   (2nd traceroute)
  1 123.1.1.3 4 msec *  0 msec
```

DMVPN Phase 1 / OSPF

Broadcast



NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip ospf network broadcast
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB
router ospf 1
 router-id 0.0.0.1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
```

```
Spoke:
router ospf 1
 router-id 0.0.0.2
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

```
Spoke:
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 ip ospf network broadcast
 ip ospf priority 0
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

DMVPN Phase 2 and EIGRP

(direct Spoke to Spoke)

-> change next-hop behaviour

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 no ip redirects
 no ip next-hop-self eigrp 10
 no ip split-horizon eigrp 10
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router eigrp 10
 network 1.0.0.0
 network 123.0.0.0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 no ip redirects
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp map multicast 200.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 123.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router eigrp 10
 network 2.0.0.0
 network 123.0.0.0
```

```
R2#show ip route | i 3.3.3.3
D     3.3.3.3 [90/28288000] via 123.1.1.3, 00:18:48, Tunnel123

R2#traceroute 3.3.3.3 source 2.2.2.2 numeric
VRF info: (vrf in name/id, vrf out name/id)
  1 123.1.1.3 1 msec *  5 msec
```

DMVPN Phase 3 and OSPF

(direct Spoke to Spoke)

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

OSPF Point2Multipoint on all routers would cause spokes to always travel via the HUB to other spokes, with Phase 3, the routes are advertised by the HUB, but travel/redirect directly from spoke to spoke!

```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 no ip redirects
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 ip nhrp redirect
 ip ospf network point-to-multipoint
 tunnel source FastEthernet0/0
 tunnel mode gre multipoint

router ospf 1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 no ip redirects
 ip nhrp map multicast 200.1.1.1
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 222
 ip nhrp nhs 123.1.1.1
 ip nhrp shortcut
 ip ospf network point-to-multipoint
 tunnel source FastEthernet0/0
 tunnel mode gre multipoint

router ospf 1
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

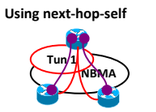
```
R3#show ip route | i 2.2.
O     2.2.2.2 [110/2001] via 123.1.1.1, 00:04:48, Tunnel123

R3#traceroute 2.2.2.2 source 3.3.3.3 numeric
  1 123.1.1.2 0 msec *  0 msec
```

As of 2nd packet!

DMVPN Phase 1 / OSPF

non-broadcast



NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip ospf network non-broadcast
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

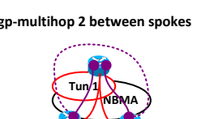
```
HUB
router ospf 1
 router-id 0.0.0.1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
 neighbor 123.1.1.3
 neighbor 123.1.1.2
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 255.255.255.0
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 ip ospf network non-broadcast
 ip ospf priority 0
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

```
Spoke
router ospf 1
 router-id 0.0.0.2
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

DMVPN Phase 2 and OSPF

(direct Spoke to Spoke)



NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 ip ospf network broadcast
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router ospf 1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp map multicast 200.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 123.1.1.1
 ip ospf network broadcast
 ip ospf priority 0
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router ospf 1
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

```
R2#show ip route ospf | i 3.3.3
O     3.3.3.0 [110/1001] via 123.1.1.3, 00:05:10, Tunnel123

R2#traceroute 3.3.3.3 source 2.2.2.2 numeric
  1 123.1.1.3 2 msec *  2 msec
```

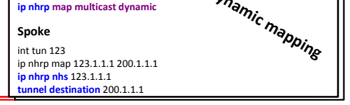
What is the difference between DMVPN Phase 2 and Phase 3 ?

Phase 2:
The routing protocol on a Spoke learns prefixes of other spokes directly of the other spokes tunnel IP address.
Traffic then forwarded directly to the spokes tunnel IP.
(Resolution done via IGP, not NHRP)

Phase 3:
A Spokes routing protocol points towards the HUB for a prefix from another Spoke, NHRP kicks in an redirects traffic directly between spokes.

On Hub: ip nhrp redirect

On Spokes: ip nhrp shortcut



DMVPN Phase 1 / OSPF

HUB: Point-to-Multipoint
Spoke: Point-to-Point

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip ospf network point-to-multipoint
 ip ospf hello-interval 10
 ip ospf dead-interval 40
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB
router ospf 1
 router-id 0.0.0.1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

```
Spoke
router ospf 1
 router-id 0.0.0.2
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

DMVPN Phase 2 and BGP

(direct Spoke to Spoke)

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 ip nhrp map multicast dynamic
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router bgp 100
 bgp log-neighbor-changes
 network 1.1.1.0 mask 255.255.255.0
 neighbor 123.1.1.2 remote-as 200
 neighbor 123.1.1.3 remote-as 300
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp map multicast 200.1.1.1
 ip nhrp network-id 111
 ip nhrp nhs 123.1.1.1
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router bgp 200
 bgp log-neighbor-changes
 network 2.2.2.0 mask 255.255.255.0
 neighbor 123.1.1.1 remote-as 100
 neighbor 123.1.1.3 remote-as 300
 neighbor 123.1.1.3 ebgp-multihop 2
```

```
R2#show ip route | i 3.3.3
B     3.3.3.0 [20/0] via 123.1.1.3, 00:13:08

R2#traceroute 3.3.3.3 source 2.2.2.2 numeric
  1 123.1.1.3 6 msec *  1 msec
```

DMVPN Phase 1 / OSPF

HUB: Point-to-Multipoint
Spoke: Point-to-Multipoint

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1 255.255.255.0
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp map multicast 200.1.2.2
 ip nhrp map multicast 200.1.3.3
 ip nhrp network-id 111
 ip ospf network point-to-multipoint
 tunnel source Ethernet0/0
 tunnel mode gre multipoint
```

```
HUB
router ospf 1
 router-id 0.0.0.1
 network 1.1.1.1 0.0.0.0 area 0
 network 123.1.1.1 0.0.0.0 area 0
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2 /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 no ip route-cache
 ip ospf network point-to-multipoint
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1
```

```
Spoke
router ospf 1
 router-id 0.0.0.2
 network 2.2.2.2 0.0.0.0 area 0
 network 123.1.1.2 0.0.0.0 area 0
```

DMVPN Phase 1

BGP

Using next-hop-self

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router bgp 100
 bgp log-neighbor-changes
 network 1.1.1.1 mask    /32
 neighbor 123.1.1.2 remote-as 200
 neighbor 123.1.1.2 next-hop-self
 neighbor 123.1.1.3 remote-as 300
 neighbor 123.1.1.3 next-hop-self
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1

router bgp 200
 bgp log-neighbor-changes
 network 2.2.2.2 mask    /24
 neighbor 123.1.1.1 remote-as 100
 neighbor 123.1.1.1 next-hop-self
```

DMVPN Phase 1

BGP

ebgp-multihop 2 between spokes

NBMA Range 200.1.x.x
Tunnel Range 123.1.1.x

```
HUB
interface Tunnel123
 ip address 123.1.1.1   /24
 ip nhrp map 123.1.1.2 200.1.2.2
 ip nhrp map 123.1.1.3 200.1.3.3
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel mode gre multipoint

router bgp 100
 bgp log-neighbor-changes
 network 1.1.1.1 mask    /32
 neighbor 123.1.1.2 remote-as 200
 neighbor 123.1.1.3 remote-as 300
```

```
Spoke
interface Tunnel123
 ip address 123.1.1.2   /24
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp network-id 111
 tunnel source Ethernet0/0
 tunnel destination 200.1.1.1

router bgp 200
 bgp log-neighbor-changes
 network 2.2.2.2 mask    /24
 neighbor 123.1.1.1 remote-as 100
 neighbor 123.1.1.3 remote-as 300
 neighbor 123.1.1.3 ebgp-multihop 2
```


What are the main differences between **DMVPN Phase 1**

Static mapping

Dynamic mapping

Static mapping

```
HUB
int tun 123
 ip nhrp map 123.1.1.x 200.1.x.x
 ip nhrp map multicast 200.1.x.x

Spoke
int tun 123
 ip nhrp map 123.1.1.x 200.1.1.1
 tunnel destination 200.1.1.1
```

Dynamic mapping

```
HUB
int tun 123
 ip nhrp map multicast dynamic

Spoke
int tun 123
 ip nhrp map 123.1.1.1 200.1.1.1
 ip nhrp nhs 123.1.1.1
 tunnel destination 200.1.1.1
```

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IP routing

Enabling / disabling Proxy-Arp:

Debugging proxy-arp:

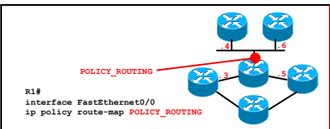
Disable:

```
interface GigabitEthernet0/0.146
 encapsulation dot1Q 146
 ip address 155.1.146.6 255.255.255.0
 no ip proxy-arp
```

Enable:

```
interface GigabitEthernet0/0.146
 encapsulation dot1Q 146
 ip address 155.1.146.6 255.255.255.0
 no ip proxy-arp

Debug arp
Debug ip packet

IP ARP: rcvd rep src 150.1.6.6 0026.0b57.b960, dst 155.1.146.1 FastEthernet0/0
```

Policy routing configuration:




```
R1#
interface FastEthernet0/0
ip policy route-map POLICY_ROUTING

ip access-list extended FROM_R4
permit ip host 155.1.146.4 any

ip access-list extended FROM_R6
permit ip host 155.1.146.6 any

route-map POLICY_ROUTING permit 10
match ip address FROM_R4
set ip next-hop 155.1.13.3

route-map POLICY_ROUTING permit 20
match ip address FROM_R6
set ip next-hop 155.1.0.5
```

Local Policy Routing

Configuration:

ip local policy route-map RMP-POL-LOCAL

route-map RMP-POL-LOCAL permit 10
 match ip address TO_R4
 set ip next-hop 155.1.0.5
!
route-map RMP-POL-LOCAL permit 20
 match ip address TO_R5
 set ip next-hop 155.1.146.4

Affects local by the router generated traffic.

Routing to NBMA Interfaces

Possible configurations (two):

Use static route **using Next-hop IP / LMI:**

ip route X.X.X.X 255.255.255.255 **10.0.0.1**
(Frame-Relay **PVC learned via LMI** for 10.0.0.1)

Using Interface command and frame-relay map:

```
Int Serial0
frame-relay map ip 10.0.0.1 502 broadcast
Exit
Ip route 10.0.0.1 255.255.255.255 Serial0
```

Debugging Policy routing:

```
R1#debug ip policy
Policy routing debugging is on
R1#
*Jul 15 10:34:39.146: IP: s=155.1.146.6 (FastEthernet0/0), d=155.1.5.5, len 100, FIB policy match
*Jul 15 10:34:39.146: IP: s=155.1.146.6 (FastEthernet0/0), d=155.1.5.5, g=155.1.0.5, len 100, FIB policy routed

*Jul 15 10:39:11.902: IP: s=54.1.1.6 (FastEthernet0/0), d=54.1.2.254, len 56, FIB policy rejected(no match) - normal forwarding
*Jul 15 10:39:11.906: IP: s=54.1.1.6 (FastEthernet0/0), d=54.1.2.254, len 56, policy rejected -- normal forwarding
```

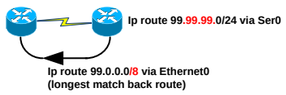
What is the pre-requisite for visible output on the following command?

debug ip packet detail

Int X
no ip route-cache

debug ip packet detail

Where to use Longest Match Routing?



If you need to create a backup path in case the primary more specific route goes down.

Show track brief output:

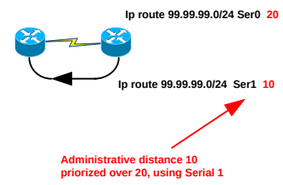
```
R1# show track brief
Track  Object          Parameter     Value
123    rtr     1      reachability  Up
124    rtr     2      reachability  Up
```

GRE Tunneling and Recursive Routing

Using RIP

```
Interface Loopback0
Ip address 150.1.9.9 255.255.255.0    (/24 Mask!)

interface Tunnel34
tunnel source Loopback0                 IF NOT SPECIFIED WILL USE ACL PFX.. PITFALL !!

router rip

distribute-list prefix PFX-DISALLOW-TUN-DST out Tunnel34

ip prefix-list PFX-DISALLOW-TUN-DST seq 5 deny 150.1.9.0/24
ip prefix-list PFX-DISALLOW-TUN-DST seq 10 permit 0.0.0.0/0 le 32

  Dis-allow the tunnel SOURCE PREFIX out the
  tunnel to the other side. Need to be done on
  both sides!
```

Floating Static Routes



Reliable Policy Routing

(ip policy with IP SLA combined)

```
Interface X
Ip policy route-map RMP-POL-R3-IN

route-map RMP-POL-R3-IN permit 20                    Sequence Nr
 match ip address ACL_SRC_R3_DST_R5
 set ip next-hop verify-availability 155.1.146.10 1 track 50
 set ip next-hop verify-availability 155.1.146.20 2 track 99
 set ip next-hop 155.1.146.10
 set ip next-hop 155.1.146.20
 set ip default next-hop 155.1.0.5                   Track Nr
```

GRE Tunneling and Recursive Routing

What two solutions are there?

Solution A:

Use prefix list outbound the Tunnel interface, dis-allowing the Tunnel Source to be advertise through the Tunnel.

Solution B:

Using static routes with lower administrative Distance.

Backup Interface on switches and routers:

Routers:

```
interface Serial0/0/0.10 point-to-point
backup delay 3 60
backup interface Serial0/1/0
```

Switches:

```
Int Port-Channel 22
switchport backup interface Fa0/16
switchport backup interface Fa0/16 preemption mode forced
switchport backup interface Fa0/16 preemption delay 20
```

What two possible ways of tracking are available in policy routing, Unsing an IP and a non-IP protocol?

Tracking through IP SLA

Tracking by the use of CDP

What is special about routes with Administrative Distance, but are configured as the Backup interface?

They can not be used, only if the primary interface goes down, are the backup interfaces/routes installed!

IP SLA (RTR) configuration and monitoring:

Config:

```
ip sla monitor 10
 type echo protocol ipicmpEcho 150.1.1.1 source-interface Gi0/1
 timeout 2000
 frequency 5
ip sla monitor schedule 10 life forever start-time now

ip sla 1
icmp-echo 155.1.146.1 source-interface FastEthernet0/1
timeout 2000
frequency 5
ip sla schedule 1 life forever start-time now
```

Monitoring:

```
Show rtr config
Show rtr statistics
Show ip sla XX
```

Reliable Policy Routing

(ip policy utilizing CDP, not IP SLA)

```
Neighbour interface
Cdp enable
Ip address 155.1.0.5   255.255.255.0

Interface X
Cdp enable
Ip addr 155.1.0.1  255.255.255.0

route-map RELIABLE_POLICY_ROUTING permit 10
match ip address FROM_R3_TO_R4_LOOPBACK
set ip next-hop 155.1.0.5
set ip next-hop verify-availability
set ip default next-hop 155.1.146.4

As long as 155.1.0.5 is learned via CDP that next-hop is used as it is verified available.
```

Reliable Backup Interface with GRE

Using Keepalives to detect End-To-End connectivity over Frame-Relay Networks

```
without GRE-Keepalives the router would not be able to detect an underlying path error. If the Keepalive stop, the tunnel line-protocol goes down, and the backup interface is triggered.


interface Tunnel0
ip address 10.0.0.5 255.255.255.0
tunnel source Serial0/0/0
tunnel destination 155.1.0.4
keepalive 1 3
backup interface Serial0/1/0
```

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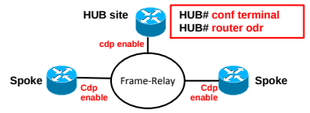
On-Demand Routing (ODR)



Spoke# sh ip route
o* **0.0.0.0/0** [**160**/1] via 155.1.0.5, 00:00:28, Serial0/0/0.1

HUB#sh ip route
o 150.1.4.0 [**160**/1] via 155.1.0.4, 00:00:16, Serial0/0/0
o 150.1.3.0 [**160**/1] via 155.1.0.3, 00:00:15, Serial0/0/0

What types of aggregation modes are there for OER?

```
aggregation-type
{bgp | non-bgp | prefix-length <prefix-mask>}
```

What is measured in OER passive mode?

Enabled by default, uses NetFlow

Delay - OER measures the average delay of TCP flows for a given prefix

Packet loss - OER measures packet loss by tracking TCP sequence Numbers

Reachability - OER measures reachability by tracking TCP SYN messages without receiving a TCP ACK packet

throughput - OER measures throughput by measuring the total number of bytes and packets for each traffic class enabled by default

On-Demand Routing (ODR)

conf t

router odr
timers basic <update> <invalid> <holddown> <flushtimer>
distribute-list route-map in interface X

Use distribute-list to filter the routes in a "complex" ODR scenario! ☺

```
OER:

Periodic interval <minute>
```

prefixes <number>

OER Prefix learning starts every time interval

By default, 100 top flows are learned

What are properties of OER active mode?

synthetic traffic are applied to the corresponding traffic class in the MTC list

OER activates the probes on all the Border Routers

```
oer-map OER 20
set mode monitor active

oer master
active-probe tcp-conn 150.1.1.1 target-port 23
active-probe tcp-conn 150.1.4.4 target-port 23
```

OER / PfR Phases:

(1) OER Profile phase:
Discovering traffic classes.

(2) OER Measure phase:
OER Border Routers measure traffic actively (SLA) or passively (Netflow)

(3) OER Apply Policy phase:
Master controller has set of thresholds

(4) OER Control phase.
Injecting routes, changing metrics

(5) OER Verify phase.
Verifies new policies, checking if in-policy

How do you exclude certain prefixes from OERs monitoring?

```
ip prefix-list MONITOR deny 114.0.1.0/24
ip prefix-list MONITOR permit 114.0.0.0/8
!
oer-map OER 10
match ip address prefix-list MONITOR

oer master
policy-rules OER
```

show oer master prefix

Output explanations:

PasSDly – passively measured delay, short-range (5 minutes interval)
ActSDly – actively measured delay, short-range
PasLDly – passively measured delay, long-range (60 minute interval)
PasSUn/PasLUn – passively measured short and long range unreachable metric
ActSUn/ActLUn – the same unreachable, just measured actively
PasSLos/PasSLos – short and long range loss, measured passively
EBw/IBw – egress and ingress bandwidth usage for this class in kbps
State – any of the states from the traffic state diagram
Time – the amount of time spent in the state
Curr BR – current Border Router selected for this class
Curr I/F – current exit interface selected for this class
Protocol – protocol used to influence routing for this traffic class

OER traffic class

Can be a network prefix

Can be a complex object consisting of network prefix and application port number.

IP SLA jitter emulating G.729 codec between R6 and SW2

R6:

```
ip sla 2
udp-jitter 150.1.8.8 16384 source-ip 150.1.6.6
codec g729a codec-numpackets 10 codec-interval
10
exit
!
ip sla schedule 2 life forever start-time now
```

SW2:

```
ip sla responder
```

show oer master active-probes

```
Rack1R5#show oer master active-probes
OER Master Controller active-probes
Border = Border Router running this Probe
State = Un/Assigned to a Prefix
Prefix = Probe is assigned to this Prefix
Type = Probe Type
Target = Target Address
TPort = Target Port
How = Was the probe Learned or Configured
N - Not applicable
The following Probes exist:
State Prefix Type Target TPort How Codec
Assigned 150.1.6.0/24 tcp-conn 150.1.6.6 23 Cfgd N
Assigned 150.1.4.0/24 tcp-conn 150.1.4.4 23 Cfgd N
Assigned 150.1.1.0/24 tcp-conn 150.1.1.1 23 Cfgd N
Assigned 150.1.6.0/24 echo 150.1.6.6 N Lrnd N
Assigned 150.1.1.0/24 echo 150.1.1.1 N Lrnd N
Assigned 150.1.4.0/24 echo 150.1.4.4 N Lrnd N
The following Probes are running:
Border State Prefix Type Target TPort
150.1.3.3 ACTIVE 150.1.1.0/24 echo 150.1.1.1 N
150.1.3.3 ACTIVE 150.1.1.0/24 echo 150.1.1.1 N
150.1.5.5 ACTIVE 150.1.1.0/24 echo 150.1.1.1 N
150.1.3.3 ACTIVE 150.1.6.0/24 echo 150.1.6.6 N
```

OER Automatic prefix traffic class learning is based on what:

Master Controller collects NetFlow information from the Border Routers

show oer border

```
show oer border
OER BR 150.1.2.2 ACTIVE, MC 150.1.5.5 UP/DOWN: UP 00:20:04,
Auth Failures: 0
Conn Status: SUCCESS, PORT: 3949
Exits
Fa0/0       EXTERNAL
Se0/0.1     INTERNAL
```

RIPv2 Authentication

Configuration:

```
R1:
key chain RIP
key 1
key-string CCIE
!
interface FastEthernet0/0
ip rip authentication mode text
(ip rip authentication mode md5)

ip rip authentication key-chain RIP
```

```
oer master
 learn
 throughpug
 delay
```

highest *outbound* throughput (number of bytes transferred)

delay (RTT time)

show oer master

```
Rack1R5#show oer master
OER state: ENABLED and ACTIVE
Conn Status: SUCCESS, PORT: 3949
Version: 2.2
Number of Border routers: 3
Number of Exits: 4
Number of monitored prefixes: 0 (max 5000)
Max prefixes: total 5000 learn 2500
Prefix count: total 0, learn 0, cfg 0
PBR Requirements not met
Nbar Status: Inactive
Border Status UP/DOWN AuthFail Version
150.1.5.5 ACTIVE UP 00:01:12 0 2.2
150.1.2.2 ACTIVE UP 00:11:08 0 1.0
150.1.3.3 ACTIVE UP 00:12:06 0 1.0
.....
.....
```

How to find spaces within Passwords:

What can "**show key chain**" reveal?

Can **identify spaces within a password** at its end, which can not be seen otherwise.

R6# **show key chain**

```
Key-chain RIP:
  key 1 -- text "CCIE"
    accept lifetime (always valid) - (always valid) [valid now]
    send lifetime (always valid) - (always valid) [valid now]
```

```
show run | i CCIE$

R2#sh run | i CCIE$
No output due to the password being "CCIE "

R2#sh run | i CCIE $
 key-string CCIE
```

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IP routing

Clearing routing processes in

RIP, EIGRP, OSPF and BGP:

RIP:
clear ip route *

EIGRP:
clear ip eigrp 100 neighbors

OSPF:
clear ip ospf process
yes

BGP:
clear ip bgp *

Don't waste time looking at stars!
If you forgotten how to use control, shift, 6 and X or what it was, change it to something you remember:

R1#**traceroute 2.2.2.2 numeric**

Type escape sequence to abort.
Tracing the route to 2.2.2.2
VRF info: (vrf in name/id, vrf out name/id)
1 * * *
2 * * *
3 * * *
4 *

Change the escape-character to your easy to remember escape-character:

Permanent:
line con 0
escape-character 27

Per session
R1#terminal escape-character 27

Decimal	Hex	Key
27	**1B**	**ESC**
3	03	Ctrl-C
127	7F	Delete

Lookup in document:
"ASCII Character Set and Hex Values"

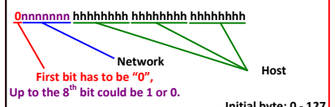
PREFIX Lists:

Match all **un**subnetted /8 prefixes:

ALL unsubnetted /8

ip prefix-list BLA permit 0.0.0.0/1 ge 8 le 8

R 1.0.0.0/**8** [120/1] via 10.1.12.1, 00:00:01, e0/0
R 2.0.0.0/**8** [120/1] via 10.1.12.1, 00:00:01, e0/0
R 3.0.0.0/**8** [120/1] via 10.1.12.1, 00:00:01, e0/0



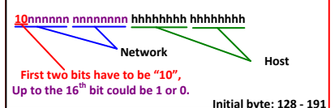
Initial byte: 0 - 127

PREFIX Lists:

Match all **un**subnetted /16 prefixes:

ip prefix-list ROUTES seq 5 permit **128**.0.0.0/**2 ge 16 le 16**

R **128.1.0.0/16** [120/1] via 10.1.12.1, 00:00:02, e0/0
R **191.1.0.0/16** [120/1] via 10.1.12.1, 00:00:02, e0/0



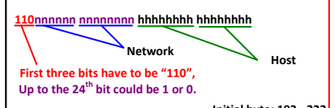
Initial byte: 128 - 191

PREFIX Lists:

Match all **un**subnetted /24 prefixes:

ip prefix-list ROUTES seq 5 permit **192**.0.0.0/**3 ge 24 le 24**

R **192.1.1.0/24** [120/1] via 10.1.12.1, 00:00:01, e0/0
R **195.1.1.0/24** [120/1] via 10.1.12.1, 00:00:01, e0/0



Initial byte: 192 - 223

PREFIX Lists:

Allow Class A networks which are NOT subnetted:

- class A, with a prefix-length of greater than or equal 8 and less than or equal 32
- class A plus all class A networks that are subnetted

ip prefix-list PFX permit 0.0.0.0/1 ge 8 le 32

R **3**.0.0.0/**8** [120/1] via 10.1.12.1, 00:00:02, e0/0
4.0.0.0/**16** is subnetted, 1 subnets
R 4.4.0.0 [120/1] via 10.1.12.1, 00:00:02, e0/0
5.0.0.0/**24** is subnetted, 1 subnets
R 5.5.5.0 [120/1] via 10.1.12.1, 00:00:02, e0/0
6.0.0.0/**26** is subnetted, 1 subnets
R 6.6.6.0 [120/1] via 10.1.12.1, 00:00:02, e0/0

PREFIX Lists

Allow networks that are or are not subnetted

ip prefix-list PFX seq 5 permit 128.0.0.0/2 ge 16

R **128.1.0.0/16** [120/1] via 10.1.12.1, 00:00:01, e0/0
132.1.0.0/24 is subnetted, 1 subnets
R **132.1.1.0** [120/1] via 10.1.12.1, 00:00:01, e0/0
R **191.1.0.0/16** [120/1] via 10.1.12.1, 00:00:01, e0/0

PREFIX Lists:

Allow class C networks that are or are not subnetted:

ip prefix-list PFX seq 5 permit 192.0.0.0/3 ge 24 le 32

R **192**.1.1.0/**24** [120/1] via 10.1.12.1, 00:00:02, e0/0
193.1.1.0/**25** is subnetted, 1 subnets
R **193**.1.1.0 [120/1] via 10.1.12.1, 00:00:02, e0/0
194.1.1.0/**26** is subnetted, 1 subnets

PREFIX Lists:

Allows networks with a prefix-length of 25 or greater in its routing table:

ip prefix-list PFX seq 5 permit 0.0.0.0/0 ge 25

6.0.0.0/**26** is subnetted, 1 subnets
R 6.6.6.**0** [120/1] via 10.1.12.1, 00:00:01, e0/0
193.1.1.**0**/**25** is subnetted, 1 subnets
R 193.1.1.**0** [120/1] via 10.1.12.1, 00:00:01, et0/0

PREFIX Lists:

Allow networks with a prefix-length of 16 or less in its routing table:

ip prefix-list PFX seq 5 permit 0.0.0.0/0 le 16

R **3.0.0.0/8** [120/1] via 10.1.12.1, 00:00:01, e0/0
4.0.0.0/16 is subnetted, 1 subnets
R **4.4.0.0** [120/1] via 10.1.12.1, 00:00:01, e0/0
R **125.0.0.0/8** [120/1] via 10.1.12.1, 00:00:01, e0/0
R **128.1.0.0/16** [120/1] via 10.1.12.1, 00:00:01, e0/0

PREFIX Lists

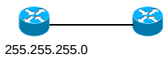
Allow networks with a prefix-length of 16 to 25 in its routing table:

ip prefix-list PFX seq 5 permit 0.0.0.0/0 ge 16 le 25

R 128.1.0.0/**16** [120/1] via 10.1.12.1, 00:00:00, e0/0
132.1.0.0/**24** is subnetted, 1 subnets
R 132.1.1.0 [120/1] via 10.1.12.1, 00:00:00, e0/0
R 191.1.0.0/**16** [120/1] via 10.1.12.1, 00:00:00, e0/0
R 192.1.1.0/**24** [120/1] via 10.1.12.1, 00:00:00, e0/0
193.1.1.0/**25** is subnetted, 1 subnets
R 193.1.1.0 [120/1] via 10.1.12.1, 00:00:00, e0/0

PREFIX lists:

Only permit the 10.7.0.0/22 networks, using one line:



10.7.1.1 255.255.255.0
10.7.0.1 255.255.255.0
10.7.3.1 255.255.255.0
10.7.2.1 255.255.255.0
~~10.7.9.1 255.255.252.0~~

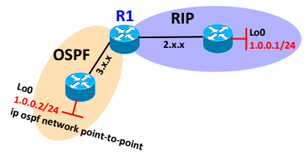
Checks the first 22 bits,
Then the subnet mask needs to be GE 23 and LE 24

ip prefix-list PFX seq 5 permit 10.7.0.0/22 ge 23 le 24

10.7.1.1 255.255.255.0
10.7.0.1 255.255.255.0
10.7.3.1 255.255.255.0
10.7.2.1 255.255.255.0
~~10.7.9.1 255.255.252.0~~

What will R1 routing table show?

What will R1 RIP and OSPF database show?



R1#**show ip route | I 1.0.0.**
O IA 1.0.0.0/24 [**110**/11] via 2.0.0.3, 00:00:23, e0/0.13

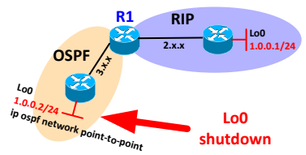
R1#**show ip rip database** | I 1.0.0.0
1.0.0.0/24 auto-summary
1.0.0.0/24 redistributed
[1] via 10.1.13.3, from 0.0.0.3,

R1#**show ip ospf database**
Summary Net Link States (Area 0)
1.0.0.0 0.0.0.3 752 0x80000001 0x00D1E6

OSPF has the better admin distance than RIP! Therefore the OSPF route ends in the routing table!

What will R1 routing table show?

What will R1 RIP and OSPF database show?



R1#**show ip route**
R 1.0.0.0/24 [120/1] via 10.1.12.2, 00:00:01, e0/0.12

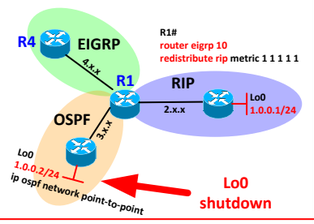
R1#**show ip rip database**
1.0.0.0/24 auto-summary
1.0.0.0/24
[1] via 10.1.12.2, 00:00:00, e0/0.12

R1#**show ip ospf database** | I 1.0.0.0
→ EMPTY

As soon as the OSPF route disapears, the RIP route to 1.0.0.0/24 will be visible via the RIP domain!

(-> OSPF has the better Admin Distance)

Will R4 see 1.0.0.0 in its routing table?



In this case we are redistributing RIP prefixes into EIGRP.

1.0.0.0/24 will show up in R4's routing table as the prefix is NOT learned from the OSPF database.

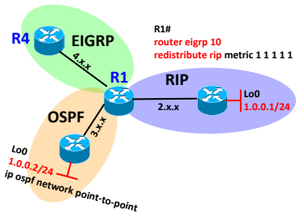
If the prefix 1.0.0.0/24 "would" be learned via OSPF *(no shut of Lo0)* with a lower Admin distance, the route would NOT be redistributed into EIGRP as the route 1.0.0.0 is installed into the routing table based on OSPF and not RIP!

1.0.0.0 is still visible in the RIP database but learned from OSPF!

Admin Distance:
RIP 120
OSPF 110
EIGRP 90

R1#show ip route 1.0.0.0
Known via "rip"

Will R4 see 1.0.0.0 in its routing table?



1.0.0.0 is inserted by OSPF into R1's the routing table. Therefore, 1.0.0.0 will NOT be redistributed into EIGRP, due to the fact that 1.0.0.0 was inserted to R1's routing table via OSPF and not RIP!

1.0.0.0 is found in R1'2 RIP database, but learned via OSPF.

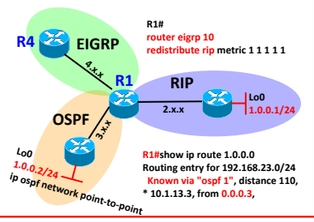
Admin Distance:
RIP 120
OSPF 110
EIGRP 90

OSPF Router-ID

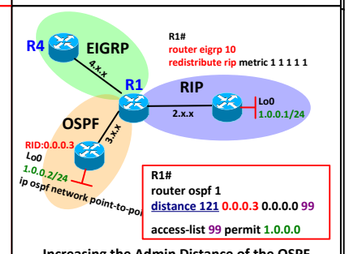
R1#show ip rip database
1.0.0.0/24 auto-summary
1.0.0.0/24 redistributed
[1] via 10.1.13.3, from 0.0.0.3,

R1#show ip route 1.0.0.0
Known via "ospf 1"

How can you solve this situation so that 1.0.0.0/24 ends up in R4's routing table?



R1#show ip route 1.0.0.0
Routing entry for 192.168.23.0/24
Known via "ospf 1", distance 110,
*** 10.1.13.3, from 0.0.0.3,**



Increasing the Admin Distance of the OSPF route, in order to trigger the RIP route on R1!

---

ping ipv6

And all its options:

R6#**ping ipv6**
Target IPv6 address: 12::4
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands? [no]: y
Source address or interface: 12::6
UDP protocol? [no]:
Verbose? [no]:
Precedence [0]: 0
DSCP [0]: 20
Include hop by hop option? [no]:
Include destination option? [no]:
Sweep range of sizes? [no]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12::4, timeout is 2 seconds:
Packet sent with a source address of 12::6
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

---

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RIP

debug ip rip

Output, seeking for authentication:

int fa0/0
ip rip authentication **mode** md5
ip rip authentication **key-chain RIP**

ALWAYS KEY-CHAIN FIRST -> order of operation

debug ip rip
RIP: received packet with **MD5 authentication**
RIP: received v2 update from 192.10.1.254 on FastEthernet0/0

key chain RIP
key 1 **Key ID value must match!**
key-string CCIE

int fa0/0
ip rip authentication **mode** text
ip rip authentication **key-chain RIP**

debug ip rip
RIP: received packet with **text authentication CCIE**
RIP: received v2 update from 155.1.146.1 on GigabitEthernet0/0

Prefix lists for:

The default route:

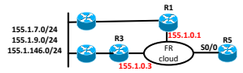
ALL routes (any):

The default route:

ip prefix-list **DEFAULT** permit 0.0.0.0/0

ANY ANY, all routes:

ip prefix-list **ANY** permit 0.0.0.0/0 **le 32**



Explain RIP filtering with Extended ACLs:

```
R5#
router rip
distribute-list 100 in Serial0/0

access-list 100 deny ip host 155.1.0.3 host 155.1.7.0
access-list 100 deny ip host 155.1.0.3 host 155.1.9.0
access-list 100 permit ip any any
```

```
router rip
distribute-list 100 in Serial0/0

access-list 100 deny ip host 155.1.0.3 host 155.1.7.0
```
Prefix/network to be filtered

```
access-list 100 deny ip host 155.1.0.3 host 155.1.9.0
```
Source Next-Hop

```
access-list 100 permit ip any any
```
Permit all other prefixes

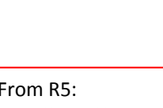
Configuring IP rip versions (send/receive):

router rip
network 150.1.0.0
no auto-summary

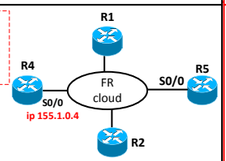
interface fa0/0
ip address 155.1.108.8 255.255.255.0
ip rip send version 1
ip rip **receive version 1**

Filtering RIP route updates from a single router, connected to a **frame-relay cloud** using **extended access-lists**

R1 – R3 should be allowed updates, whereas R4 is not.



PFX from R1-R3 allowed, R4 updates are denied over Frame-Relay



router rip
version 2
distribute-list prefix PERMIT-ALL-OTHER **gateway** DENY-R4-IN **in**

ip prefix-list **DENY-R4-IN** seq 5 **deny 155.1.0.4**/32
ip prefix-list DENY-R4-IN seq 10 permit 0.0.0.0/0 le 32

ip prefix-list PERMIT-ALL-OTHER seq 5 **permit** 0.0.0.**0/0 le 32**

What differences are there with **Extended access-lists** between IGPs and BGP

Extended ACLs:

BGP:

Source field = Network Address
Destination field = Subnet Mask

access-list 100 permit ip **10.1.1.0** 0.0.0.0 **255.255.255.0** 0.0.0.0

IGP:

Source field = Source Next-Hop
Destination field = Network Address

```
access-list 100 deny ip host 155.1.0.3 host 155.1.7.0
```

Configuring IP RIP summarization:

```
interface Serial0/0/0.1 point-to-point
ip summary-address rip 30.0.0.0 255.252.0.0
ip summary-address rip 31.0.0.0 255.252.0.0
```

Don't forget to turn off auto-summary!!

What can be used to handle route feedback with RIP ?

Use static Null routes for summaries.

Use distribute lists, which prevent the outbound summaries being learned back to the router.

Explain the different **extended ACLs** used with **BGP**:

access-list 100 permit ip **10.1.1.0** 0.0.0.0 **255.255.255.0** 0.0.0.0

access-list 100 permit ip **10.0.0.0** 0.0.**255**.0 **255.255.255.0** 0.0.0.0

access-list 100 permit ip 10.0.0.0 0.0.**0.255 255.255.255.240** 0.0.0.0

Matches 10.1.1.0/24 – Only

Matches 10.0.**X**.0/24 – Any for X with /24 prefix length

Matches 10.0.0.**X/28** – Any for X with /28 prefix length

Changing RIP's default timers:

router rip
version 2
timers basic 10 60 60 80 100

Postpone periodic updates for 100 msec until sent

timers <update-interval> <invalid> <holddown> <flush> <sleep-time in msec>

Show ip protocol helps to see the original timers in case you are asked to tune them to a third of the **defaults** which are:

timers basic 30 180 180 240 100

Interface Fa0/0
Ip rip advertise 30 **<- Updates per interface config**

Standard ACLs, filtering all ODD IPs on the 2nd Octet:

ALL ODD IPs in 2rd octet:

access-list 50 permit 0.1.0.0 255.254.255.255

00000001

.254. instructs to look at the last bit within the 2nd octet.

RIPv2 Filtering with Offset Lists

Alternative to passive interface, per prefix:

router rip
offset-list 1 out 16 Vlan79

access-list 1 permit 155.1.5.0

Setting Hop-Count to 16 for prefix 155.1.5.0/24 outbound of Vlan79

router rip
offset-list 22 out 9 Fa0/0

Set offset to 9 for all routes except for 1.0.0.0/8

access-list **22 deny 1.0.0.0**
access-list 22 **permit any**

How to check timers of RIP protocol:

```
R1#show ip protocols | include seconds
Sending updates every 30 seconds, next due in 22 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
```

Standard ACL, filtering all EVEN IPs on the 2nd Octet:

ALL EVEN IPs in 2rd octet:

access-list 51 permit 0.0.0.0 255.254.255.255

00000000

.254. instructs to look at the last bit within the 2nd octet.

RIPv2 Filtering with Administrative Distance

```
Filtering prefixes by setting the admin distance to UNKNOWN for certain prefixes:   (locally significant only)

router rip
distance 255 0.0.0.0 255.255.255.255 88
```
From any neighbor

```
access-list 88 permit 150.1.4.0
```

RIP offset list configuration:

router rip
version 2
offset-list 1 out 4 fa0/0
network 150.1.0.0
no auto-summary

access-list 1 permit 99.99.99.0 0.0.0.0 (dst prefix)

Adding 4 Hops to the path out over Fa0/0, making sure 99.99.99.0 is reached via Fa0/1

RIP From R5:
Allowing Vlan 7, 9 via R1.

Allowing Vlan 146 and R1's Lo0 via R3 config:


```
R5#
router rip
distribute-list 100 in Serial0/0

access-list 100 deny ip host 155.1.0.3 host 155.1.7.0
access-list 100 deny ip host 155.1.0.3 host 155.1.9.0
access-list 100 deny ip host 155.1.0.1 host 155.1.146.0
access-list 100 deny ip host 155.1.0.1 host 150.1.1.0
access-list 100 permit ip any any
```

Allow Vlan 7 and Vlan 9 via R1 while denying via R3.
Allow Vlan 146 and R1's Loopback 155.1.1.1 via R3, while denying via R1

RIPv2 Filtering with Per Neighbor AD

```
router rip
distance 255 155.1.37.3 0.0.0.0 22
```
Source Next-Hop Router
Exact match

```
access-list 22 permit 150.1.3.0
```

Filtering out prefix 150.1.3.0/24 from Neighbour 155.1.37.3 by setting the Admin Distance to UNKNOWN 255.

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RIP

How can the distance command be applied with RIP ?

- globally for the routing process
- globally for the routing process per route type
- on a per-prefix basis
- on a per-neighbor per-prefix basis

RIPv2 Unicast Updates

Router rip
passive-interface default
neighbor 1.1.1.1

If passive int not set, router can still process Multicast announcements!

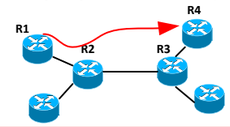
Can be verified by **show ip protocol**

Tricky RIP problem

Find the fault:

R1#ping 4.4.4.4
..... Not successful

show ip route | i 4.4.4.4
R 4.4.4.4 [**120/3**] via x.x.x.x, 00:00:06, Fa0/1

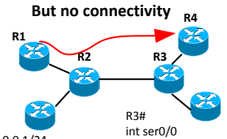


R1#ping 4.4.4.4
..... Not successful

ALL routers have rip configured correctly

show ip route | i 4.4.4.4
R 4.4.4.4 [**120/3**] via x.x.x.x, 00:00:06, Fa0/1

RIP routes visible!
But no connectivity



R2#
int ser0/0
ip address 10.0.0.1/24

R3#
int ser0/0
no ip address

How can one prevent route-feedback in RIP?

Configure static routes for summaries pointing to the NULL0.

Make sure that the summary is denied coming back to the router via Distribute-list or similar via one path, but is allowed via the other.

RIPv2 Broadcast Updates

R6#sh run int gi0/0.146
interface GigabitEthernet0/0.146
encapsulation dot1Q 146
ip address 155.1.146.6 255.255.255.0
ip rip v2-broadcast

Debug ip packet:
IP: s=155.1.146.6 (local), **d=255.255.255.255** (GigabitEthernet0/0.146), len 272, sending broad/multicast

Broadcast can be changed from 255.255.255.255 to:

int gi0/0.146
ip broadcast-address **155.1.146.255**

RIP BFD

RIPv2 BFD

debug ip rip bfd events

router rip
version 2
bfd all-interfaces
network 10.0.0.0
neighbor 10.10.20.2 bfd

int fa0/1
Ip address **10.10.20.**1 255.255.255.0
bfd interval 50 min_rx 50 multiplier 5

int fa0/2
ip address 10.90.90.1 255.255.255.0
bfd interval 50 min_rx 50 multiplier 5

RIPv2 Default Routing

Setting the source

```
router rip
default-information originate route-map DEFAULT_TO_R1

route-map DEFAULT_TO_R1 permit 10
set interface FastEthernet0/0.146
```

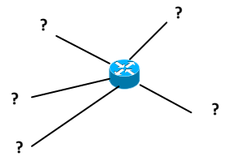
RIPv2 Triggered Updates

RIP sends entire routing table every 30 seconds by default:

interface Serial0/0/0.1 point-to-point
ip address 155.1.0.4 255.255.255.0
ip rip triggered

Triggered updates used in order to Support Demand Circuits.With the triggered option RIP converts in an EVENT triggered protocol, only sending changes based on changes to its database.

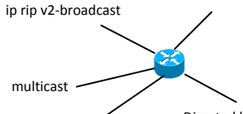
SHUT / NO SHUT to take action!



What are all the variations one can run RIPv1 and RIPv2 in?

Broadcast
ip rip v2-broadcast

send version [1,2]



multicast

Unicast
Neigbor cmd and
Passive interface

Directed broadcast
neigbor

RIPv2 Conditional Default Routing

Announcing a default route, if another prefix exists utilizing a RMP:

router rip
version 2
default-information originate **route-map RMP-DEFAULT**

route-map RMP-DEFAULT permit 10
match ip address **prefix-list CHECK_EXISTING_ROUTE**

ip prefix-list CHECK_EXISTING_ROUTE seq 5 **permit 204.12.1.0/24**

IF 204.12.1.0/24 exists in the routing table, announce the default-route via RIP.

How can **triggered updates** within RIP be identified by using:

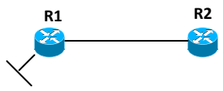
show ip rip database:

interface Serial0/1/0
ip rip triggered

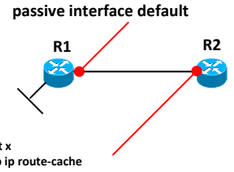
Show ip rip database

150.1.5.0/24
[1] via 155.1.45.5, 00:00:16 **(permanent)**, Serial0/1/0
[1] via 155.1.0.5, 00:00:01, Serial0/0/0.1

Filter RIP routes so that R2 will not see the announcements of R1:



router rip
passive interface default



int x
no ip route-cache
debug ip packets

should not see RIP updates sourced from R1 (mcast)

RIPv2 Reliable Conditional Default Routing

```
ip sla 1
icmp-echo 204.12.1.254 source-interface FastEthernet0/0
timeout 50
frequency 1
ip sla schedule 1 start-time now

track 99 rtr 1

!
router rip
default-information originate route-map RMP-TRACK

ip route 169.254.0.1 255.255.255.255 Null0 track 99

ip prefix-list PFX-DUMMY seq 5 permit 169.254.0.1/32

route-map RMP-TRACK permit 10 match ip address
prefix-list PFX-DUMMY
```

Tracking Route the DUMMY route via SLA and Track 99, if successful announce the default route.

RIPv2 Source Validation

the two links negotiate a host route and are no longer considered on the same network. no validate needed to get RIP process talking

```
R1:
interface Serial1/1
ip address negotiated
encapsulation ppp

router rip
no validate-update-source
```

```
R3:
interface Serial1/2
encapsulation ppp
peer default ip address 155.1.13.1
```

Speciality about the RIP Process:

The RIP process does not start unless you have entered a network statement below:

router rip
network X.X.X.X

How to disable split-horizon on RIP?

Conf t
Int fa0/0
no ip split-horizon
End

How to inject a RIP default route

1)
2)
3)
 3a)
 3b)
4)

RIPv1 / RIPv2 default route:

1) int fa0/x
ip summary-address rip 0.0.0.0 0.0.0.0 (per neighbor)

2) router rip
default-information originate route-map RMP
(use route-map if used with conditions)

3) ip route 0.0.0.0 0.0.0.0 Null0
3a) router rip
network 0.0.0.0

If the static route from 3) is removed, ALL routes will be advertised!

3b) router rip
redistribute static

4) ip default network 1.0.0.0

How will R2 routing table look in regards to 1.0.0.0/8

router rip
network 1.0.0.0
offset-list 0 out 7

router rip
network 1.0.0.0
offset-list 0 out 7

offset-list 0 will add 7 hops to ALL routes!!

R2#
R 1.0.0.0/8 [120/8] via 10.0.0.1, 00:00:03, e0/0

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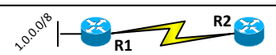
RIP

Explain what the following does:

router rip
no validate-update-source



R1#
int ser0/0
ip address **10.0.0.1** 255.255.255.0

router rip
no validate-update-source

R2#
int ser0/0
ip address **22.0.0.22** 255.255.255.0

router rip
no validate-update-source

R2#
R 1.0.0.0/8 [120/2] via **10.0.0.1**, 00:00:03

RIP:

How to add an offset value of 7 to ALL routes

---

router rip
offset-list 0 out 7

What filtering options are there in regards to RIP?

Option 1:

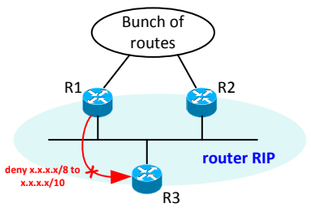
router rip
distribute-list X

Option 2:

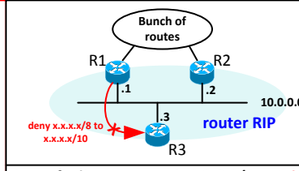
router rip
offset-list X

Option 3:

router rip
distance 255 ...

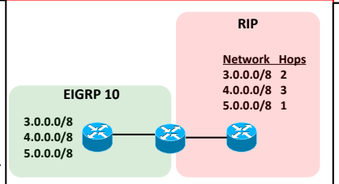


Filter out routes with a /8 to /10 prefix sourced from Router R1



ip prefix-list NET permit 0.0.0.0/0 ge 8 le 10
ip prefix-list R2 permit 10.0.0.2/32

router rip
distribute-list prefix NET gateway R2 in



Redistribute prefixes from EIGRP to RIP setting the hop count for 3.0.0.0 networks to 2 and for 4.0.0.0 to 3, anything else to 1:

```
router rip
 version 2
 redistribute eigrp 10 route-map EIGRP-2-RIP

ip prefix-list PFX-3 seq 5 permit 3.0.0.0/8
ip prefix-list PFX-4 seq 5 permit 4.0.0.0/8

route-map EIGRP-2-RIP permit 10
 match ip address prefix-list PFX-3
 set metric 2

route-map EIGRP-2-RIP permit 20
 match ip address prefix-list PFX-4
 set metric 3

route-map EIGRP-2-RIP permit 30
```

What filtering options are there in regards to RIP while redistribution routes from other protocols?

---

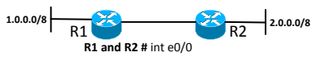
1) matching the prefixes with a ACL/PFX-list and denying them into RIP.

2) matching prefix via ACL/PFX-list and setting hop count (to infinity) for the different prefixes via route-map

3) Setting a tag value on the originating router, denying that tag to be redistributed using route-maps

4) using distribute lists

5) using an offset-list (RIP sourced PFXs)



R1 and R2 # int e0/0
ip rip authentication mode **md5**
ip rip authentication key-chain BLA

R1:
key chain BLA
key 1
key-string CISCO

R2:
key chain BLA
key 2
key-string CISCO

What can happen in this scenario?

R1 and R2 # int e0/0
ip rip authentication mode **md5**
ip rip authentication **key-chain BLA**

R1:
key chain BLA
key 1
key-string CISCO

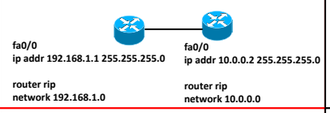
R2:
key chain BLA
key 2
key-string CISCO

R1#show ip route
NO ROUTE

R1 and R2 use the same password, but R2 has the greater Key value! R2 see's R1 routes, but not the other way around!

R2#show ip route
R 1.1.1.1 [120/1] via 10.0.0.1, 00:00:24, e0/0

What methods are there to bypass RIP's sanity checks if you have the following situation:



---

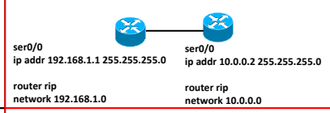
1. **host route** to the other interface IP
   specifying the **local interface**
   (ip route x.x.x.x/32 fa0/x)
   router rip
   no-validate-source

2. on the connecting interface use:
   ip unnumbered LoX
   in order to bypass the sanity check, using the interface rather then the IP address as next-hop

3. change the **encapsulation** to **PPP** and do
   router rip
   no validate-update-source

4. "adjust" the problem by using a correct **secondary IP address** (may not be a valid CCIE Lab answer)

How to bypass RIP's sanity check by using ip unnumbered LoX



```
R1#
int ser0/0
ip address unnumbered lo88

int lo88
ip address 192.168.1.1 255.255.255.0

router rip
version 2
no auto
network 192.168.1.0
```

using ip unnumbered loopback, sets the Interface as the next-hop and not the source IP address, bypassing the sanity check!

```
R2#
int ser0/1
ip address unnumbered lo99

int lo99
ip address 10.0.0.2 255.255.255.0

router rip
version 2
no auto
network 10.0.0.0
```

What does the following RIP command do?

router rip
flash-update-threshold <seconds>
10

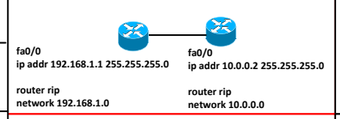
Suppresses triggered updates when the arrival of a regularly scheduled update matches, or is less than the number of seconds that is configured.

If configured visible via

show ip protocol | i Flash
Flash update is suppressed when next update due within 10 seconds

If not used, show ip protocol:
Sending updates every 60 seconds, next due in 41 seconds

How to bypass RIP's sanity check by using the "host route method"

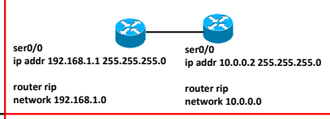



```
R1#
int fa0/0
ip address 192.168.1.1 255.255.255.0
ip route 10.0.0.2 255.255.255.255 fa0/0
router rip
version 2
no auto
no validate-update-source
Network 192.168.1.0

R2#
int fa0/1
ip address 10.0.0.2 255.255.255.0
ip route 192.168.1.1 255.255.255.255 fa0/0
router rip
version 2
no auto
no validate-update-source
Network 10.0.0.0
```

Bypassing the sanity check via no-validate-source, and routing towards the other IP via specifiying the interface rather then the IP.

How to bypass RIP's sanity check by changing the encapsulation to PPP



```
R1#
int ser0/0
ip address 192.168.1.1 255.255.255.0
encapsulation ppp
shutdown
no shut

router rip
version 2
no auto
network 192.168.1.0
no validate-update-source
```

Change encpasulation to PPP
Then shut/no shut
Ping the other side to verify connectivity, add no validate, clear ip route *, sit back and relax

```
R2#
int ser0/1
ip address 10.0.0.2 255.255.255.0
encapsulation ppp
shutdown
no shutdown

router rip
version 2
no auto
network 10.0.0.0
no validate-update-source
```

How to check which key-chain is used on which interface with RIP?

R2#**show ip protocols**
....

Interface	Send	Recv	Triggered RIP	Key-chain
FastEthernet0/0	2	2		KEY
FastEthernet0/1	2	2		KEY23

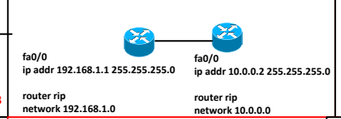
key chain **KEY**
key 1
key-string cisco

interface FastEthernet**0/0**
ip address x.x.x.x 255.255.255.0
ip rip authentication **key-chain KEY**

key chain **KEY23**
key 1
key-string cisco23

interface FastEthernet**0/1**
ip address y.y.y.y 255.255.255.0
ip rip authentication mode md5
ip rip authentication key-chain **KEY23**

How to "bypass" RIP's sanity check by using a secondary address:




```
R1#
int fa0/0
ip address 192.168.1.1 255.255.255.0
ip address 10.0.0.1 255.255.255.0 secondary

router rip
version 2
no auto
network 10.0.0.0
network 192.168.1.0

R2#
int fa0/1
ip address 10.0.0.2 255.255.255.0

router rip
version 2
no auto
network 10.0.0.0
```

Bypassing the RIP sanity check by using a secondary address "adjusting" the problem.

How can you instruct the fast RIP router to slow down its pace while sending updates to the slow one?

Fast Router running RIP — **Slow Router running RIP**

Fast Router running RIP — **Slow Router running RIP**

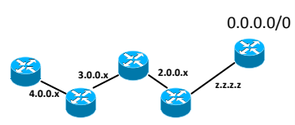
FastRouter#
router rip
output-delay <50 in msec>

The fast router adds 50 msec delay between each of the update packet.

On which router would you configure:

ip default-network x.x.x.x

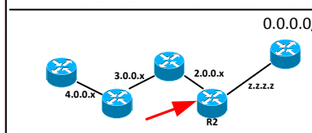
In this RIP network?



R2#conf t
Has to be a classful network!!
ip default-network 2.0.0.0

R3#show ip route
Gateway of last resort is 2.0.0.2 to network 0.0.0.0

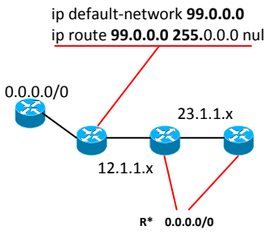
R* 0.0.0.0/0 [120/1] via 2.0.0.2, 00:00:01, Serial1/2



Describe

ip default-network x.x.x.x

in a **RIP domain:**



---

increase the capable number of NOT yet processed RIP update packets to 120 on a RIP router:

---

router rip
input-queue 120

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---

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RIP

Injecting a default route in RIP

If there are two networks which either OR have to be up

If there are two networks which both (AND) have to be up

In order to generate the default route:

OR case:

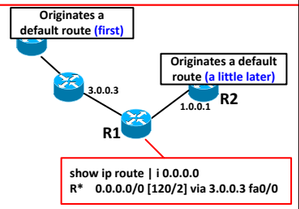
```
router rip
default-information originate route-map DEFAULT

ip prefix-list PFX-1 permit 1.0.0.0/8
ip prefix-list PFX-1 permit 2.0.0.0/8

route-map RMP-DEFAULT
match ip address prefix PFX-1
```

track 90 list boolean and
object 15
object 16

track 15 interface loopback 15
track 16 interface loopback 16

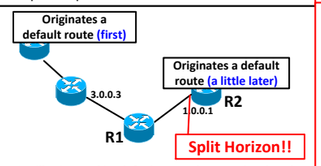
AND case:

```
ip route 169.254.0.0 255.255.255.0 null 0 track 90

router rip
default-information originate route-map DEFAULT

ip prefix-list DUMMY permit 169.254.0.0/24

route-map RMP-DEFAULT
match ip address prefix DUMMY
```




```
show ip route | i 0.0.0.0
R*    0.0.0.0/0 [120/2] via 3.0.0.3 fa0/0
```

Which default route will R1 use?



R2 will NOT send its default route, because its already receiving a default route through the same interface its about to send its default route out!
-> split horizon prevents this

In order for R2 to send a default route, deny the incoming default route via distribute-list, so R1 will use R2 due to shorter hop-count!

Advertise a default route in RIP if

loopback 9 is up
and
loopback 99 is down:

```
int loopback 9
ip address 9.9.9.9 255.255.255.0

int loopback 99
ip address 99.99.99.99 255.255.255.0

track 9 interface Loopback9 line-protocol
track 99 interface Loopback99 line-protocol

track 20 list boolean and
 object 9
 object 99 not

router rip
 network 0.0.0.0

ip route 0.0.0.0 0.0.0.0 Null0 track 20
```

How to match a default route with standard ACLs, extended ACLs, and a prefix list:

Deny the default route, allow everything else

Standard access-list:

```
access-list 22 deny host 0.0.0.0
access-list 22 permit any
```

Extended access-list:

```
access-list 102 deny host 0.0.0.0 host 0.0.0.0
access-list 102 permit any any
```

Prefix-list:

```
ip prefix-list DEFAULT deny 0.0.0.0/0
ip prefix-list DEFAULT permit 0.0.0.0/0 le 32
```

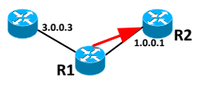
Configuring RIP authentication before configuring the key chain can cause problems that no RIP routes are being passed on.

Can these problems "survive" a reload?

The answer is YES!!

The only way on fixing this is:

```
Int ser0/x
No ip rip authentication mode text
No ip rip authentication key-chain XXX

Key-chain BLA
Key 1
Key-string blabla

Int ser0/x
Ip rip authentication mode text
Ip rip authentication key-chain BLA
```



Explain two options on how to send a default route only on the link towards R2 in RIP

```
int fa0/x
ip summary-address rip 0.0.0.0 0.0.0.0
```

```
router rip
default-information originate route-map
rMP-DEF-fa0/x

route-map RMP-DEF-fa0/x permit 10
set interface fa0/x
```

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EIGRP

`show ip eigrp neighbors:`

What does one have to watch out for?

Time it took to neighbor and a ACK is received back.

Amount of time EIGRP waits to re-send a packet from the queue

```
R3#show ip eigrp neighbors
IP-EIGRP neighbors for process 100
H  Address         Interface   Hold  Uptime   SRTT  RTO  Q   Seq
                               (sec)  (ms)          Cnt Num
2  155.1.37.7      Fa0/0       12    00:05:22  6     200  0   27
1  155.1.0.5       Se1/0.1     139   00:07:12  39    1140 0   124
0  155.1.13.1      Se1/2       11    00:07:51  20    1140 0   104
```

Q Cnt Num should be 0, meaning there are no packets in the queue. No congestion present.

EIGRP Unicast Updates / Neighbor

```
router eigrp 100
neighbor 155.1.58.8 Fa0/0
```

EIGRP Filtering with Prefix-Lists

(not from gateway)

```
router eigrp 100
distribute-list prefix PERMIT_ALL gateway NOT_FROM_R4 in

ip prefix-list NOT_FROM_R4 seq 5 deny 155.1.146.4/32
ip prefix-list NOT_FROM_R4 seq 10 permit 0.0.0.0/0 le 32

ip prefix-list PERMIT_ALL seq 5 permit 0.0.0.0/0 le 32
```

How to disable EIGRP Split Horizon

```
interface Serial0/0/0
no ip split-horizon eigrp 100
```

Verify using:

show ip eigrp interface

Debugging EIGRP traffic using “debug ip packet detail”:

EIGRP Using static neigborship statements:

```
R5#debug ip packet detail
IP packet debugging is on (detailed)
IP: s=155.1.58.5 (local), d=155.1.58.8 (Fa0/0),
len 60, sending, proto=88
```

EIGRP Using multicast:

```
R5#debug ip packet detail
IP packet debugging is on (detailed)
IP: s=155.1.58.5 (local), d=224.0.0.10 (Fa0/0),
len 60, sending broad/multicast, proto=88
```

EIGRP Filtering with Standard Access-Lists

(allowing all EVEN prefixes, disallowing all ODD prefixes)

```
router eigrp 10
distribute-list 1 in Serial0/0/0

access-list 1 permit 0.0.0.0 255.255.254.255
```

Explain the EIGRP feasibility condition?

- end-to-end composite metric is compared between routes.

- If the Advertised Distance is equal to the Feasible Distance, it is considered an alternative path.

- if the Advertised Distance is smaller than the Feasible Distance, it is considered as a new Feasible successor.

EIGRP Default Network

```
router eigrp 10
network 200.0.0.0
!
ip default-network 200.0.0.0
```

(Prefix 200.0.0.0 was **received from** a **EIGRP neighbor**)

```
R5#  show ip route eigrp | i EX
D*EX 200.0.0.0/24 [170/2812416] via 155.1.0.1, 00:00:52, Ser0/0/0
```

R5# sh ip route
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route

Gateway of last resort is 155.1.0.1 to network 200.0.0.0

EIGRP Filtering with Extended Access-Lists

access-list 100 deny ip host 155.1.0.2 host 150.1.2.0
access-list 100 deny ip host 155.1.0.4 host 150.1.2.0
access-list 100 permit ip any any

router eigrp 100
distribute-list 100 in Serial0/0/0

access-list 100 deny ip host 155.1.0.2 host 150.1.2.0

Where 155.1.0.2 is the next hop
150.1.2.0 is the prefix.

EIGRP MD5 Authentication

```
key chain MD5_KEYS
key 1
key-string CISCO

interface Serial0/0/0
ip authentication mode eigrp 10 md5
ip authentication key-chain eigrp 10 MD5_KEYS
```

How to **identify** the **default network** with a **show ip route** output:

```
R1#
ip default-network 200.0.0.0

R3#sh ip route 200.0.0.0
Routing entry for 200.0.0.0/24
  Known via "eigrp 10", distance 170, metric 2300, candidate default path, type external
  Redistributing via eigrp 100
  Last update from 155.1.37.7 on FastEthernet0/0, 00:07:47 ago
  Routing Descriptor Blocks:
  * 155.1.37.7, from 155.1.37.7, 00:07:47 ago, via FastEthernet0/0
      Route metric is 2300672, traffic share count is 1
      Total delay is 25110 microseconds, minimum bandwidth is 1544 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 3
```

EIGRP Filtering with Offset Lists

router eigrp 100
offset-list 99 in 2147483647 Fa0/3

access-list 99 permit 150.1.3.0

modify the metric on a per route basis or a per-interface basis, setting the maximum value inbound for that prefix.

What are usefull EIGRP Debug commands:

debug eigrp packets hello

debug eigrp fsm

Configuring EIGRP summary addresses

```
Interface fa0/0

ip  summary-address  eigrp  100  30.0.0.0 0.0.0.0

EIGRP AS: 100
```

EIGRP Filtering with Administrative Distance

Per prefix, any neighbour:

access-list 4 permit 150.1.4.0

router eigrp 100
distance 255 0.0.0.0 255.255.255.255 4

0.0.0.0 255.255.255.255 specify from any neighbour.

Setting the Admin Distance to UNKNOWN 255 from any neighbour for prefix 150.1.4.0/xx

Key Chain Rotation

key chain KEY_ROTATION

key 10
key-string CISCO10
accept-lifetime 00:00:00 Jan 1 1993 **00:15:00 Jan 1 2030**
send-lifetime 00:00:00 Jan 1 1993 00:05:00 Jan 1 2030

key 20
key-string CISCO20
accept-lifetime 00:00:00 Jan 1 2030 **infinite**
send-lifetime 00:00:00 Jan 1 2030 **infinite**

! Make sure the clocks are syncronized either by “clock set” or NTP !

Show commands with special includes:

```
show ip route | include via 155.1.(0|45).4

show ip route | include 30\.|31\.

show ip route | include 3(0|1).[0-3].0.0
```

EIGRP Filtering with Per Neighbor AD

Per prefix, per neighbour:

access-list **7** permit 150.1.7.0

router eigrp 100
distance 255 155.1.37.7 0.0.0.0 7

Route: 150.1.7.0/24
Next-Hop: 155.1.37.7

Making the route unreachable outbound to Host 155.1.37.7.

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EIGRP

EIGRP Summarization sending only a Default Route:

```
interface Ser0/0/0.1 point-to-point
ip summary-address eigrp 100 0.0.0.0 0.0.0.0 5
```

Everything else will be suppressed out this interface, only the Default route will be advertised out Ser0/0/0.1.

Checking the usage of the EIGRP **Metric Weights / K-Values** using:

`show ip protocols`

```
Router# show ip protocols
Routing Protocol is "eigrp 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 100
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    150.1.0.0
    155.1.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    155.1.0.2             90      00:15:49
    155.1.45.4            90      00:15:06
  Distance: internal 90 external 170
```

Configure EIGRP so that if a query to a missing route is stuck in Active will be declared dead after one minute:

```
router eigrp 100
timers active-time 1
```

(Stuck in Active SIA) Declare route down if no answer was received after one minute.

Configure EIGRP so that SIA condition can remain indefinitely

router eigrp 100
timers active-time disable

Disables the timers and permits the routing wait time to remain active indefinitely.

EIGRP **Summarization** with **Leak Map**

```
interface Serial0/1/0
ip summary-address eigrp 100 0.0.0.0 0.0.0.0 5
leak-map LEAK_LOOPBACK0

route-map LEAK_LOOPBACK0 permit 10
match ip address prefix-list LOOPBACK0

ip prefix-list LOOPBACK0 seq 5 permit 150.1.4.0/24
```

This will send out only a default route and the **leaked** out Loopback0 **prefix** of 150.1.4.0/24

(subnets will be advertised / leaked in addition to the summary)

Checking the values of EIGRP Metric Weights / K-Values using the:

`show ip eigrp topology PREFIX MASK`

```
SW3#show ip eigrp topology 150.1.9.0 255.255.255.0
IP-EIGRP (AS 100): Topology entry for 150.1.9.0/24
State is Passive, Query origin flag is 1, 1 Successor(s), FD is 128000
Routing Descriptor Blocks:
0.0.0.0 (Loopback0), from Connected, Send flag is 0x0
Composite metric is (128000/0), Route is Internal
Vector metric:
Minimum bandwidth is 10000000 Kbit
Total delay is 5000 microseconds
Reliability is 255/255
Load is 1/255
Minimum MTU is 1514
Hop count is 0
```

RD

FD

What needs to be considered with Hello Timers and EIGRP?

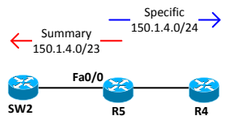
EIGRP neighbours will form anyways, even if Hello intervals are miss-matched.

If after 5 seconds the adjacency is NOT established use UNICAST.

EIGRP Floating Summarization

Generates summary with route to Null0.
having more specific route:

```
interface FastEthernet0/0
ip summary-address eigrp 100 150.1.4.0 255.255.254.0 5
!
ip route 150.1.4.0 255.255.254.0 155.1.0.4
```



R5 will generate a Null0 route, without any more specific routes, packets would be dropped for the 150.1.4.0 network

Using solely EIGRPs Delay K-Value, after performed changes, what needs to be done?

conf t
interface fa0/0
delay 999999
end

clear ip eigrp neighbours

Which debug command would you use to troubleshoot **EIGRP Stuck In Active** situations?

`debug eigrp packet terse`

```
EIGRP: Enqueueing QUERY on Port-channel1
EIGRP: Received QUERY on Vlan79 nbr 155.1.79.7
EIGRP: Enqueueing ACK on Vlan79 nbr 155.1.79.7
```

EIGRP **Poisoned** Floating **Summarization**

Propagating a summary out, but locally deny of using it via AD:

```
interface GigabitEthernet0/0
ip summary-address eigrp 100 150.1.4.0 255.255.254.0 255
```

Poisoning the route via setting the Admin Distance to UNKNOWN, prevents the summary to be announced out Gi0/0

Feasible Distance:

Reported Distance:

Advertised Distance:

```
155.1.67.6 (Vlan67), from 155.1.67.6, Send flag is 0x0
Composite metric is (25728000/128000), Route is Internal
```

(Feasible Distance FD / Advertised Distance AD)

Advertised Distance is the distance received from the neighbour.

Feasible Distance is the routers distance to the network, once added the local interface "cost" / metric to the path.

What for does one use EIGRP stub routing?

EIGRP stub is used to **limit the query** messages, **limiting SIA conditions**.

```
router eigrp 100
eigrp stub connected
```

```
R5#show ip eigrp neighbors detail
IP-EIGRP neighbors for process 100
H  Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                           (sec)         (ms)       Cnt Num
5  155.1.58.8              Gi0/0            29 00:00:28    8   200  0  150
   Version 12.2/3.0, Retrans: 0, Retries: 0, Prefixes: 3
   Stub Peer Advertising ( CONNECTED ) Routes
   Suppressing queries
```

Changing EIGRP **Metric Weights**

(use of K-Values)

conf t
router eigrp 100
metric weights 0 0 0 1 0 0

metric weights 0 K1 K2 K3 K4 K5

K1 bandwidth , K2 load, **K3 delay**, K4 reliability, K5 MTU

VERIFY using used K Values via
`show ip protocols`

How can one identify the effect of EIGRP variance of an IP route?

```
R6#show ip route 155.1.9.9
Routing entry for 155.1.9.0/24
  Known via "eigrp 100", distance 90, metric 3072, type internal
  Redistributing via eigrp 10, eigrp 100
  Advertised by eigrp 10
  Last update from 155.1.146.1 on GigabitEthernet0/0.146, 00:00:43 ago
  Routing Descriptor Blocks:
    155.1.146.1, from 155.1.146.1, 00:00:43 ago, via GigabitEthernet0/0.146
      Route metric is 15360, traffic share count is 1
      Total delay is 600 microseconds, minimum bandwidth is 1544 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 4
  * 155.1.67.7, from 155.1.67.7, 00:00:43 ago, via GigabitEthernet0/0.67
      Route metric is 3072, traffic share count is 5
      Total delay is 120 microseconds, minimum bandwidth is 100000 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 2

conf t
 int fa0/x , fa0/z
 no route-cache
 ip load-sharing per-packet
```

USE ACLs to count ICMPs on the opposite side, to count packets to analyse traffic share.

EIGRP Stub Routing with Leak Map

```
ip prefix-list SW2_LOOPBACK seq 5 permit 150.1.8.0/24
!
route-map STUB_LEAK_MAP deny 10
match ip address prefix-list SW2_LOOPBACK
!
route-map STUB_LEAK_MAP permit 20
!
router eigrp 100
eigrp stub connected leak-map STUB_LEAK_MAP
```

Leaks out all routes exept of 150.1.8.0/24.

EIGRP composite metric calculation formula:

`metric = [k1 * bandwidth + (k2 * bandwidth)/(256 - load) + k3 * delay] * [k5/(reliability + k4)]`

Breaks down to (metric weights)

256 (BW + DLY)

EIGRP Convergence Timers:

```
(eigrp AS 100)

interface FastEthernet0/0
ip hello-interval eigrp 100 1
ip hold-time eigrp 100 3
```

in seconds

`Explain the passive-interface` command in EIGRP:

will stop the forming of an adjacency on the interface, and hence the learning of any updates on the link.

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EIGRP

EIGRP Filtering with Per Neighbor AD

Differences between Internal EIGRP routes and External ones:

The administrative distance for EIGRP internal routes can be changed on a per prefix basis, but external EIGRP routes cannot.

EIGRP Router-ID

router eigrp 100
eigrp router-id 150.1.2.2

Can be used to filter out external EIGRP routes of a different router, by using his Router-ID, the local Router will ignore those routing updates.

EIGRP BFD

Interface e0/0
bfd interval 50 min_rx 50 multiplier 3

router eigrp 100

bfd interface e0/0

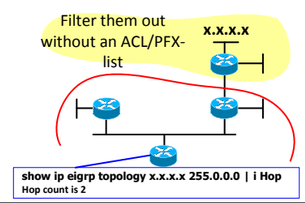
bfd all-interfaces

EIGRP Filtering with Route Maps

router eigrp 100
distribute-list route-map FILTER_ON in
!
route-map FILTER_ON deny 10
match tag 4
!
route-map FILTER_ON permit 20

EIGRP Maximum Hops

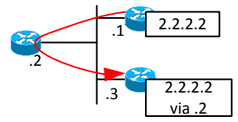
router eigrp 100
metric maximum-hops 1



Interface X
no ipv6 next-hop-self eigrp 55

by default, the IPv6 next-hop value is set to be itself for routes that it is advertising, even when advertising those routes back out the same interface where it learned them

interface type number
no ipv6 next-hop-self eigrp as-number



Configure a route-map filter for EIGRP that filters routes with a metric that ranges within 500000 – 700000 from entering the routing table:

metric +/-

router eigrp 100
distribute-list route-map METRIC_RANGE in

route-map METRIC_RANGE deny 10
match metric 625000 +- 125000

route-map METRIC_RANGE permit 20

(METRIC 625K +/- 125K = 500K or 750K)

EIGRP Default routes

3 options

ip route 0.0.0.0 0.0.0.0 Null0

A) network 0.0.0.0
B) redistribute static into EIGRP

ip summary-address eigrp 100 0.0.0.0 0.0.0.0

ip default network 99.99.0.0

router eigrp 100
network 99.99.0.0

Route-map METRIC

match different metrics

metric +/-

match routes with a metric of 110, or 200, or a metric within a range of 700 to 800
(750 plus / minus 50 = low 700 high 800)

route-map METRIC
match metric 110 200 750 +- 50

router eigrp 1
redistribute ospf route-map METRIC

EIGRP Bandwidth Pacing

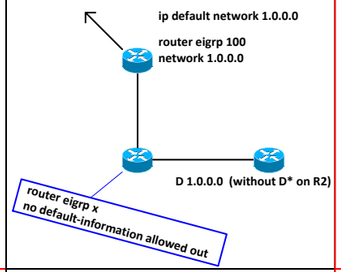
Make sure EIGRP does not use more than 154Kbit of Bandwith on the link:

interface Serial0/1
bandwidth 1544
ip bandwidth-percent eigrp 100 **10**

(**10%** of 1544 is 154Kbit)

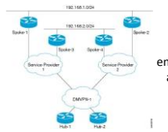
EIGRP

no default-information allowed out



EIGRP named mode

Add path support



enables hubs in DMVPN to advertise multiple best paths to spokes

Add Path Support on a Hub:

router eigrp name
address-family ipv4 autonomous-system 10
af-interface tunnel 0
no next-hop-self no-ecmp-mode
add-paths 4

Add Path only with EIGRP named mode!

Add Path Support on Spoke:

router eigrp name
address-family ipv6 autonomous-system 10
af-interface tunnel 0
no next-hop-self no-ecmp-mode
add-paths 4

EIGRP Default Metric

Redistributing a static route, changing default metrics:

ip route 222.22.2.2 255.255.255.255 192.10.1.254

router eigrp 100
redistribute static default-metric 100000 10 255 1 1500

EIGRP

default-information

default-information allowed { in | out }
default-information { in | out } [**acl**]

no default-information ...

allowed	Configures EIGRP to accept default routing information.
in	Configures EIGRP to accept exterior or default routing information.
out	Configures EIGRP to advertise external routing information.
acl-number	(Optional) Standard access list number from 1 to 99 or an expanded standard access list from 1300 to 1999.
acl-name	(Optional) Named standard access list.

ACL specifies for which prefix the default D* prefix is allowed to be allowed in/out

EIGRP Stub

possiblilties

router eigrp 100

eigrp stub	connected and summary
eigrp stub receive-only	Nothing sent
eigrp stub leak-map RMP-NAME	**identifies suppressed PFXs**
eigrp stub connected	Connected routes
eigrp stub static	static routes, **no summaries**
eigrp stub summary	Allows summaries
eigrp stub redistributed	redistributes other proto's

router eigrp NAME
address-familiy ipv4 vrf X
eigrp stub connected

EIGRP Neighbor Logging

router eigrp 100
no eigrp log-neighbor-changes
eigrp log-neighbor-warnings **20**

Only create a warning message every 20 seconds.

EIGRP

neighbor maximum prefix

per vrf / per neighbor

router eigrp **55**
address-family ipv4 **vrf X autonomous-system 66**
neighbor 1.2.3.4 description MY-DESCRIPTION
neighbor 1.2.3.4 maximum-prefix 600 <threshold> [warning-only]

neighbor 1.2.3.4 maximum-prefix 600 <threshold> reset-time <min> restart <min> ...

router eigrp INSTANCE-NAME
address-family ipv4 vrf X autonomous-system 66
neighbor 1.2.3.4 **description MY-DESCRIPTION**
neighbor 1.2.3.4 maximum-prefix 600 <threshold> [warning-only]

EIGRP

Redistribute maximum-prefix

Autonomous-System

Named-Mode

router eigrp **100**
address-family ipv4 [unicast] vrf vrf-name
redistribute maximum-prefix maximum

router eigrp **INSTANCE-NAME**
address-family ipv4 vrf X autonomous-system 66
topology {base | topology-name tid number}
redistribute maximum-prefix maximum

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EIGRP

EIGRP Route Tag Enhancements

conf t
route-tag notation dotted-decimal

range: 1 to 4294967295
range: 0.0.0.0 to 255.255.255.255

eigrp default-route-tag <123 or 0.0.1.2>
for internal routes only

route-map X permit
match tag 1235
match tag 0.0.12.99
match tag list TAG-LIST1

conf t
route-tag list NAME permit 1235 8879

show route-tag list

route-tag list TAG-LIST1 permit 2.2.2.1 0.0.0.1 tag, wildcard

EIGRP

Nonstop Forwarding (NSF) Awareness

Graceful-restart

Sets the route-hold timer to determine how long an NSF-aware router that is running EIGRP will hold routes for an inactive peer.

timers graceful-restart purge-time <seconds>

Verify using: **show ip protocols**

debug ip eigrp notifications

EIGRP:NSF:AS2. Rec RS update from x.x, Wait for EOT.

UAL-5-NBRCHANGE:IP-EIGRP(0) 2:Neighbor x.x (fa3/0) is up:peer NSF restarted

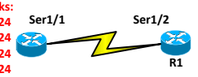
EIGRP-IPv4 100: Neighbor x.x (fa1/0) is resync: peer graceful-restart

What will R1 have in its routing table in regards to the 1.0.0.0 networks?

R2#
router eigrp 100
network 1.1.0.0 0.0.255.255

interface Serial1/2
ip summary-address eigrp 100 1.1.0.0 255.255.252.0

router eigrp 100
eigrp stub connected



R1#show ip route eigrp
1.0.0.0/24 is subnetted, 4 subnets
D 1.1.0.0 [90/206400] via 12.1.1.1, 00:02:08, Serial1/1
D 1.1.1.0 [90/206400] via 12.1.1.1, 00:02:08, Serial1/1
D 1.1.2.0 [90/206400] via 12.1.1.1, 00:02:08, Serial1/1
D 1.1.3.0 [90/206400] via 12.1.1.1, 00:02:08, Serial1/1

THE INDIVIDUAL ROUTES SEEN!!!
NO SUMMARY, even it is configured!

EIGRP Wide Metrics

- supports 64-bit metric calculations
- (classic mode configurations use 32-bit calculations)
- > 1 Gbit and up to 4.2 terabits EIGRP path selections

metric rib-scale

router eigrp name1
address-family ipv4 autonomous-system 4533
metric weights 0 2 0 1 0 0 1

K1 Bandwith set to 2

EIGRP Loop-Free Alternate Fast Reroute

IP FRR/fast reroute (single hop)

router eigrp NAME
address-family ipv4 autonomous-system 88
topology base
fast-reroute per-prefix all
fast-reroute per prefix route-map RMP-NAME

Disabling Load sharing among prefixes:

fast-reroute load-sharing disable

Enabling Tie breaking rules:

fast-reroute tie-break {interface-disjoint | linecard-disjoint | lowest-backup-path-metric | srlg-disjoint} priority-number

show ip eigrp topology frr

Configuring EIGRP stub connected In Classic Mode

router eigrp 100
eigrp stub connected

In EIGRP Named Mode

router eigrp NAME
address-family ipv4 unicast autonomous-system 100
eigrp stub connected

Named EIGRP Authentication md5

router **eigrp NAME**
address-family ipv4 autonomous-system 258
af-interface [default | fa0/x]
af-interface fa0/0
authentication key-chain KEY-CHAIN
authentication mode md5

Named EIGRP Authentication HMAC-SHA-256

router **eigrp NAME**
address-family ipv4 autonomous-system 258
af-interface [default | fa0/x]
af-interface default
authentication mode hmac-sha-256 0 PASSWORD

Redistributing static and connected routes into router EIGRP:

router eigrp 100
redistribute static

ip route 3.0.0.0 255.0.0.0 Null0

When redistributing connected or static routes into EIGRP **NO seed metric** is **required**!

What will R1 have in its routing table in regards to the 1.0.0.0 networks?

R2#
router eigrp 100
network 1.1.0.0 0.0.255.255

interface Serial1/2
ip summary-address eigrp 100 1.1.0.0 255.255.252.0

router eigrp 100
eigrp stub summary

R1#show ip route eigrp
1.0.0.0/22 is subnetted, 1 subnets
D 1.1.0.0 [90/206400] via 12.1.1.1, 00:00:12, Serial1/1

R2#show ip route eigrp
1.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
D 1.1.0.0/22 is a summary, 00:56:55, Null0

EIGRP over the top

Background info:

EIGRP on the control plane and Locator ID Separation Protocol (LISP) encapsulation

- must configure the neighbor command with LISP encapsulation on every CE

- having many CE, could use EIGRP Route Reflectors (E-RRs)

E-RR: remote-neighbors source
to listen to unicast messages from peer Ces

Make sure EIGRP uses max 520 kbit of bandwith, do NOT use ip bandwith-percent eigrp x 520 or any service-policy applied to the interface:

R1#
conf t
interface serial 1/0
bandwith 1040

By default EIGRP will use up to 50% of the links bandwith for EIGRP.

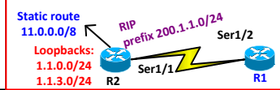
bandwith 1040 / 2 = 520 kbit/s

What will R1 have in its routing table ?

R2#
router eigrp 100
network 1.1.0.0 0.0.255.255

interface Serial1/2
ip summary-address eigrp 100 1.1.0.0 255.255.252.0

router eigrp 100
redistribute static
redistribute rip metric 1 1 1 1 1
eigrp stub redistributed



R2#
router eigrp 100
eigrp stub redistributed

R1#show ip route eigrp
D EX 11.0.0.0/8 [170/2051] via 12.1.1.1, 00:00:36, Ser1/1
D EX 200.1.1.0/24 [170/2560] via 12.1.1.1, 00:00:36, Ser1/1

EIGRP over the top

E-RR

EIGRP over the top on CE

router eigrp virtual-name
address-family ipv4 autonomous-system 65
neighbor 1.2.3.4 fa0/x remote <max-hops> lisp-encap <lisp-id>

EIGRP over the top Route Reflectors **E-RR**

router eigrp NAME
address-family ipv4 unicast autonomous-system 55
af-interface fa0/0
no next-hop-self
no split-horizon
!
remote-neighbors source fa0/x unicast-listen lisp-encap 1

EIGRP Summary-address (classic, old fashioned)

EIGRP Named Mode Summary-address

router eigrp 100
network 1.1.0.0 0.0.255.255
OLD

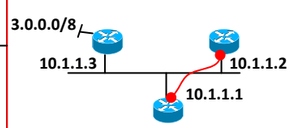
interface Serial1/2
ip summary-address eigrp 100 1.1.0.0 255.255.252.0

NEW

router eigrp NAME
address-family ipv4 unicast autonomous-system 100
af-interface Serial1/1
summary-address 2.2.0.0 255.255.252.0
exit-af-interface

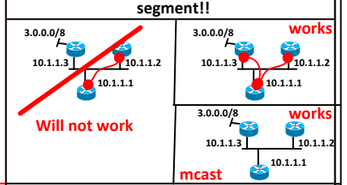
topology base
exit-af-topology
network 2.2.0.0 0.0.255.255

Will 3.0.0.0/8 be seen by the other two routers in this EIGRP network?



R1#
router eigrp NAME
address-family ipv4 autonomous-system 100
neigbor 10.1.1.2 fa0/x

EIGRP a neigbor command is used on an Ethernet Broadcast medium, EIGRP will no longer use broadcast for other still broadcast enabled routers on the same segment!!



EIGRP

Classic to Named Mode Conversion

EIGRP conversion

Convert from EIGRP classic mode to Named mode, BUT NOT backwards from Named to Classic!!

eigrp upgrade-cli

write memory

From:

router **eigrp 6524**

to

router **eigrp NAME**

How to redistribute static routes

In EIGRP "classic" mode:

In EIGRP Named Mode:

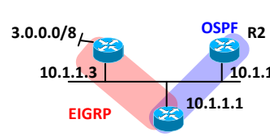
ip route X.0.0.0 255.0.0.0 FastEthernet0/0
Classic

router eigrp 100
redistribute static

ip route X.0.0.0 255.0.0.0 FastEthernet0/0
Named

router eigrp NAME
address-family ipv4 unicast autonomous-system 100
topology base
redistribute static

Redistribute OSPF into EIGRP so that R2 see's 3.0.0.0/8 with a next hop of 10.1.1.3



Perform EIGRP "classic config" and EIGRP named mode

R1#
router ospf 1
network 10.1.1.1 0.0.0.0 area 0

router eigrp 100
network 10.1.1.1 0.0.0.0
redistribute ospf 1 metric 1 1 1 1 1

int fa0/0
no ip next-hop-self eigrp 100

R2#show ip route 3.0.0.0
D 3.0.0.0 via 10.1.1.3

router ospf 1
network 10.1.1.1 0.0.0.0 area 0

router eigrp TST

address-family ipv4 unicast autonomous-system 200

af-interface FastEthernet0/1
no next-hop-self
exit-af-interface

topology base
redistribute ospf 1 metric 1 1 1 1 1

R2#show ip route 3.0.0.0
D 3.0.0.0 via 10.1.1.3

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EIGRP

How to configure / change hold-down and hello interval in EIGRP

"classic mode"

And

Named Mode:

classic

```
router eigrp 100
network 10.1.1.2 0.0.0.0

interface FastEthernet0/1
 ip address 10.1.1.2 255.255.255.0
 ip hello-interval eigrp 200 10
 ip hold-time eigrp 200 30
```

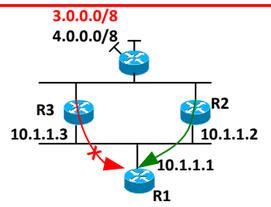
Verify:
`show ip eigrp 100 interfaces detail fa0/1 | i time`

named

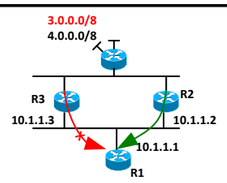
```
router eigrp TST

address-family ipv4 unicast autonomous-system 200

 af-interface FastEthernet0/1
  hello-interval 10
  hold-time 30
```

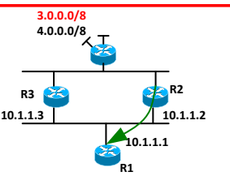


R1 should filter out 3.0.0.0 via R3, while receiving 3.0.0.0 and 4.0.0.0 via R2

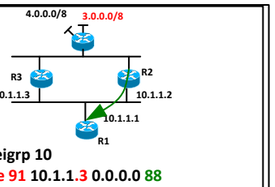



```
R1#
router eigrp 100
 distribute-list 102 in FastEthernet0/0

access-list 102 deny   ip host 10.1.1.3 3.0.0.0 0.0.0.255
access-list 102 permit ip any any
```



R1 should prefer R2 for prefix 3.0.0.0 as long as R2 is up within EIGRP AS 10




```
router eigrp 10
distance 91 10.1.1.3 0.0.0.0 88

access-list 88 permit 3.0.0.0 0.0.0.255
access-list 88 deny   any
```

Making the path worse for 3.0.0.0 from R3

How to configure the router to never exceed more then 10% of any links bandwith for EIGRP in named mode:

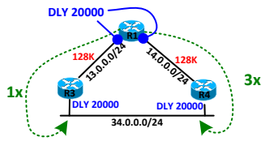
```
router eigrp NAME

address-family ipv4 unicast autonomous-system 100

 af-interface default
  bandwidth-percent 10
```

Unequal cost calculation EIGRP

You want to get a ration 1:3 from R1 to 34.0.0.0/24




```
R1#show ip route 34.1.1.0 | i via|share
  14.1.1.4, from 14.1.1.4, 00:00:29 ago, via Serial1/4
    Route metric is 21024000, traffic share count is 1
* 13.1.1.3, from 13.1.1.3, 00:00:29 ago, via Serial1/3
    Route metric is 21024000, traffic share count is 1
```

You have to make path via Ser1/3 **3x worse than via Ser 1/4**
In oder to end up with a load-distribution of 1x via R3 and 3x via R4

3x 21024000 = 63072000

63072000 = 256 (BW + DLY)

Check the Vector metrics Bandwith and Delay for the Path from R1 to 34.1.1.0/24 and extract the two values per path

```
R1#show ip eigrp 300 topology 34.1.1.0 255.255.255.0
EIGRP-IPv4 Topology Entry for AS(300)/ID(0.0.0.1) for 34.1.1.0/24
  State is Passive, Query origin flag is 1, 2 Successor(s), FD is 1024000
  Descriptor Blocks:
  13.1.1.3 (Serial1/3), from 13.1.1.3, Send flag is 0x0
    Composite metric is (1024000/512000), route is Internal
    Vector metric:
      Minimum bandwidth is 128 Kbit
      Total delay is 40000 microseconds
        Hop count is 1
      Originating router is 0.0.0.1
  14.1.1.4 (Serial1/4), from 14.1.1.4, Send flag is 0x0
    Composite metric is (1024000/512000), route is Internal
    Vector metric:
      Minimum bandwidth is 128 Kbit
      Total delay is 40000 microseconds
      Hop count is 1
      Originating router is 0.0.0.4
```

Background info regarding the calculation:
Bandwith: 10'000'000 is a fixed EIGRP value.
Delay: under the interface delay is configured in 10^{th} of micro-seconds

Calculate Path via Serial 1/3

Bandwith = 10'000'000 / 128 = 78125

Delay 40000 / 10 = 4000

You have two choices, either manipulate the Delay value or the Bandwith Value. Its recommended to use Delay, as routing protocols and QoS uses the Bandwith statement under the interface for their calculations, whereas only EIGRP considers delay.

EIGRP Metric formula:

256 (BW + DLY) = COMPOSITE-Metric

In order to have 3x the metric (63072000) received from R4 (21024000)we need to calculate the following:

63072000 = 256 (BW + DLY)

63072000 = 256 (78125 + 4000)

63072000 = 256 (82125)

$$\frac{63072000}{256} = 82125$$

*X = the value you need to add to R3's path to make it 3x worse then via R4! You could add the delay or a value for bandwith! -> I use **delay** in this example*

$$\frac{63072000}{256} = 82125 + X$$

246375 = 82125 + X

246375 - 82125 = X

164250 = X

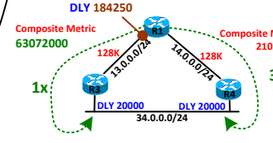
R1#show interface ser 1/3
MTU 1500 bytes, BW 128 Kbit/sec, DLY 20000 usec,

164250 + 20000 = 184250

The solution:

```
R1#conf t
int serial 1/3
delay 184250

router eigrp X
variance 4
```



Via R3: 63072000 = 256 [(10'000'000 /128) + {(40000/10)+164250}]
Via R4: 21024000 = 256 [(10'000'000 /128) + (40000/10)]

clear ip eigrp neigbors!

```
R1#show ip route 34.1.1.0
  * 14.1.1.4, from 14.1.1.4, 00:01:45 ago, via Serial1/4
    Route metric is 21024000, traffic share count is 16
    13.1.1.3, from 13.1.1.3, 00:01:45 ago, via Serial1/3
    Route metric is 67680000, traffic share count is 5
```

Share count between path R3 and R4 is:

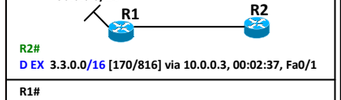
16 / 5 = **3.2**

Variance needs to be set to **4.0** !!

R2 should receive the following:


```
R2#
D EX  3.3.0.0/16 [170/816] via 10.0.0.3, 00:02:37, Fa0/1
```

You should use "redistribute static" under the EIGRP process on R1, but do NOT use a static route on R1!




```
R2#
D EX  3.3.0.0/16 [170/816] via 10.0.0.3, 00:02:37, Fa0/1
```

```
R1#
int loopback30
ip address 30.0.0.3 255.255.255.0

ip default-network 3.3.0.0

router eigrp 500
 redistribute static metric 1 1 1 1 1
```

```
R1#show ip route | I S
S      30.3.0.0/16 [1/0] via 130.3.3.0
```

EIGRP offset-lists Configuration:

"classic mode"

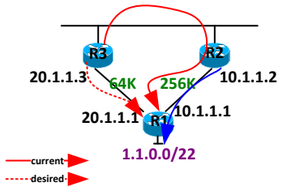
Named mode:

```
access-list 99 permit 1.1.0.0 0.0.255.255

router eigrp A-100
 address-family ipv4 unicast autonomous-system 100
  topology base
   offset-list 99 out 8888 Serial1/3
```

```
access-list 99 permit 1.1.0.0 0.0.255.255

router eigrp 10
 offset-list 99 out 8888 FastEthernet0/17
```



R1 generates a **summary 1.1.0.0/22** to R2 and R3, make sure R3 will not use R2 to reach the summary.
EIGRP should be configured in **named mode**
Send the summary with equal cost to both R2, and R3!

```
router eigrp A-100
 address-family ipv4 unicast autonomous-system 100
  af-interface Serial1/2
   summary-address 1.1.0.0 255.255.252.0
   exit-af-interface
  af-interface Serial1/3
   summary-address 1.1.0.0 255.255.252.0
   exit-af-interface
  topology base
   summary-metric 1.1.0.0/22 1 1 1 1 1 distance 90
```

```
R3#show ip route 1.1.0.0 | i metri
  Known via "eigrp 100", distance 90, metric 2560512256, type internal

R2#show ip route 1.1.0.0 | i met
  Known via "eigrp 100", distance 90, metric 2560512256, type internal
```

What is the difference between the following:

RIP:
router rip
passive-interface fa0/x
neigbor 10.0.0.1 fa0/x

RIP:
router rip
passive-interface fa0/x
neigbor 10.0.0.1 fa0/x

works

EIGRP
router eigrp 100
passive-interface fa0/x
neigbor 10.0.0.1 fa0/x

EIGRP
router eigrp 100
passive-interface fa0/x
neigbor 10.0.0.1 fa0/x

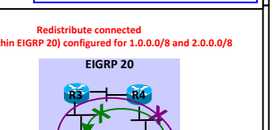
WILL NOT WORK

What parameter have to match in order to have EIGRP establish an adjacency?

K-Values

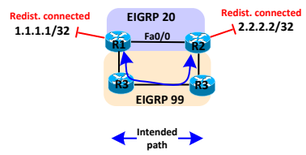
Autonomous System Number

Authentication

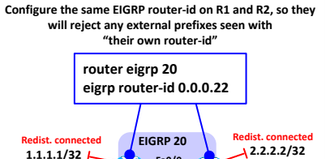


Ensure that R1 and R2 do never accept External routes from each other.
Do not use a distribute-list / offset-list / Distance.
Any future external route should be accounted for.

Set the same router-id on R1 and R2!!

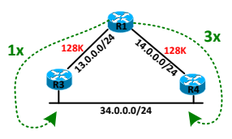


Make sure the that R1 and R2 never use the direct fa0/0 to reach each others external prefixes.
Do not use distribute-list / offset-list / distance.



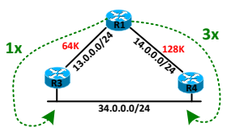
Configure the same EIGRP router-id on R1 and R2, so they will reject any external prefixes seen with "their own router-id"

EIGRP
Desired Ratio 1:3 between R3 and R4 from R1 to 34.0.0.0/24



Unequal cost calculation EIGRP

EIGRP
Desired Ratio 1:3 between R3 and R4 from R1 to 34.0.0.0/24
(Quick Guide, 10 steps)



Unequal cost calculation EIGRP

```
R1#show ip route 34.1.1.0 | i share
    Route metric is 21024000, traffic share count is 1    (Serial 1/3)
    Route metric is 21024000, traffic share count is 1    (Serial 1/4)
Currently the share is 1:1, use the metric multiply by 3x
3x 21024000 = 63072000    (used to make R3's path 3x worse than R4s)
R1#show ip eigrp 300 topology 34.1.1.0 255.255.255.0
  Composite metric is (1024000/512000), route is Internal
  Vector metric:
    Minimum bandwidth is 128 Kbit          Check min bandwith/delay
    Total delay is 40000 microseconds      along the path
    Bandwith: 10'000'000 / 128 = 78125
    Delay: 40'000 / 10 = 4000              Calculation!
```

```
4000 + 78125 = 82125
63072000 / 256 = 82125 + X
246375 = 82125 + X
246375 - 82125 = X
164250 = X
```

```
R1#show int ser 1/3
..., BW 128 Kbit/sec, DLY 20000
164250 + 20000 = 184250
```

router eigrp X
variance 3

```
R1#conf t
int serial 1/3
delay 184250
```

1. Show ip route 34.0.0.0 | I metric
   Path 1 via R3 metric = 21024000
   Path 2 via R4 metric = 21024000
2. Calculate the needed metric, to make the second path worse enough to fit variance (3x 21024000 = 63072000)
3. Identify Path Total Delay and minimum bandwith using show ip eigrp X topology 34.0.0.0 255.255.255.0
4. Calculate 10'000'000 / Minimum Bandwith = BW (78125)
   Calculate Total Delay / 10 = DLY (4000)
   63072000 = 256 (BW + DLY)
5. $\frac{63072000}{256} = 82125$
6. $\frac{63072000}{256} = 82125 + X$
7. 246375 = 82125 + X
   246375 - 82125 = 164250
8. Check interface delay R1 to R3 show ip int ser1/3 | i Delay
   DLY 20000 usec
9. add 164250 to 20000 = 184250
10. R1#conf t
    int serial 1/3
    delay 184250
    router eigrp X
    variance 3

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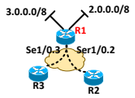
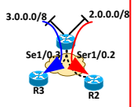
EIGRP

Have R1 leak 2.0.0.0/8 to R2 while you leak 3.0.0.0/8 to R3. Do not remove "eigrp stub connected" on R1:



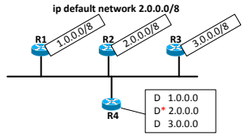

```
R1#
router eigrp 100
network 2.0.0.0
network 3.0.0.0
 eigrp stub connected leak-map RMP-LEAK-EIGRP

ip prefix-list PFX-LEAK-2 seq 5 permit 2.0.0.0/8

ip prefix-list PFX-LEAK-3 seq 10 permit 3.0.0.0/8

route-map RMP-LEAK-EIGRP permit 10
 match ip address prefix-list PFX-LEAK-2
 match interface ser0/0.2

route-map RMP-LEAK-EIGRP permit 20
 match ip address prefix-list PFX-LEAK-3
 match interface Ser0/0.3
```




```
R1#
router eigrp 100
network 1.0.0.0
ip default network 1.0.0.0/8
```

```
R3#
router eigrp 100
network 3.0.0.0
ip default network 3.0.0.0/8
```

```
R2#
router eigrp 100
network 2.0.0.0
ip default network 2.0.0.0/8
```



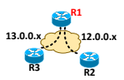
How can you instruct R4 to have all 3 routes in its routing table, but only accepts 2.0.0.0 as the default route?

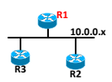
R4#
router eigrp 100
default-information in 2

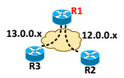
access-list 2 permit 2.0.0.0

```
R1#show ip route
D    1.0.0.0/8 [90/156160] via 10.0.0.2, 00:09:53, Fa0/0
D*   2.0.0.0/8 [90/156160] via 10.0.0.2, 00:09:53, Fa0/0
D    3.0.0.0/8 [90/156160] via 10.0.0.2, 00:09:53, Fa0/0
```

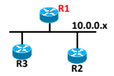
Configure R1 into an EIGRP stub in these to Situations





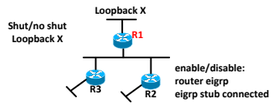



```
R1#
router eigrp 100
network 12.0.0.1 0.0.0.0
network 13.0.0.1 0.0.0.0
eigrp stub
```




```
R1#
router eigrp 100
network 10.0.0.1 0.0.0.0
neigbor 10.0.0.2 fa0/0
neigbor 10.0.0.3 fa0/0
eigrp stub

R2 and R3#
router eigrp 100
network 10.0.0.[2,3] 0.0.0.0
neigbor 10.0.0.1 fa0/0
```

How to test EIGRP Stub behaviour:



What will debug eigrp packets terse display in the case R2 and R3 have eigrp stub connected enabled and once disabled?

NO EIGRP STUB:

debug ip packet terse (on R1 and then shutdown loopback X)

```
EIGRP: Enqueueing QUERY on Fa0/21 tid 0 iidbQ un/rely 0/1 serno 43-43
EIGRP: Enqueueing QUERY on Fa0/19 tid 0 iidbQ un/rely 0/1 serno 43-43
EIGRP: Sending QUERY on Fa0/21 tid 0
EIGRP: Sending QUERY on Fa0/19 tid 0
```

EIGRP is enqueueing and sending a querry to R2 and R3.

EIGRP STUB enabled on R2

debug ip packet terse (on R1 and then shutdown loopback X)

```
EIGRP: Enqueueing QUERY on Fa0/21 tid 0 iidbQ un/rely 0/1 serno 43-43
EIGRP: Enqueueing QUERY on Fa0/19 tid 0 iidbQ un/rely 0/1 serno 43-43
EIGRP: Sending QUERY on Fa0/19 tid 0
```

EIGRP is enqueueing for both but only sending the querry to R3!

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Redistribution

Narbiks Redistribution Route-Map:

2 to 1 route-map

```
route-map O->E deny 10
match tag 90

route-map O->E permit 20
set tag  110


route-map E->O deny 10
match tag 110

route-map E->O permit 20
set tag  90


router ospf 1
 redistribute eigrp 35 subnets route-map E->O metric-type 2

router eigrp 35
 redistribute ospf 1 metric 100000 100 255 1 1500 route-map O->E
```

Show ip alias output explained:

```
SW4#show ip alias
Address Type        IP Address      Port
Interface           150.1.10.10
Interface           155.1.10.10
Interface           155.1.108.10
```

Shows all connected interfaces:

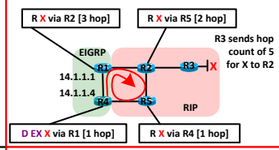
Similar to show ip int brie | e una

Redistribution solution 1

R1 and R4
router eigrp 20
redistribute rip metric 1 1 1 1 1
distance eigrp 90 110

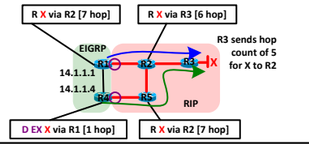
Use distribute-lists

router rip
redistribute eigrp 20 metric 1



R1 and R4
access-list 30 deny X
access-list 30 deny ALL RIP NETWORKS
access-list 30 permit any (EIGRP)
router rip
distribute-list 30 out fa0/0

Deny all RIP networks out towards the RIP side!



Handy VTP debug commands:

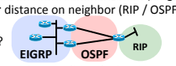
debug sw-vlan vtp events

debug sw-vlan vtp packets

Narbiks 8 redistribution methods

Briefly mentioned:

1. RIP distribute list, deny advertised routes inbound
2. Same Router ID on EIGRP
3. Redistribute appropriate routes using RMPs and PFX
4. 2 to 1 route-map
5. Filter based on route summarization (longest match)
6. Set lower distance on neighbor (RIP / OSPF)
7. Distance?



8. EIGRP races OSPF condition (EIGRP is super quick)

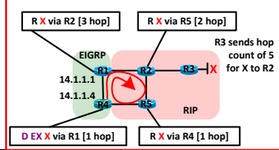
```
acl into-eigrp deny 5.0.0.0
acl into-eigrp permit any

router ospf 1
distribute-list into-eigrp out ospf 1
router eigrp  100
distribute-list into-ospf out eigrp 100
```

Redistribution solution 2

R1 and R4
router eigrp 20
redistribute rip metric 1 1 1 1 1
distance eigrp 90 110

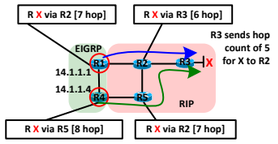
Use EIGRP duplicated router-id

router rip
redistribute eigrp 20 metric 1



R1 and R4
router eigrp 20
eigrp router-id 0.0.0.1

Using the same EIGRP router-id to block out EIGRP external networks!



Disable error messages for MOSPF LSA Type 6 messages

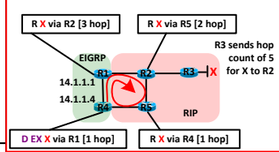
Conf t
Router ospf X
Ignore LSA MOSPF

Redistribution solution 3

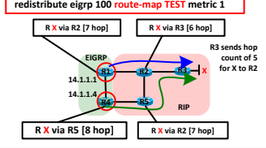
R1 and R4
router eigrp 20
redistribute rip metric 1 1 1 1 1
distance eigrp 90 110

Using a route-map and prefix-lists

router rip
redistribute eigrp 20 metric 1



R1 and R4
ip prefix-list BLA deny ALL-RIP-NETWORKS/24
ip prefix-list BLA deny X/24
ip prefix-list BLA permit 0.0.0.0/0 le 32
route-map TEST
match ip address prefix BLA
router rip
redistribute eigrp 100 route-map TEST metric 1



How to troubleshoot redistribution issues?

Use the following command on all redistributing routers:

debug ip routing

Wait a few moments and see what routes are flapping due to wrong redistribution

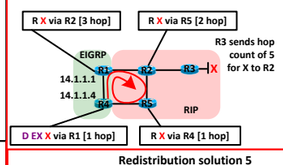
SW4# debug ip routing
RT: add 54.1.1.0/24 via 183.1.105.5, eigrp metric [170/2560002816]

Redistribution solution 4

R1 and R4
router eigrp 20
redistribute rip metric 1 1 1 1 1
distance eigrp 90 110

Use the 2-to-1 route-map

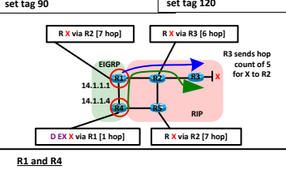
router rip
redistribute eigrp 20 metric 1



R1 and R4
router eigrp 100
redistribute rip metric 1 1 1 1 1 route-map RMP-R-2-E
router rip
redistribute eigrp 100 metric 1 route-map RMP-E-2-R

route-map RMP-E-2-R deny 10
match tag 120
route-map RMP-E-2-R permit 20
set tag 90

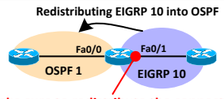
route-map RMP-R-2-E deny 10
match tag 90
route-map RMP-R-2-E permit 20
set tag 120



What could be forgotten to redistribute in this situation?

Redistributing EIGRP 10 into OSPF

Redistributing EIGRP 10 into OSPF



Make sure to redistribute the connected interface on the EIGRP side into OSPF too!!!!

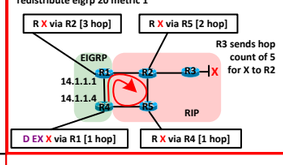
```
router ospf 1
redist eigrp 10 subnets route-map RMP-E-2-O

route-map RMP-E-2-O deny 10
match tag 110

route-map RMP-E-2-O permit 20
set tag 90

route-map RMP-E-2-O permit 20
match interface Fa0/1
```

Redistribution solution 5

R1 and R4
router eigrp 20
redistribute rip metric 1 1 1 1 1
distance eigrp 90 110

Using Summaries

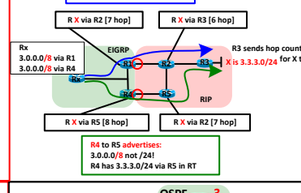
router rip
redistribute eigrp 20 metric 1



R1 and R4
int fa0/0 (int pointing to R2, R5)
ip summary-address eigrp 20 3.0.0.0 255.0.0.0

R1 to R2 advertises:
3.0.0.0/8 not /24!
R1 has 3.3.3.0/24 via R2 in RT

R4 to R5 advertises:
3.0.0.0/8 not /24!
R4 has 3.3.3.0/24 via R5 in RT



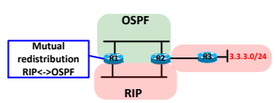
What could be the problem here:

```
R1#show run | i route
ip route 200.1.12.0 255.255.255.0 200.1.12.11

R1(config)#no ip route 200.1.12.0 255.255.255.0 200.1.12.11
%No matching route to delete
```

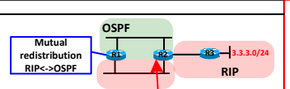
```
R1#show run | i route
ip route 200.1.12.0 255.255.255.0 200.1.12.11

R1(config)#no ip route 200.1.12.0 255.255.255.0 200.1.12.11
%No matching route to delete
```

Someone configured a default network, but not to a classfull network! You will not be able to NO out the static route other than doing this:

```
R1#conf t
R1(config)#no ip default-network 200.1.12.11
```



How can you solve this that R1 and R2 will be able to ping the 3.3.3.0/24 network?



Troubleshoot using:

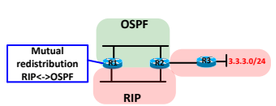
debug ip routing

debug ip rip
watch for inaccessible

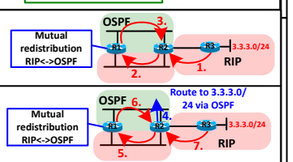
debug ip ospf lsa-generation
(watch for Rcv Maxage LSA, Type 5, LSID 3.3.3.0)

Fix:
router rip
distance 109

Will R2 be able to ping 3.3.3.3 ?



What happens here in detail?



1. R2 received route 3.x via RIP from R3
2. R2 advertises 3.0.0.0 via RIP to R1
3. R1 redistributes 3.0.0.0 into OSPF advertises towards R2
4. R2 starts using OSPF route to 3.x flushes the RIP route and announces it as inaccessible within RIP.
5. R1 receives inaccessible RIP route from R2 for 3.0.0.0 and
6. R1 advertises OSPF max-age for 3.0.0.0 route, R2 flushes route
7. R2 receives RIP update from R3, and it starts at 1. again

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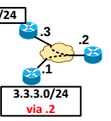
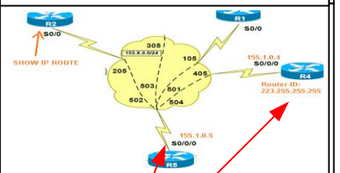
OSPF

Configure OSPFv2 for a prefix without using the network statement:	**OSPFv2** **interface FastEthernet0/0** **ip ospf 1 area 1**	**`show ip ospf interface Serial0/0:`**	**Serial0/0 is up, line protocol is up** **Internet Address 155.1.0.5/24, Area 0** **Process ID 1, Router ID 150.1.5.5, Network Type NON_BROADCAST, Cost: 64** **Enabled by interface config, including secondary ip addresses** **Transmit Delay is 1 sec, State DR, Priority 1** **Designated Router (ID) 150.1.5.5, Interface address 155.1.0.5** **Backup Designated router (ID) 223.255.255.255, Interface address 155.1.0.4** **Timer intervals configured, Hello 30, Dead 120, Wait 120, Retransmit 5** **oob-resync timeout 120** **Hello due in 00:00:16** **Supports Link-local Signaling (LLS)** **Index 1/2, flood queue length 0** **Next 0x0(0)/0x0(0)** **Last flood scan length is 1, maximum is 4** **Last flood scan time is 0 msec, maximum is 4 msec** **Neighbor Count is 4, Adjacent neighbor count is 4** **Adjacent with neighbor 150.1.3.3** **Adjacent with neighbor 150.1.1.1** **Adjacent with neighbor 150.1.2.2** **Adjacent with neighbor 223.255.255.255 (Backup Designated Router)**	Serial interfaces P-2-P output of OSPF	interface Serial1/3 ip address 155.1.23.3 255.255.255.0 ip ospf 1 area 5 clock rate 64000 R3#sh ip ospf neighbor Neighbor ID Pri State Dead Time Address Interface 150.1.2.2 0 FULL/ - 00:00:37 155.1.23.2 Serial1/3 R3#sh ip ospf interface brief Interface PID Area IP Address/Mask Cost State Nbrs F/C Se1/3 1 5 155.1.23.3/24 781 P2P 1/1
Configure all attached interfaces into OSPF area 2 with one line:	router ospf 1 **network 0.0.0.0 255.255.255.255** area 2	Show ip ospf neighbor Output:	**sh ip ospf neighbor** Neighbor ID Pri State Dead Time Address Interface 150.1.1.1 1 FULL/DR 00:00:34 155.1.146.1 Gi0/1 150.1.6.6 1 FULL/DROTHER 00:00:38 155.1.146.6 Gi0/1	**OSPF Point-2-Multipoint:**	**OSPF Point-2-Multipoint** - Statically configured - Host Routes for reachability - 30/120 timers - **Next-Hop Advertising Router** - NO DR / BDR election!  interface Serial0/0 **ip ospf network point-to-multipoint** frame-relay map ip 155.1.0.5 105 **broadcast**
What is special about OSPF network statement and ip unnumbered interfaces?	If there is an IP unnumbered command configured on Fa0/0 and the network statement covers only the IP unnumbered address space, Fa0/0 will also be enabled for that OSPF instance. Interface fa0/0 Ip unnumbered	What is important to keep in mind when it comes to OSPF configuration with Loopbacks and Router-ID?	Within lab, double check for highest Loopback, in case you do not configure a router-id for OSPF, they may deliberately want to break it like that.	Show IP route output explained in combination with OSPF	 **R2#show ip route 155.1.0.4** **Routing entry for 155.1.0.4/32** **Known via "ospf 1", distance 110, metric 128, type intra area** **Last update from 155.1.0.5 on Serial0/0, 00:23:39 ago** **Routing Descriptor Blocks:** *** 155.1.0.5, from 223.255.255.255, 00:23:39 ago, via Serial0/0** **Route metric is 128, traffic share count is 1**
OSPF network statement described:	it simply enables the OSPF process on the interface. If multiple network statements overlap the same interface, the most specific match based on the wildcard mask wins.	How to detect a dublicated router-id in ospf?	**Router1:** int Loopback222 ip address 222.255.255.255 /32 **Router3:** int Loopback222 ip address 222.255.255.255 /32 **%OSPF-4-DUP_RTRID_AREA: Detected** router with **duplicate router ID** 222.255.255.255 in area 2 **%OSPF-4-FLOOD_WAR:** Process 1 re-originates LSA ID 155.1.79.9 type-2 adv-rtr 222.255.255.255 in area 2	**OSPF Broadcast:**	**OSPF Broadcast** - Ethernet - DR / BDR Election - Multicast 224.0.0.5 / 224.0.0.6 - 10/40 Timers - Next-hop does not change
Matching specifically one address into OSPF area 3:	**router ospf** **network 155.1.10.10 0.0.0.0** area 3 IP 155.1.10.10 Total match via 0.0.0.0	What to check if networks are visible in the OSPF database but not in the routing table:	**R2#show ip ospf database router** **OSPF Router with ID (150.1.2.2) (Process ID 1)** **Router Link States (Area 0)** **Adv Router is not-reachable** **LS age: 1419** **Options: (No TOS-capability, DC)** **LS Type: Router Links** **Link State ID: 150.1.1.1** **Advertising Router: 150.1.1.1** **LS Seq Number: 80000007** **Checksum: 0x4B33** **Length: 36** **.....** **.....**	**OSPF Non-Broadcast:** (Frame-Relay Multipoint)	**OSPF Non-Broadcast** - Frame-Relay Multipoint - DR / BDR - Unicast (Neigbor command) - 30/120 Timers - Next-hop does not change
`show ip ospf interface brief:`	**show ip ospf interface brief** R2#show ip ospf interface brief Interface PID Area IP Address/Mask Cost State Nbrs F/C Fa0/0 1 51 192.10.1.2/24 1 BDR 1/1 **Use this command after initial ospf config, to verify**	Show ip ospf database (what Net Link status'es reveal):	R3#show ip ospf database OSPF Router with ID (150.1.3.3) (Process ID 1) Net Link States (Area 2) Link ID ADV Router Age Seq# Checksum 155.1.37.7 150.1.7.7 428 0x80000005 0x0098E8 155.1.67.6 150.1.6.6 1314 0x80000007 0x0089A7 155.1.79.7 150.1.7.7 1403 0x80000004 0x006DE1 DR or advertising router network segment If no "**Net Link States (Area X)**" is visible in the OSPF database, there was no DR elected!	**OSPF Point-to-Point:** HDLC / FR P-2-P / PPP	**OSPF Point-to-Point** - No DR / BDR Election - Traffic to 224.0.0.5 - 10/40 Timers - Next-hop own address

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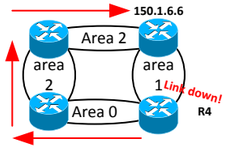
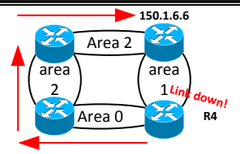
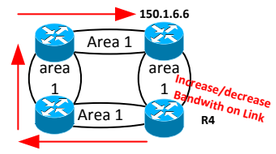
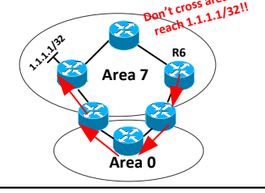
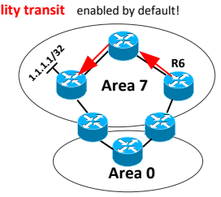
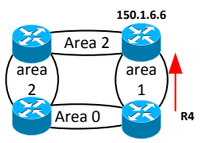
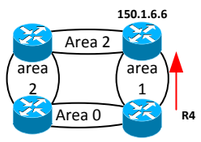
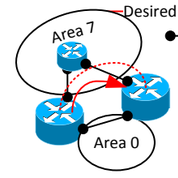
OSPF

OSPF Point-Multipoint Non-Broadcast	**OSPF Point-2-Multipoint NON-Broadcast** - **Unicast** Neighbor command! - Host Routes for reachability - 30/120 timers - Next-Hop Advertising Router - NO DR / BDR election! interface Serial0/0 **ip ospf network point-to-multipoint non-broadcast** frame-relay map ip 155.1.0.5 105 router ospf X **neighbour 155.1.0.5**	Show ip route output of R4 using an **inter-area** route to R6: 	 R4# sh ip route 150.1.6.6 Routing entry for 150.1.6.6/32 Known via "ospf 1", distance 110, metric 40431, **type inter area** Last update from 155.1.45.5 on Serial0/1/0, 00:00:00 ago Routing Descriptor Blocks: 155.1.45.5, from 150.1.1.1, 00:00:00 ago, via Serial0/1/0 Route metric is 40431, traffic share count is 1	**What does (DNA) within a "show ip ospf database" stand for?**	R6# show ip ospf database OSPF Router with ID (150.1.6.6) (Process ID 1) Router Link States (Area 0) Link ID ADV Router Age Seq# Checksum Link count 150.1.1.1 150.1.1.1 1 **(DNA)** 0x8023 0x002C1E 4 150.1.2.2 150.1.2.2 793 **(DNA)** 0x8028 0x00CB61 3 150.1.3.3 150.1.3.3 760 **(DNA)** 0x8025 0x00C76B 3 **Do Not Age bit, or learned via Virtual Link most likely**
Different OSPF network types:	**ip ospf network point-to-point** **ip ospf network broadcast** **ip ospf network non-broadcast** **ip ospf network point-to-multipoint** **ip ospf network point-to-multipoint non-broadcast**	Useful command troubleshooting IP OSPF Cost and paths:	R5#show ip ospf interface | i Cost Process ID 1, Router ID 150.1.5.5, Network Type POINT_TO_POINT, Cost: 15 Process ID 1, Router ID 150.1.5.5, Network Type POINT_TO_MULTIPOINT, Cost: 15 Process ID 1, Router ID 150.1.5.5, Network Type POINT_TO_POINT, Cost: 1 Process ID 1, Router ID 150.1.5.5, Network Type BROADCAST, Cost: 10 Process ID 1, Router ID 150.1.5.5, Network Type BROADCAST, Cost: 10	What is special in terms of Virtual Link and Router-IDs, assosiated to the highest interface?	If a Virtual link is setup, pointing to the current Router-ID which happens to be the highest Loopback interface. A new, even higher Loopback number is configured, the Virtual Link will be broken, in the event that the OSPF process is restarted as the new even higher Loopback will take its place as OSPF Router-ID, whereas the other, configured Router is pointing at the wrong Router-ID and will fail to establish the virtual-link. **Virtual-link is only a control-plane solution, and not a data-plane!**
Debug IP packet of OSPF: Point-2-Point Broadcast Point-to-multipoint non-broadcast	interface **Serial0/1/0** ip ospf 1 area 0 **IP: s=155.1.45.4 (Serial0/1/0), d=224.0.0.5, len 80, rcvd 0, proto=89** interface GigabitEthernet0/0 ip address 155.1.58.5 255.255.255.0 ip ospf 1 area 3 **s=155.1.58.8 (GigabitEthernet0/0), d=224.0.0.5, len 80, rcvd 0, proto=89** interface Serial0/0/0 ip address 155.1.0.5 255.255.255.0 encapsulation frame-relay ip ospf network point-to-multipoint non-broadcast frame-relay map ip 155.1.0.1 501 no frame-relay inverse-arp **IP: s=155.1.0.5 (local), d=155.1.0.3 (Serial0/0/0), len 92, sending, proto=89**	How to display the local OSPF database which all local networks	**show ip ospf database router 150.1.8.8 self-originate** (150.1.8.8 is its own local Loopback IP address)	**Repairing Discontiguous OSPF Areas with Virtual-Links**	R1: router ospf 1 area 1 virtual-link 150.1.6.6 R6: router ospf 1 area 1 virtual-link 150.1.1.1 **Make sure Router-ID has been manually configured!**
How do you advertise the same prefix into two OSPF areas using one network statement and one interface command?	Int loopback99 Ip address 99.99.99.99 255.255.255.255 Ip ospf 1 **area 88** router ospf 1 network 99.99.99.99 255.255.255.255 **area 99**	**OSPF Path Selection with Bandwidth**	 **interface Serial0/0** **bandwidth 10000**	**OSPF** **router ospf 1** **no capability transit** **What does this command do?**	**Within Area 1:** router ospf 1 **no capability transit** 
Auto-cost reference bandwith could potentially harm the network, explain why:	A routing loop could occur due to mis-matched auto-cost reference bandwith. Set the auto-cost value consistently throughout the entire OSPF domain	**Calculating OSPF path costs** Calculate cost via ABR: Calculate cost to ABR: Summarize both = route metric:	**show ip ospf database summary 150.1.8.0** Link State ID: 150.1.8.0 (summary Network Number) Advertising Router: 150.1.1.1 **(IP of the ABR)** Metric: **19731 (shows metric as of the ABR)** **show ip ospf database router 150.1.6.6 self-originate** Link connected to: a Transit Network (Link ID) Designated Router address: 155.1.146.6 (Link Data) Router Interface address: 155.1.146.6 Number of TOS metrics: 0 TOS 0 Metrics: **300 (shows metric to the ABR)** R6#show ip route 150.1.8.8 via FastEthernet0/0.146 Route metric is **20031**, traffic share count is 1	What does the following OSPF command do? **router ospf 1** **capability transit**	capability transit is set as default, which means, IF there is a shorter intra-area path, it will be preferred than the inter-area path, via Area 0. **capability transit** enabled by default! 
Show ip route output of R4 using an **intra-area** route to R6: 	 R4#sh ip route 150.1.6.6 Routing entry for 150.1.6.6/32 Known via "ospf 1", distance 110, metric 301, **type intra area** Last update from 155.1.146.6 on GigabitEthernet0/1, 00:14:19 ago Routing Descriptor Blocks: * 155.1.146.6, from 150.1.6.6, 00:14:19 ago, via GigabitEthernet0/1 Route metric is 301, traffic share count is 1	**OSPF Path Selection with Per-Neighbor Cost**	**router ospf 1** **neighbor** 155.1.0.1 **cost 1000** **neighbor** 155.1.0.4 **cost 9999**	**OSPF Path Selection with Virtual-Links**	Virtual link Desired Traffic flow Physical link  Use Virtual links to adjust traffic flow over other areas. Cost for Vlink calculated based on physical interfaces!

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OSPF

OSPF Demand Circuit

reduce periodic OSPF hello transmission

interface Serial0/1/0
ip ospf demand-circuit

R4# show ip ospf interface Serial0/1/0
Serial0/1/0 is up, line protocol is up
.....
Enabled by interface config, including secondary ip addresses
Configured as demand circuit.
Run as demand circuit.
DoNotAge LSA allowed.
....
oob-resync timeout 40
Hello due in 00:00:07
Supports Link-local Signaling (LLS)
....
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
Adjacent with neighbor 150.1.5.5 (Hello suppressed)
Suppress hello for 1 neighbor(s)

Suppresses Hello msg, while maintaining the ADJ

OSPF Flooding Reduction

Reducing “paranoid update”

feature stops unnecessary LSA flooding by setting the DoNotAge (DNA) bit in the LSA, removing the requirement for the periodic refresh.

interface Vlan10
ip ospf flood-reduction

OSPF Type 1 (clear text) Authentication

Per interface

interface FastEthernet0/0
ip ospf authentication
ip ospf authentication-key SECRET

OSPF Type 1 (clear text) Authentication

Per area / interface

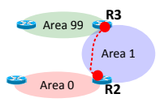
interface Vlan67
ip ospf authentication-key SECRET

router ospf 1
area 2 authentication

OSPF MD5 Authentication

interface Serial0/0
ip ospf 1 **area 0**
ip ospf message-digest-key 1 md5 KEY

router ospf 1
area 0 authentication message-digest
area 1 virtual-link 150.1.6.6 message-digest-key 1 **md5 KEY**



Authentication and Area 0 or Virtual links:

a virtual-link is an interface in area 0 !!

Be carefull not to forget this while enabling:

area 0 authentication

OSPF Null Authentication

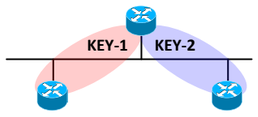
interface Vlan7
ip ospf authentication null

OSPF authentication, the difference between interface / process config:

The authentication type configured at the interface level overrides the authentication type configured at the process level

OSPF MD5 Authentication with Multiple Keys

interface FastEthernet0/0
ip ospf authentication message-digest
ip ospf message-digest-key 16 md5 KEY-1
ip ospf message-digest-key 46 md5 KEY-2



Debugging different received OSPF MD5 Keys on the same interface:

debug ip ospf adj

OSPF: Send with youngest Key 0
OSPF: **Rcv pkt** from 155.1.146.4, **Fa0/0** : Mismatch Authentication
Key - No **message digest** **key 46** on interface
OSPF: **Rcv pkt** from 155.1.146.1, **Fa0/0**: Mismatch Authentication
Key - No **message digest** **key 16** on interface

OSPF Internal Area Summarization

router ospf 1
area 3 range 155.1.8.0 255.255.252.0

OSPF Path Selection with Summarization

Deliberately make routes a longer prefix to force traffic another, more specific way.

Use

Router ospf X
Area X range x.x.x.x 255.255.254.0 to make a /24 look like a /23 to force a different route.

OSPF **metric** and **forward metric** on **E2** routes:

SW3#**show ip route** 51.51.51.51
Routing entry for 51.51.51.51/32
Known via "ospf 1", distance 110, **metric 20**,
type extern 2, **forward metric 50**
Last update from 155.1.79.7 on Vlan79, 00:06:49 ago
Routing Descriptor Blocks:
* 155.1.79.7, from 192.10.1.254, 00:06:49 ago, via Vlan79
Route metric is 20, traffic share count is 1

Forward metric, gives information about which paths is taken effectively to the E2 destination.

OSPF Stub config and output:

router ospf 1
area 3 stub

Show ip route

O 155.1.5.0/24 [110/2] via 155.1.58.5, 00:38:42, Vlan58
O IA 150.1.1.1/32 [110/66] via 155.1.58.5, 00:00:21, Vlan58
O*IA 0.0.0.0/0 [110/2] via 155.1.58.5, 00:00:21, Vlan58

SW4#sh ip ospf database
OSPF Router with ID (150.1.10.10) (Process ID 1)
Router Link States (Area 3)
Net Link States (Area 3)
Summary Net Link States (Area 3)
Several entries due to IA routes

OSPF Totally Stubby Areas

Config:

ONLY ON ABR:

router ospf 1
area 3 stub **no-summary**

Internal Area routers have:

router ospf 1
area 3 stub

stub area

totally stubby area

not-so-stubby area (NSSA)

not-so-totallystubby area

How to troubleshoot OSPF Authentication mis-match:

debug ip ospf adj

OSPF: Send with youngest Key 0
OSPF: Rcv pkt from 155.1.79.7, Vlan79 : **Mismatch Authentication type**. Input packet specified type 1, we use type 2

(Mis-match can be either authentication type or the password.)

Default route within the OSPF Database:

```
show ip ospf database
summary 0.0.0.0
```

Output:

LSA Type3

Router ospf 1
Area 3 stub

SW4#**show ip ospf database** **summary 0.0.0.0**

OSPF Router with ID (150.1.10.10) (Process ID 1)

Summary Net Link States (Area 3)

Routing Bit Set on this LSA
LS age: 1415
Options: (No TOS-capability, DC, Upward)
LS Type: Summary Links(Network)
Link State ID: 0.0.0.0 (summary Network Number)
Advertising Router: 150.1.5.5
LS Seq Number: 80000001
Checksum: 0x1D7F
Length: 28
Network Mask: /0
TOS: 0 Metric: 1

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OSPF

OSPF Totally Stubby Areas

show ip ospf database

Output:

ABR:
Router ospf 1
Area 3 stub no-summary

Internal Area Router:
Router ospf 1
Area 3 stub

Show ip route

O 150.1.8.8/32 [110/2] via 155.1.108.8, 00:31:57, Po1
O*IA 0.0.0.0/0 [110/3] via 155.1.108.8, 00:03:46, Po1

SW4#show ip ospf database
OSPF Router with ID (150.1.10.10) (Process ID 1)

Router Link States (Area 3)

Net Link States (Area 3)

Summary Net Link States (Area 3)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	150.1.5.5	49	0x80000002	0x001B80

Only 0.0.0.0 entry in Summary Net Link States! LSA Type 3

OSPF Not-So-Totally-Stubby Areas

ABR:
router ospf 1
area 2 nssa no-summary
area 2 default-cost 500

Internal Area Router:
Router ospf 1
area 2 nssa

O 155.1.67.0 [110/2] via 155.1.79.7, 00:01:19, Vlan79
O N2 200.0.3.0/24 [110/20] via 155.1.79.7, 00:01:20, Vlan79
O*IA 0.0.0.0/0 [110/**502**] via 155.1.79.7, 00:01:20, Vlan79

SW3#sh ip ospf database
OSPF Router with ID (150.1.9.9) (Process ID 1)
Router Link States (Area 2)
Net Link States (Area 2)
Summary Net Link States (Area 2)

0.0.0.0	150.1.3.3	382	0x80000001 0x004F54

Type-7 AS External Link States (Area 2)

OSPF Forwarding Address Suppression

OSPF Forwarding Address Suppression in Translated Type-5 LSAs

with forwarding address suppression enabled the traffic will always flow through the Type-7 to 5 translator.
(NSSA with multiple exits, Highest IP is translator)

router ospf 1
area 3 nssa no-redistribution no-summary
translate type7 suppress-fa

Instructs the ABR not to send the original forward address but to set it to 0.0.0.0.

Show ip ospf database ?

Output:

SW4# show ip ospf database ?

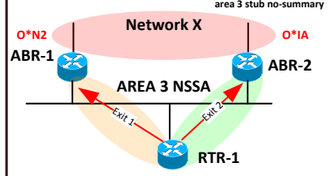
router	Type 1
network	Type 2 (ADV Router is the DR)
summary	Type 3
asbr-summary	Type 4
external	Type 5, translated Type 7's
nssa-external	NSSA External link states
self-originate	Self-originated link states

OSPF Stub Areas with Multiple Exit Points

(O*IA / O*N2)

router ospf 1
area 2 **nssa default-information-originate**
area 2 default-cost 500

ABR:
router ospf 1
area 3 stub no-summary



O*IA 0.0.0.0/0 (Type 3 Sum)
O*N2 0.0.0.0/0 (Type 7)

OSPF Default Routing

2 config options:

router ospf 1
default-information originate always

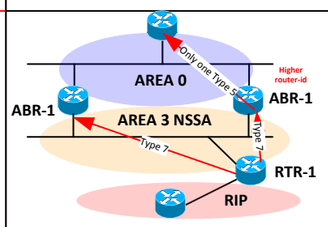
---

ip route 0.0.0.0 0.0.0.0 54.1.1.254

router ospf 1
default-information originate metric 60

OSPF Not-So-Stubby Areas

Speciality about the Type 7 to Type 5 conversion:



Only one ABR is sending the translated Type 5 into Area 0!

OSPF Not-So-Stubby Areas

List ospf route preference:

1. intra-area (to disable:**no capability transit**)
2. inter-area
3. external
4. nssa-external

OSPF Conditional Default Routing

Config:

router ospf 1
default-information originate always route-map RMP-TRACK

ip prefix-list **PFX-BB1** seq 5 **permit** 54.1.1.0/24

ip prefix-list **PFX-R3** seq 5 **permit** 150.3.3.0/24

route-map RMP-TRACK permit 10
match ip address **prefix-list PFX-BB1 PFX-R3**

(Advertise 0.0.0.0/0 if 54.1.1.0/24 or 150.3.3.0/24 is in the routing table)

show ip ospf database nssa-external x.x.x.x

Output:

Rack1R3#show ip ospf database nssa-external 200.0.0.0
OSPF Router with ID (150.1.3.3) (Process ID 1)
Type-7 AS External Link States (Area 2)
Routing Bit Set on this LSA
LS age: 312
Options: (No TOS-capability, **Type 7/5 translation**, DC)
LS Type: AS External Link
Link State ID: 200.0.0.0 (External Network Number)
Advertising Router: 150.1.6.6
LS Seq Number: 80000001
Checksum: 0xF94A
Length: 36
Network Mask: /24
Metric **Type: 2** (Larger than any link state path)
TOS: 0
Metric: 20
Forward Address: 155.1.67.6
External Route Tag: 0

OSPF NSSA Type-7 to Type-5 Translator Election

Multiple ABRs connect the NSSA to area 0

ABR with the highest router-id is elected as the Type-7 to 5 translator and is responsible for re-originating the Type-5 LSA into area 0.

OSPF Reliable Conditional Default Routing

Config:

ip **sla monitor 10**
type echo protocol ipIcmpEcho **204.12.1.254**
timeout 2000
frequency 5
ip sla monitor schedule 10 life forever start-time now

track 1 rtr 10

ip route **169.254.0.1** 255.255.255.255 **Null0** **track 1** name is.up.always.as.is.route.to.Null0

ip prefix-list **PLACEHOLDER** seq 5 permit **169.254.0.1/32**

route-map **TRACK_PLACEHOLDER** permit 10
match ip address **prefix-list PLACEHOLDER**

router ospf 1
default-information originate always route-map **TRACK_PLACEHOLDER**

Logic uses Track on a dummy route which is always UP/UP due to pointed at Null0. Therefore only the IP SLA is important.

OSPF Not-So-Stubby Areas

router ospf 1
area 2 **nssa**

No OSPF domain external routes visible! Default route not automatically generated on ABR!

Show ip route

O 150.1.7.7/32 [110/2] via 155.1.79.7, 00:31:00, Vlan79
O IA 150.1.5.5/32 [110/784] via 155.1.79.7, 00:31:00, Vlan79
O N1 200.0.0.0/24 [110/20] via 155.1.79.7, 00:30:59, Vlan79
O N2 200.0.1.0/24 [110/20] via 155.1.79.7, 00:30:59, Vlan79

SW3#show ip ospf database
OSPF Router with ID (150.1.9.9) (Process ID 1)
Router Link States (Area 2)
Net Link States (Area 2)
Summary Net Link States (Area 2)
Type-7 AS External Link States (Area 2)

OSPF NSSA Redistribution Filtering

SW2#show ip route ospf

O N2 5.5.5.5 [110/20] via 155.1.58.5, 00:05:32, Vlan58
O*IA 0.0.0.0/0 [110/2] via 155.1.58.5, 00:01:58, Vlan58

Additional N2 is not needed due to the existing default route pointing to the same ABR. The **additional N2's can be disabled** via:

ABR#
router ospf 1
area 3 nssa **no-redistribution no-summary**

OSPF Filtering with Distribute-Lists

Intra-area filtering

Config:

Intra-area filtering can be accomplished in OSPF with an inbound distribute-list:

All routers have to have the same config, otherwise there is a danger of blackholing networks!

router ospf 1
distribute-list 1 in

Intra-area filtering
Affects local routing table only!

access-list **1 deny 150.1.1.1**
access-list 1 deny 150.1.2.2
access-list 1 permit any

OSPF Not-So-Stubby Areas and Default Routing

router ospf 1
area 2 **nssa** **default-information-originate**
area 2 default-cost 500

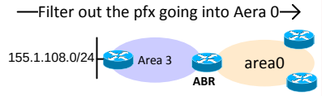
Internal Area Router output:

O 150.1.7.7/32 [110/2] via 155.1.79.7, 00:46:01, Vlan79
O IA 150.1.1.1/32 [110/848] via 155.1.79.7, 00:46:01, Vlan79
O*N2 0.0.0.0/0 [110/500] via 155.1.79.7, 00:00:38, Vlan79

OSPF LSA Type-3 Filtering

Config:

—Filter out the pfx going into Aera 0→



ABR#
ip prefix-list AREA_3_ROUTES **deny 155.1.108.0/24**
ip prefix-list AREA_3_ROUTES **permit 0.0.0.0/0 le 32**

router ospf 1
area 3 filter-list prefix AREA_3_ROUTES out

—Filter out the pfx going into Aera 0→

OSPF LSA Type-3 Filtering

Inter-area filtering

Config:

←Deny pfx from entering Area0—

Inter-area filtering

coming from Area 0 going out to Area 2

router ospf 1
area 0 filter-list prefix FILTER in

ip prefix-list FILTER seq 5 deny 155.1.23.0/24
ip prefix-list FILTER seq 10 permit 0.0.0.0/0 le 32

←Deny pfx from entering Area0—

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OSPF

OSPF Summarization and Discard Routes

router ospf 1
no discard-route internal
area 0 range 150.1.0.0 255.255.252.0

Discard-route prevent the forwarding of traffic towards a shorter match.

automatic origination of the discard route can be disabled via “no discard-route”

Internal = inter-area
External = summary-address

Discard route a ospf generated Null0 route for area range or ip summary address command. If this automatic Null route should be disabled, use NO discard-route (internal/external)

OSPF Stub Router Advertisement

Config:

router ospf 1
max-metric router-lsa

- prevent traffic black holes
- advertise a maximum metric for non-stub destinations
- initializing the OSPF process, transit traffic will not flow through the stub router
- once the ospf domain is converged, the max metric is withdrawn.

max-metric router-lsa on-startup wait-for-bgp
(waits for BGP keepalives)
max-metric router-lsa on-startup announce-time
(how long to wait after a reload)

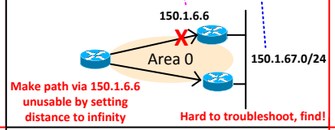
Ignore OSPF LSA type 6 error messages:

router ospf 1
ignore lsa mospf

OSPF Filtering with Administrative Distance

access-list **99** permit 155.1.67.0

router ospf 1
distance 255 150.1.6.6 0.0.0.0 **99**



Make path via 150.1.6.6 unusable by setting distance to infinity

Hard to troubleshoot, find!

OSPF Interface Timers

interface Serial0/0
ip ospf hello-interval **5**
ip ospf dead-interval (seconds)

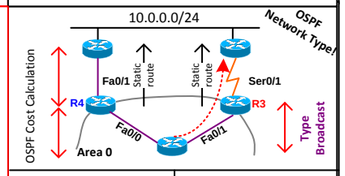
interface Serial0/1/0 **Sub-second!**
ip ospf dead-interval minimal hello-multiplier 4

minimal hello-multiplier 4 = 250 msec

Timers need to match on all Routers, otherwise the Adjacency will not form!

OSPF cost calculation

Changing network types



Cost via **R4**		Cost via **R3**	
Fa0/1	1	Ser0/1	
Redir static	20	Redir static	20
Fa0/0	1	**Fa0/1**	1
Cost sum:	**22**	Cost sum:	**21**

OSPF Filtering with Route-Maps

Config:

router ospf 1
distribute-list route-map DENY_R3_LOOPB_FROM_R4 **in**

access-list 3 permit 150.1.3.3
access-list 4 permit 155.1.146.4

route-map DENY_R3_LOOPB_FROM_R4 deny 10
match ip **address 3**
match ip **next-hop 4**

Make pfx unique by specifying pfx and next-hop

route-map DENY_R3_LOOPB_FROM_R4 permit 20

Loopback IP is 150.1.3.3/32
Next-Hop of R4 is 155.1.146.4

OSPF Global Timers

router ospf 1
timers throttle spf 100 1000 10000
timers pacing flood 50
timers pacing retransmission 75
timers throttle lsa all 10 4000 6000
timers lsa arrival 2000
!
interface Serial0/1
ip ospf transmit-delay 2
ip ospf retransmit-interval 10

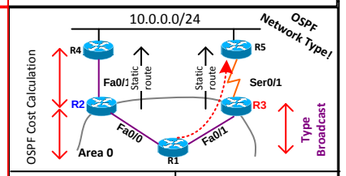
SPF pacing/throttling timers control how fast OSPF responds to convergence events.

Check via: **show ip ospf**

OSPF cost calculation

Changing network types

Next



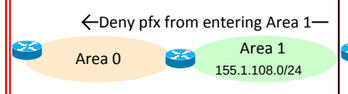
R1 will see R4's IP address as forward-address and will calculate the cost to it!
→ Cost of 1+20+1 = 22

R1 will see R3's IP address as forward-address due to the Serial Link and calculate the cost to it:
→ Cost of 1+20 = 21

OSPF LSA Type-3 Filtering

Inter-area filtering

Config:

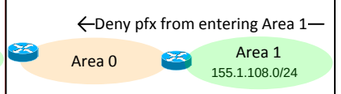


Inter-area filtering

coming from Area 1 going out to Area 0

router ospf 1
area 1 filter-list prefix FILTER out

ip prefix-list FILTER seq 5 deny 155.1.23.0/24
ip prefix-list FILTER seq 10 permit 0.0.0.0/0 le 32



OSPF Resource Limiting

Config:

router ospf 1
max-lsa 5000
redistribute maximum-prefix 500
process-min-time percent 20

max-lsa: defines a max of 5000 LSA in the OSPF database

Redistribute maximum-pref 500: No more then 500 pfx show be originated through redistribution

Process-min-time percent: OSPF should not use more then 20% of the CPU ressources

OSPF

Auto-cost reference-bandwith

Calculation:

cost = Reference-Bandwidth / Bandwidth_of_the_link

Desired metrics: **20000/10 = 2000**

Bandwith	OSPF Cost
10'000	2
10	2000
1.544	12953
0.768	26041

Used command:

auto-cost reference-bandwidth 20000

OSPF NSSA ABR External Prefix Filtering

Config:

On ABR:

router ospf 1
area 2 nssa
summary-address 200.0.0.0 255.255.255.0 **not-advertise**

On internal Area router:

router ospf 1
area 2 nssa

ABR translates Type-7 NSSA External LSA to a Type-5 External LSA. Now creating a **summary address** and using "**not-advertise**" in order to suppress that LSA Type 5.

Use DNS resolution on the OSPF router-id value in show commands:

R5#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
150.1.4.4	0	FULL/ -	00:00:33	155.1.45.4	Serial0
Globi-R1	0	FULL/ -	00:00:39	155.1.0.1	Serial0
150.1.4.4	0	FULL/ -	00:00:38	155.1.0.4	Serial0
HOBBIT-R2	0	FULL/ -	00:00:39	155.1.0.2	Serial0
150.1.3.3	0	FULL/ -	00:00:38	155.1.0.3	Serial0

ip host Globi-R1 150.1.1.1
ip host HOBBIT-R2 150.1.2.2

ip ospf name-lookup

R5#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
150.1.4.4	0	FULL/ -	00:00:33	155.1.45.4	Serial0
Globi-R1	0	FULL/ -	00:00:39	155.1.0.1	Serial0
150.1.4.4	0	FULL/ -	00:00:38	155.1.0.4	Serial0
HOBBIT-R2	0	FULL/ -	00:00:39	155.1.0.2	Serial0
150.1.3.3	0	FULL/ -	00:00:38	155.1.0.3	Serial0
150.1.8.8	1	FULL/BDR	00:00:31	155.1.58.8	Gi0/0

OSPF Database Filtering

Config per interface:

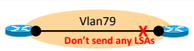
Config per neighbor:

Per interface: clear ip ospf process!

interface Vlan79
ip ospf database-filter all out

Per Neighbor:

router ospf 1
neighbor 155.1.0.2 database-filter all out



OSPF, ignore MTU while creating OSPF Adjacency:

interface Port-channel1
ip ospf mtu-ignore

Parameters that have to match for a OSPF adjacency to come up:

OSPF parameters that have to match for OSPF Adjacency:

- Timers
- Area ID
- Authentication
- Area Stub Flag
- MTU

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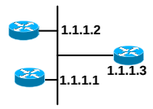
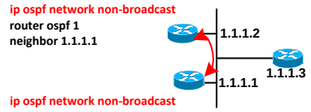
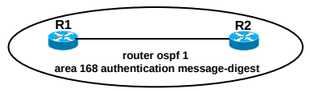
OSPF

Ensure other routers of segment cannot intercept the OSPF communication:



Using unicast, instead of multicast via the LAN segment so Router 3 "can" not intercept the ospf conversation between R1 and R2





What does one have to keep in mind when dealing with

ip ospf message-digest-key X

In this situation?

R1
interface Vlan18
ip ospf message-digest-key 8 md5 7 CISCO

R2
int fa0/0
ip ospf message-digest-key 7 md5 7 CISCO

If the key IDs are different, the ADJ will NOT come up!!!

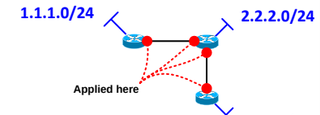
Vlan18 : Mismatch Authentication Key - No message digest key 7 on interface

What does

ip ospf prefix-suppression

do?

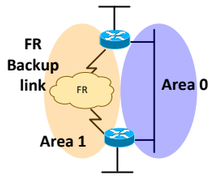
interface fa0/x
ip ospf prefix-suppression



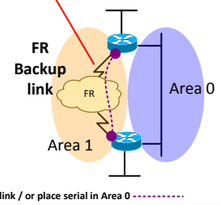
Will hide the transit networks between the routers

Prefixes in routing table:
1.1.1.0 / 2.2.2.0 and 3.3.3.0

What options are there if you would like to use the FR connection as a backup in case the ethernet segment goes down in respect to OSPF?

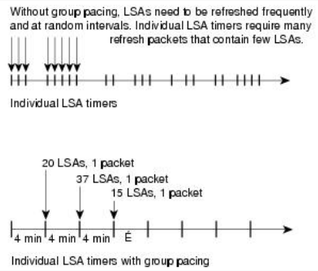


If this should be the backup path, make sure its in AREA 0, If not, use a virtual-link. Otherwise no traffic will use the serial link as transit interface.



Virtual-link / or place serial in Area 0 ----------

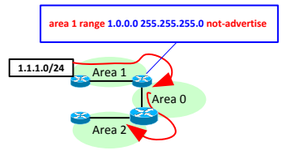
OSPF LSAs on Individual Timers with Group Pacing



LSA Type 3 filtering via

area 1 range x.x.x.x y.y.y.y not-advertise

LSA Type 3 filtering via
area x range x x not-advertise



Similar to area X filter-list [in/out]

OSPF

show ip ospf virtual-links

R4#**show ip ospf virtual-links**
Virtual Link OSPF_VL0 to router 150.1.5.5 is up
Run as demand circuit
DoNotAge LSA allowed.
Transit area 45, via interface GigabitEthernet0/0, **Cost of** using 10000
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer **intervals** configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:02
Adjacency **State FULL (Hello suppressed)**
Index 2/4, retransmission queue length 0, number of retransmission 0
First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
Last retransmission scan length is 0, maximum is 0
Last retransmission scan time is 0 msec, maximum is 0 msec

Configuring OSPF Distance

For intra-area / inter-area / external:

router ospf 1

distance ospf intra-area 200

distance ospf inter-area 100

distance ospf external 120

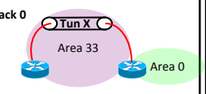
What could be used instead of using a Virtual-Link in order to connect discontigous OSPF Areas to Area 0?

Either use

router ospf X
area 33 virtual-link 1.2.3.4

Or use a **GRE Tunnel** to interconnect

interface Tunnel X
ip unnumbered Loopback 0
ip ospf X area 0



OSPF

Verifiying OSPF fast hello's:

R5#**show ip ospf interface S0/0/0 | include Timer**
Timer intervals configured, Hello 333 msec, Dead 1, Wait 1, Retransmit 5

Interface ser0/0/0
ip ospf dead-interval minimal hello-multiplier 3

OSPF

no discard-route

no discard-route [internal] [external]

If not specified, will remove the route for both.

LSA	Advertising Router	Routing Table	OSPF Database
1 (intra)	?	?	show ip ospf database ?
2 (intra)	?	?	show ip ospf database ?
3 (inter)	?	?	show ip ospf database ?
4			
5 (Ext)	?	?	show ip ospf database ?

LSA	Advertising Router	Routing Table	OSPF Database
1 (intra)	ALL	O	show ip ospf database router
2 (intra)	DR	O	show ip ospf database network
3 (inter)	ABR	OIA	show ip ospf database summary
4			
5 (Ext)	ASBR	E2, E1	show ip ospf database external

Stub	Type Keyword	LSAs	Default injected
Stub			
Totally Stubby			
Not-So-Stub			
Not-So-Totally Stubby Area			

Stub	Type Keyword	LSAs	Default injected
Stub	area x stub	1,2,3 (default 3)	YES
Totally Stubby	area x stub no-sum	1,2, (default 3)	YES
Not-So-Stub	area x nssa	1,2,3,7	NO
Not-So-Totally Stubby Area	area x nssa no-sum	1,2,(default 3), 7	YES

Conditional default route

TRACK NOT

(if SLA X down / network x is NOT in the table, advertise the default route)

ip sla 53
icmp-echo 172.16.0.22
timeout 500
frequency 3
ip sla schedule 53 life forever start-time now

track 13 rtr 53 reachability

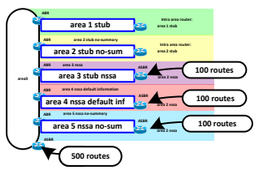
! Define another object that is the negation of the previous object

track 77 list boolean and
object 13 not

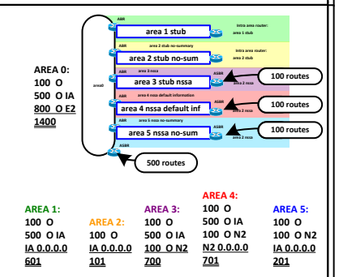
! Insert a static route if the second object is UP (thus the ! IP SLA probe failed)

ip route 1.0.0.0 255.0.0.0 Null0 **track 77**

OSPF and how many routes visible in each area:



100 routes in intra Areas



AREA 0:
100 O
500 O IA
800 O E2
1400

AREA 1:
100 O
500 O IA
IA 0.0.0.0
601

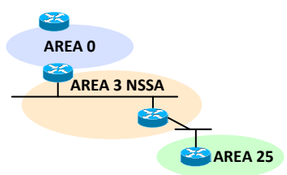
AREA 2:
100 O
IA 0.0.0.0
101

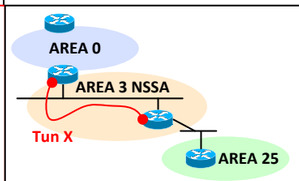
AREA 3:
100 O
500 O IA
100 O N2
700

AREA 4:
100 O
500 O IA
100 O N2
N2 0.0.0.0
701

AREA 5:
100 O
100 O N2
IA 0.0.0.0
201

How do you connect AREA 25 to Area 0 ?



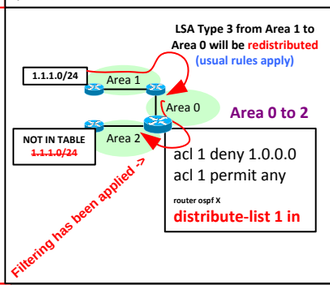


Stub / NSSA Area's do NOT support Virtual Links! Use a GRE Tunnel to connect AREA 25 to Area 0

OSPF Filtering with Distribute-Lists

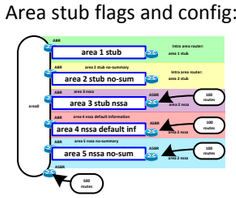
Config:

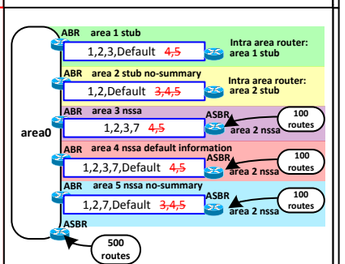
Inter-area filtering using distribute lists



OSPF

Area stub flags and config:





AREA x nssa translate type7 suppress-fa

TO BE DONE

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OSPF

IP OSPF Authentication

Enable per Interface / Area

Apply authentication per Interface

Disable authentication per interface

Enable OSPF Authentication:

Per Interface	Per Area
int ser0/x ip ospf authentication ip ospf authentication message ..	router ospf 1 area 0 authentication area 0 authentication message ..

Apply authentication

```
Int ser0/x
ip ospf authentication-key TEXT-TYPE-1
ip ospf message-digest key 1 MD5 PASSWORD
```

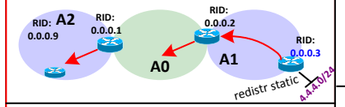
Disable authentication per link

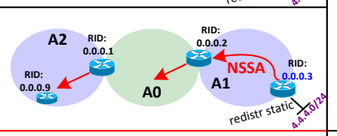
```
Int ser0/x
ip ospf authentication null
```

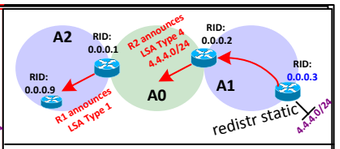
OSPFv2 Cryptographic Authentication

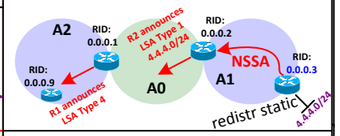
```
key chain TEST
key 1
key-string PASSWORD
cryptographic-algorithm hmac-sha-256
send-lifetime {start-time} {infinite | end-time | duration <seconds>

Interface fa0/x
ip ospf authentication key-chain TEST
```

What LSA Types will be announced in each topology, and why?







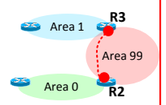


OSPF virtual-link Authentication

Problem with Area 0 authentication and VLinks

R3
router ospf 1
NO area 0 authentication
area 99 virtual-link 2.2.2.2

If the authentication would not explicitly be set to null on the Virtual link, it would try to Auth via Type 2, MD5 to R3 on R2, failing to establish the Vlink.

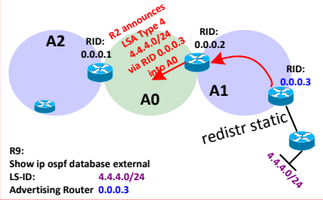


R2#
area 0 authentication
area 0 authentication message-digest
area 99 virtual-link 3.3.3.3 authentication null

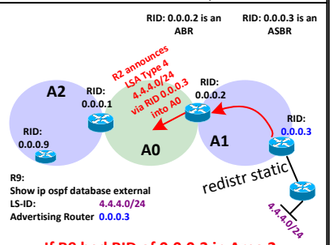
OSPFv3 IPSec ESP Encryption and Authentication

```
Interface fa0/x
ospfv3 encryption {ipsec spi spi esp encryption-algorithm key-encryption-type key authentication-algorithm key-encryption-type key | null}

ipv6 ospf encryption {ipsec spi spi esp {encryption-algorithm [[key-encryption-type] key] | null} authentication-algorithm [key-encryption-type] key | null}

ospfv3 encryption ipsec spi 1001 esp null md5 0 2757...

ipv6 ospf encryption ipsec spi 1001 esp null sha1 1234...
```

Explain why it is essential that OSPF router-id's should be kept unique within the entire OSPF domain?



R9:
Show ip ospf database external
LS-ID: 4.4.4.0/24
Advertising Router 0.0.0.3



R9:
Show ip ospf database external
LS-ID: 4.4.4.0/24
Advertising Router 0.0.0.3

If R9 had RID of 0.0.0.3 in Area 2, 4.4.4.0/24 would be filtered out!

OSPF Default route

3 different methods

1. ip route 0.0.0.0 0.0.0.0 192.168.1.1
   router ospf 1
   default information originate

2. router ospf 1
   default information originate always

3. router ospf 1
   default information originate route-map RMP-X

route-map RMP-X
match ip address 77

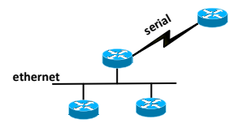
access-list 77 permit 10.0.0.1

OSPF multiarea

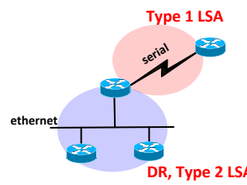
```
authentication mode {strict | deployment | normal}
```

OSPF multiarea

What segment announces which LSA Type?



What segment announces which LSA Type?



OSPF BFD

BFD is configured globally for **all interfaces** associated with the **OSPF process.**

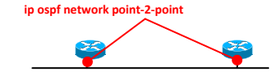
```
interface Fast Ethernet 0/1
 ip address x.x.x.x
 bfd interval 50 min_rx 50 multiplier 3

interface Fast Ethernet 0/2
 ip address u.u.u.u

router ospf 123
 log-adjacency-changes detail
 network x.x.x.x 0.0.0.0 area 0
 network u.u.u.u 0.0.0.0 area 0
 bfd all-interfaces
```

show bfd neighbors details

How can you make R1 and R2 form a working OSPF adjacency without changing the Subnet mask on the Ethernet interface?

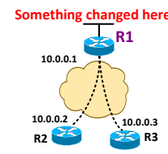
```
int fa0/0
ip address10.0.0.1 255.255.255.0
router ospf 1
network 10.0.0.1 0.0.0.0 area 0

                                  int fa0/0
                                  ip address 10.0.0.2 255.255.254.0
                                  router ospf 1
                                  network 10.0.0.2 0.0.0.0 area 0
```

```
Change the ospf network type to P-2-P
-> will ignore the mis-matched subnet mask!
Int fa0/0
ip ospf network point-2-point
```

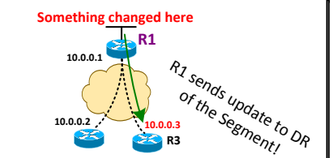


```
int fa0/0
ip address10.0.0.1 255.255.255.0
router ospf 1
network 10.0.0.1 0.0.0.0 area 0

                                  int fa0/0
                                  ip address 10.0.0.2 255.255.254.0
                                  router ospf 1
                                  network 10.0.0.2 0.0.0.0 area 0
```

What could be a potential problem here?



OSPF priority is the same on all routers



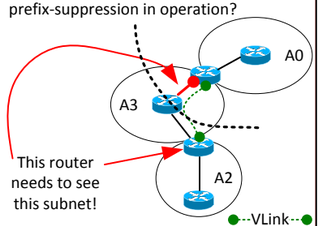
R3 has the highest IP on the common segment and is the DR.

R2 will never hear the update unless there is a static mapping from R3 to R2!

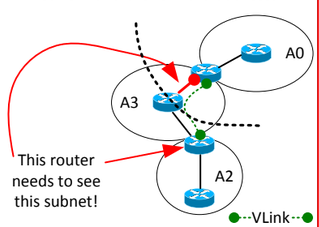
IPsec on OSPFv3

```
ospfv3 authentication {ipsec spi} {md5 | sha1}{ key-encryption-type key} | null

ipv6 ospf authentication {null | ipsec spi spi authentication-algorithm [key-encryption-type] [key]}

interface fa0/x
ospfv3 authentication md5 0   2757613409....09727

Or

ipv6 ospf authentication ipsec spi 500 md5 123456789
```

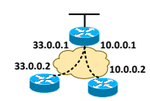
What if DB filter / distribute list / prefix-suppression in operation?



Check the ospf database for the network and the forward address!

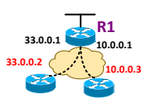


Who is going to be the DR ?



ip ospf priority all are set to the same

If the OSPF priority is the same, the higher IP wins!



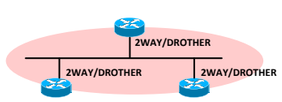
ip ospf priority all are set to the same

(R1 should be the DR in this situation)

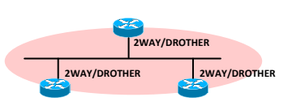
IPv6 OSPF Null authentication

```
conf t
interface fa0/x
ospfv3 authentication null
ipv6 ospf authentication null
```

What could be the problem here?



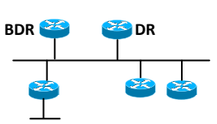
What could be the problem here?



All routers have:

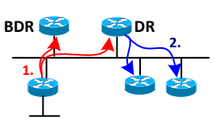
Interface e0/0
ip ospf priority 0

Explain how OSPF LSA Type 1 flooding works?



Something changed here

OSPF LSA Type 1 flooding



Something changed here

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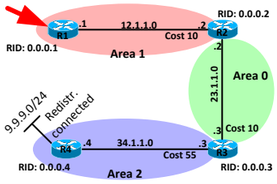
OSPF

Explain output of:

R1#show ip ospf border-routers



R1#**show ip ospf border-routers**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Base Topology (MTID 0)

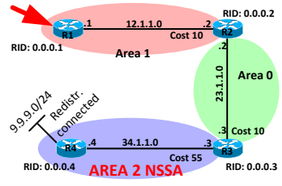
Internal Router Routing Table
Codes: i - Intra-area route, I - Inter-area route

i **0.0.0.2** [**10**] via 12.1.1.2, e0/0, **ABR**, Area 1, SPF 12
I **0.0.0.4** [**75**] via 12.1.1.2, e0/0, **ASBR**, Area 1, SPF 12

Cost to the ASBR

Explain output of:

R1#show ip ospf border-routers



R1#**show ip ospf border-routers**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Base Topology (MTID 0)

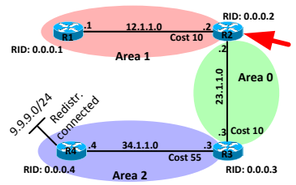
Internal Router Routing Table
Codes: i - Intra-area route, I - Inter-area route

i **0.0.0.2** [**10**] via 12.1.1.2, e0/0, **ABR**, Area 1, SPF 12
I **0.0.0.3** [**20**] via 12.1.1.2, e0/0, **ASBR**, Area 1, SPF 12

Notice R3 is the ASBR once Area 2 converted to NSSA!

Explain output of:

R2#show ip ospf database (focus on LSA type 1)



R2#**show ip ospf database**

OSPF Router with ID (0.0.0.2) (Process ID 1)

Router Link States (**Area 0**)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.2	0.0.0.2	800	0x8000000E	0x005190	1
0.0.0.3	0.0.0.3	1198	0x8000000F	0x004D90	1

Router Link States (**Area 1**)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.1	0.0.0.1	533	0x80000015	0x007B79	1
0.0.0.2	0.0.0.2	795	0x8000001B	0x00707A	1

R1#**show ip ospf database**

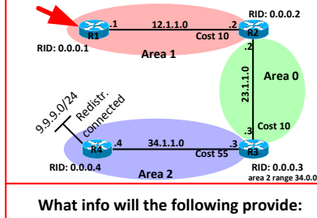
OSPF Router with ID (0.0.0.1) (Process ID 1)

Router Link States (**Area 1**)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.1	0.0.0.1	992	0x80000015	0x007B79	1
0.0.0.2	0.0.0.2	1256	0x8000001B	0x00707A	1

Explain output of:

R1#**show ip ospf database adv-router 0.0.0.4**



R1#**show ip ospf database adv-router 0.0.0.4**

OSPF Router with ID (0.0.0.1) (Process ID 1)

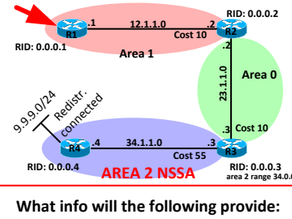
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
9.9.9.0	**0.0.0.4**	1614	0x80000002	0x003D52 0

Redistributed prefix — **Router-ID of R4**

Explain output of:

R1#**show ip ospf database adv-router 0.0.0.4**
R1#**show ip ospf database adv-router 0.0.0.3**



R1#**show ip ospf database adv-router 0.0.0.4**

OSPF Router with ID (0.0.0.1) (Process ID 1)

R1#**show ip ospf database adv-router 0.0.0.3**

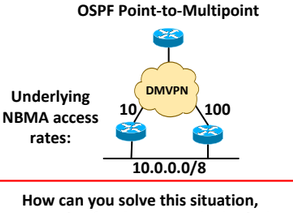
OSPF Router with ID (0.0.0.1) (Process ID 1)

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
9.9.9.0	0.0.0.3	265	0x80000001	0x000E5B 0

Explain output of:

R2#show ip ospf database (focus on LSA type 4,5)



R2#**show ip ospf database** (partial output, looking at LSA 4, 5)

Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.3	693	0x80000002	0x006795

Summary ASB Link States (Area 1)

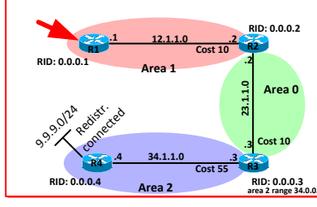
Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	296	0x80000001	0x00D321

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
9.9.9.0	0.0.0.4	331	0x80000002	0x0088F7 0

Explain output of:

R1#**show ip ospf database external**



R1#**show ip ospf database external**

OSPF Router with ID (0.0.0.1) (Process ID 1)

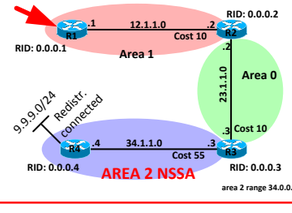
Type-5 AS External Link States

Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 1979
Options: (No TOS-capability, DC)
LS Type: AS External Link
Link State ID: 9.9.9.0 (External Network Number)
Advertising Router: 0.0.0.4
LS Seq Number: 80000002
Checksum: 0x3D52
Length: 36
Network Mask: /24
Metric Type: 2 (Larger than any link state path)
MTID: 0
Metric: 20
Forward Address: 0.0.0.0
External Route Tag: 0

What is the effective forward metric to 9.9.9.0 ? Its NOT 20!

Explain output of:

R1#**show ip ospf database external**



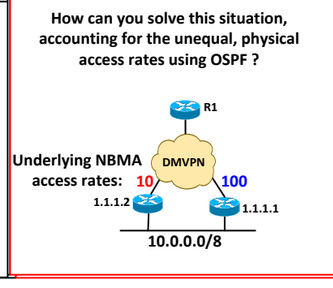
R1#**show ip ospf database external**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Type-5 AS External Link States

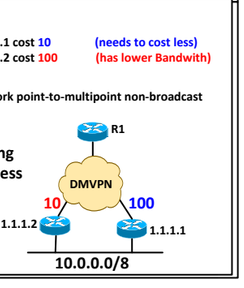
Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 431
Options: (No TOS-capability, DC)
LS Type: AS External Link
Link State ID: 9.9.9.0 (External Network Number)
Advertising Router: 0.0.0.3
LS Seq Number: 80000001
Checksum: 0xE5B
Length: 36
Network Mask: **/24**
Metric Type: 2 (Larger than any link state path)
MTID: 0
Metric: 20
Forward Address: 34.1.1.4
External Route Tag: 0

Where will you be able to summarize the E2 4.4.x.0/24 routes?



router ospf x
summary-address 4.0.0.0 255.0.0.0

Either on R4 or R3



How can you calculate the forward metric from R1 to 9.9.9.0/24 ?
What show commands are needed?

R1#**show ip route 9.9.9.0** **E2**
Known via "ospf 1", distance 110, **metric 20**, type extern 2, **forward metric 75**

R1#**show ip ospf database external**
Link State ID: **9.9.9.0** (External Network Number)
Advertising Router: **0.0.0.4**
Forward Address: **0.0.0.0** (0.0.0.0 = set to self)

R1#**show ip ospf database asbr-summary**
Link State ID: **0.0.0.4** (AS Boundary Router address)
Advertising Router: 0.0.0.2
MTID: 0 **Metric: 65** From ABR Area1 (R2) to ASBR

R1#**sh ip ospf database router 0.0.0.2**
Link State ID: 0.0.0.2
Advertising Router: 0.0.0.2
TOS 0 Metrics: 10 From R1 to ABR Area 1

How can you calculate the forward metric from R1 to 9.9.9.0/24 ?
What show commands are needed?

R1#**show ip route 9.9.9.0**
Known via "ospf 1", distance 110, **metric 20**, type extern 2, **forward metric 75**

R1#**show ip ospf database external**
Link State ID: **9.9.9.0** (External Network Number)
Advertising Router: **0.0.0.3**
Forward Address: 34.1.1.4

R1#**show ip ospf database asbr-summary**
Link State ID: **0.0.0.3** (AS Boundary Router address)
Advertising Router: 0.0.0.2
MTID: 0 **Metric: 10**

R1#**show ip ospf database summary 34.1.1.0**
Link State ID: 34.1.1.0 (summary Network Number)
Advertising Router: 0.0.0.2
Metric: 65

Where can you summarize these internal AREA 2 routes?

R1#**show ip route ospf | l 4.**
O IA 4.0.0.0/8 [110/76] via 12.1.1.2, 00:05:54, e0/0

R3#
router ospf 1
area 2 range 4.0.0.0 255.0.0.0 [not-advertise]

What info will the following provide:

R1#**show ip ospf database adv-router 0.0.0.2**

R1#**show ip ospf database adv-router 0.0.0.2**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.2	0.0.0.2	1774	0x8000000E	0x008A6D	1

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
12.1.1.2	0.0.0.2	1774	0x80000003	0x00E939

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
23.1.1.0	0.0.0.2	536	0x80000003	0x009A7B
34.0.0.0	0.0.0.2	1774	0x80000002	0x004C8A

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	43	0x80000005	0x00CB25

What info will the following provide:

R1#**show ip ospf database adv-router 0.0.0.2**

R1#**show ip ospf database adv-router 0.0.0.2**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum Link count
0.0.0.2	0.0.0.2	222	0x80000010	0x00866F 1

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
12.1.1.2	0.0.0.2	222	0x80000005	0x00E53B

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
23.1.1.0	0.0.0.2	989	0x80000004	0x00987C
34.0.0.0	0.0.0.2	222	0x80000004	0x00488C

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.3	0.0.0.2	1147	0x80000001	0x00B577

What is the potential problem of using OSPF Point-to-Multipoint in this scenario with DMVPN?

OSPF Point-to-Multipoint

You will be load-balancing over unequal, physical access rates. The DMVPN tunnel will not see the underlying access-rates!

OSPF Point-to-Multipoint

What info will the following provide:

R1# **show ip ospf database**

R1#**show ip ospf database**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.1	0.0.0.1	1952	0x80000007	0x00976B	1
0.0.0.2	0.0.0.2	6	0x8000000F	0x00886E	1

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
12.1.1.2	0.0.0.2	6	0x80000004	0x00E73A

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
23.1.1.0	0.0.0.2	748	0x80000003	0x009A7B
34.0.0.0	0.0.0.2	6	0x80000003	0x004A8B

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	254	0x80000005	0x00CB25

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
9.9.9.0	0.0.0.4	1474	0x80000003	0x003B53 0

What info will the following provide:

R1#**show ip ospf database**

R1#**show ip ospf database**

OSPF Router with ID (0.0.0.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.1	0.0.0.1	481	0x80000009	0x00936D	1
0.0.0.2	0.0.0.2	548	0x80000010	0x00866F	1

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
12.1.1.2	0.0.0.2	548	0x80000005	0x00E53B

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
23.1.1.0	0.0.0.2	1315	0x80000004	0x00987C
34.0.0.0	0.0.0.2	548	0x80000004	0x00488C

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.3	0.0.0.2	1474	0x80000001	0x00B577

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
9.9.9.0	0.0.0.3	1469	0x80000001	0x000E5B 0

How can you solve this situation, accounting for the unequal, physical access rates using OSPF ?

R1#
router ospf 1
neigbor 1.1.1.1 cost 10 (needs to cost less)
neigbor 1.1.1.2 cost 100 (has lower Bandwith)

int tun123
ip ospf network point-to-multipoint non-broadcast

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

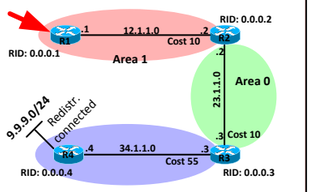
Colin

http://www.flashcardguy.ch

OSPF

What info will the following provide:

R1#show ip ospf database external

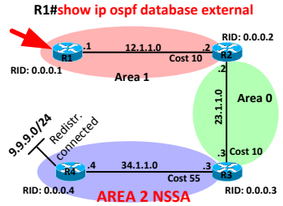


R1#show ip ospf database external
OSPF Router with ID (0.0.0.1) (Process ID 1)
Type-5 AS External Link States

Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 28
Options: (No TOS-capability, DC)
LS Type: AS External Link
Link State ID: 9.9.9.0 (External Network Number)
Advertising Router: 0.0.0.4
LS Seq Number: 80000001
Checksum: 0x8AF6
Length: 36
Network Mask: /24
Metric Type: 2 (Larger than any link state path)
MTID: 0
Metric: 20
Forward Address: 0.0.0.0
External Route Tag: 0

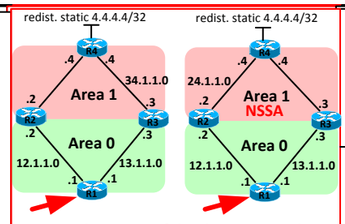
What info will the following provide:

R1#show ip ospf database external



R1#show ip ospf database external
OSPF Router with ID (0.0.0.1) (Process ID 1)
Type-5 AS External Link States

Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 300
Options: (No TOS-capability, DC)
LS Type: AS External Link
Link State ID: 9.9.9.0 (External Network Number)
Advertising Router: 0.0.0.3
LS Seq Number: 80000001
Checksum: 0x5901
Length: 36
Network Mask: /24
Metric Type: 2 (Larger than any link state path)
MTID: 0
Metric: 20
Forward Address: 34.1.1.4
External Route Tag: 0



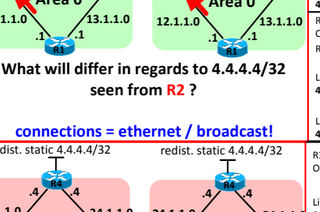
R1#show ip ospf database external
connections = e0/x
ip ospf network broadcast

R1#show ip ospf database external
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

R1#show ip ospf database external
AREA 1 NSSA
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Network Mask: /24
Metric: 20
Forward Address: 24.1.1.4

What info will the following provide:

R1#show ip ospf events



show ip ospf events: **clear ip ospf events**

Network 9.9.9.0 from UP to DOWN status:

Timer Exp: if_ack_delayed 0xAB5314C0

RIB Delete, Topo Base, **dest 9.9.9.0**, **mask 255.255.255.0**, **gw 12.1.1.2**, via Ethernet0/0, **source 0.0.0.4**, **type Ext2**

Insert MAXAGE lsa: 0xAA4223E8 **9.9.9.0**

Rcv Changed Type-5 LSA, LSID 9.9.9.0, Adv-Rtr 0.0.0.4, Seq# 80000002, Age 3600

Network 9.9.9.0 from DOWN to UP status:

Timer Exp: if_ack_delayed 0xAB5314C0

RIB Replace, Topo Base, **dest 9.9.9.0**, **mask 255.255.255.0**, **gw 12.1.1.2**, via Ethernet0/0, **source 0.0.0.4**, **type Ext2**

Rcv New Type-5 LSA, LSID 9.9.9.0, Adv-Rtr 0.0.0.4, Seq# 80000001, Age 3

DB add: 9.9.9.0 0x4223E8 175

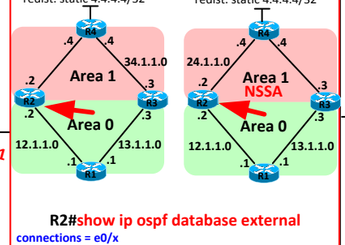
Output of

show ip ospf topology-info

R3#**show ip ospf topology-info**
OSPF Router with ID (0.0.0.3) (Process ID 1)
Base Topology (MTID 0)

Topology priority is 64
Redistributing External Routes from,
Router is not originating router-LSAs with maximum metric
Number of areas transit capable is 0
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Area BACKBONE(0)
SPF algorithm last executed 03:06:47.368 ago
SPF algorithm executed 2 times
Area ranges are
Area 1
It is a NSSA area
Perform type-7/type-5 LSA translation
SPF algorithm last executed 03:06:42.364 ago
SPF algorithm executed 3 times
Area ranges are

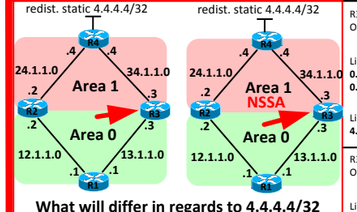
R3 has higher RID



R2#show ip ospf database external
connections = e0/x
ip ospf network broadcast

R2#show ip ospf database external
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

AREA 1 NSSA
R2#show ip ospf database external
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4



R1-4#show ip ospf database external
Link State ID: 4.4.4.0 (External Network Number)
connections = ethernet / broadcast!

R1-4#show ip ospf database external **NSSA**
Link State ID: 4.4.4.0 (External Network Number)

R1#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

R2#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

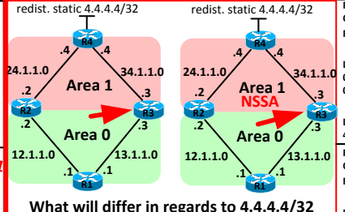
R3#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

R1#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

R2#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

R3#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

NSSA



R1-4#show ip ospf database external
Link State ID: 4.4.4.0 (External Network Number)
connections = ethernet / point-to-point

R1-4#show ip ospf database external **NSSA**
Link State ID: 4.4.4.0 (External Network Number)

R1#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

R2#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

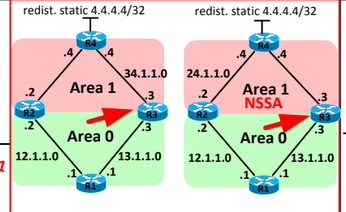
R3#
Advertising Router: 0.0.0.4
Metric: 20
Forward Address: 0.0.0.0

R1#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

R2#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

R3#
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

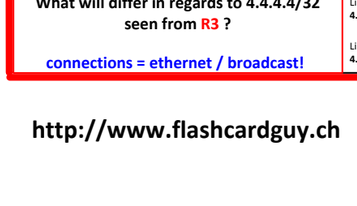
NSSA



R3#show ip ospf database external
connections = e0/x
ip ospf network broadcast

R3#show ip ospf database external
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

AREA 1 NSSA
R3#show ip ospf database external
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4



What will differ in regards to 4.4.4.4/32 seen from R1 ?

connections = ethernet / broadcast!

R1#**show ip route ospf | b 4.4.**
O E2 **4.4.4.0** [110/20] via 13.1.1.3, 00:00:02, e0/1
[110/20] via 12.1.1.2, 00:00:02, e0/0

R1#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	61	0x80000001	0x00AB80
0.0.0.4	0.0.0.3	49	0x80000003	0x00A187

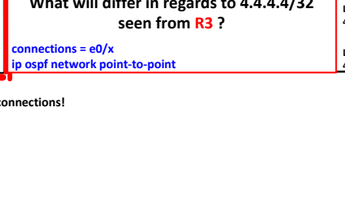
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	57	0x80000001	0x003F51 0

R1#**show ip route ospf | b 4.4.** **AREA 1 NSSA**
O E2 **4.4.4.0** [110/20] via 12.1.1.2, 00:00:03, e0/0

R1#**show ip ospf database**
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	33	0x80000001	0x009FD3 0



What will differ in regards to 4.4.4.4/32 seen from R1 ?

connections = e0/x
ip ospf network point-to-point

R1#**show ip route | b 4.4**
O E2 **4.4.4.0** [110/20] via 13.1.1.3, 00:23:45, Ethernet0/1
[110/20] via 12.1.1.2, 00:23:45, Ethernet0/0

R1#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	1446	0x80000001	0x00AB80
0.0.0.4	0.0.0.3	1441	0x80000001	0x00A585

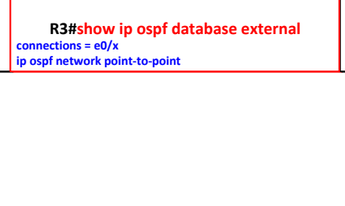
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	1451	0x80000001	0x003F51 0

R1#**show ip route | b 4.4** **AREA 1 NSSA**
O E2 **4.4.4.0** [110/20] via 12.1.1.2, 00:01:04, Ethernet0/0

R1#**show ip ospf database**
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	108	0x80000001	0x009FD3 0



R1#show ip ospf database external
connections = e0/x
ip ospf network point-to-point

R1#**show ip ospf database external**
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

R1#**show ip ospf database external** **AREA 1 NSSA**
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Network Mask: /24
Metric: 20
Forward Address: 24.1.1.4

What will differ in regards to 4.4.4.4/32 seen from R2 ?

connections = ethernet / broadcast!

R2#**show ip route | b 4.4.**
O E2 4.4.4.0 [110/20] via 24.1.1.4, 00:00:00, Ethernet0/1

R2#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	86	0x80000001	0x00AB80
0.0.0.4	0.0.0.3	76	0x80000001	0x00A585

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	83	0x80000001	0x003F51 0

R2#**show ip route** **Area 1 NSSA**
O N2 4.4.4.0 [110/20] via 24.1.1.4, 00:00:03, Ethernet0/1

R2#**show ip ospf database**
Type-7 AS External Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	39	0x80000001	0x000563 0

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	22	0x80000001	0x009FD3 0

What will differ in regards to 4.4.4.4/32 seen from R2 ?

connections = e0/x
ip ospf network point-to-point

R2#**show ip route | b 4.4**
O E2 4.4.4.0 [110/20] via 24.1.1.4, 00:00:08, Ethernet0/1

R2#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	42	0x80000001	0x00AB80
0.0.0.4	0.0.0.3	37	0x80000001	0x00A585

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	51	0x80000001	0x003F51 0

R2#**show ip route | b 4.4.** **AREA 1 NSSA**
O N2 4.4.4.0 [110/20] via 24.1.1.4, 00:00:09, Ethernet0/1

R2#**show ip ospf database**
Type-7 AS External Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	48	0x80000001	0x000563 0

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	30	0x80000001	0x009FD3 0

R2#show ip ospf database external
connections = e0/x
ip ospf network point-to-point

R2#show ip ospf database external
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

AREA 1 NSSA
R2#show ip ospf database external
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Metric: 20
Forward Address: 24.1.1.4

What will differ in regards to 4.4.4.4/32 seen from R3 ?

connections = ethernet / broadcast!

R3#**show ip route | b 4.4.**
O E2 4.4.4.0 [110/20] via 34.1.1.4, 00:00:01, Ethernet0/0

R3#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	34	0x80000003	0x00A782
0.0.0.4	0.0.0.3	35	0x80000001	0x00A585

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	43	0x80000001	0x003F51 0

R3#**show ip route | b 4.4** **Area 1 NSSA**
O N2 4.4.4.0 [110/20] via 34.1.1.4, 00:00:10, Ethernet0/0

R3#**show ip ospf database**
Type-7 AS External Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	36	0x80000001	0x000563 0

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	28	0x80000001	0x009FD3 0

What will differ in regards to 4.4.4.4/32 seen from R3 ?

connections = e0/x
ip ospf network point-to-point

R3#**show ip route | b 4.4**
O E2 4.4.4.0 [110/20] via 34.1.1.4, 00:00:07, Ethernet0/0

R3#**show ip ospf database**
Summary ASB Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.4	0.0.0.2	53	0x80000001	0x00AB80
0.0.0.4	0.0.0.3	43	0x80000001	0x00A585

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	58	0x80000001	0x003F51 0

R3#**show ip route** **AREA 1 NSSA**
O N2 4.4.4.0 [110/20] via 34.1.1.4, 00:00:09, Ethernet0/0

R3#**show ip ospf database**
Type-7 AS External Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.4	50	0x80000001	0x000563 0

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum Tag
4.4.4.0	0.0.0.3	35	0x80000001	0x009FD3 0

R3#show ip ospf database external
connections = e0/x
ip ospf network point-to-point

R3#**show ip ospf database external**
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.4
Network Mask: /24
Metric: 20
Forward Address: 0.0.0.0

R3#**show ip ospf database external** **AREA 1 NSSA**
LS Type: AS External Link
Link State ID: 4.4.4.0 (External Network Number)
Advertising Router: 0.0.0.3
Network Mask: /24
Metric: 20
Forward Address: 24.1.1.4

http://www.flashcardguy.ch

I used ethernet connections instead of serial connections!
Int e0/0
Ip ospf network broadcast

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

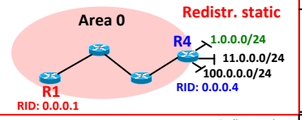
Donate

Thanks for appreciating my efforts

Colin

OSPF

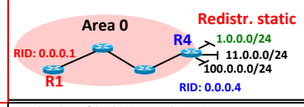
What options are available to filter out 1.0.0.0/24 on R4 ?



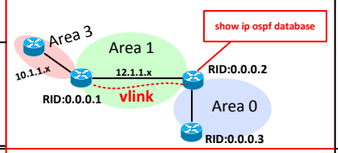
Option 1:
R4#
router ospf 1
summary-address 1.0.0.0 255.255.255.0 **not-advertise**

Option 2:
ip prefix-list PFX-1 deny 1.0.0.0/24
ip prefix-list PFX-1 permit 0.0.0.0/0 le 32

router ospf 1
distribute-list prefix PFX-1 out



What should be the expected output in regards to the **Virtual Link** in this example of the following show command?



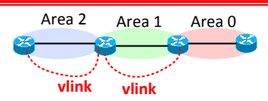
R2#show ip ospf database
OSPF Router with ID (0.0.0.2) (Process ID 1)

Router Link States (**Area 0**)

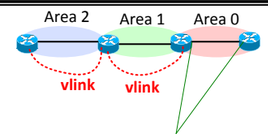
Link ID	ADV Router	Age	Seq#	Checksum	Link count
0.0.0.1	0.0.0.1	1 (DNA)	0x800002	0x00C646	1
0.0.0.2	0.0.0.2	300	0x800004	0x00088E	3
0.0.0.3	0.0.0.3	559	0x800003	0x0015A4	2

Summary Net Link States (**Area 0**)

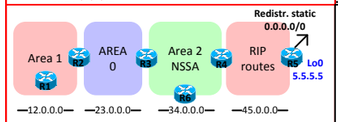
Link ID	ADV Router	Age	Seq#	Checksum
1.1.1.1	0.0.0.1	6 (DNA)	0x800001	0x005FD7
1.1.1.1	0.0.0.2	547	0x800002	0x00F430
10.1.1.1	0.0.0.1	6 (DNA)	0x800001	0x00E944
12.1.1.0	0.0.0.1	6 (DNA)	0x800001	0x006DB0
12.1.1.0	0.0.0.2	547	0x800002	0x0065B6



What does one have to remember about Virtual-links and OSPF Authentication?



If you change authentication type here, the vlinks will not "updating" this info due to their demand circuit behaviour.
Bounce an interface to force a Area 0 topology change in order to verify the VLINKs status.
If necessary add authentication or set it to Null.



What will be seen by using the following command:

R1#show ip ospf database external 5.5.5.5

R1#show ip ospf database external 5.5.5.5

OSPF Router with ID (0.0.0.1) (Process ID 1)

Type-5 AS External Link States

Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 121
Options: (No TOS-capability, DC)
LS Type: AS External Link
Link State ID: 5.5.5.5 (External Network Number)
Advertising Router: 0.0.0.3
LS Seq Number: 80000003
Checksum: 0x9AC6
Length: 36
Network Mask: /32
Metric Type: 2 (Larger than any link state path)
MTID: 0
Metric: 20
Forward Address: 34.0.0.4
External Route Tag: 0

How to verify OSPF authentication?

Type 1

Config

router ospf 1
router-id 0.0.0.2
area 0 authentication

interface Serial1/1
ip address 12.1.1.2 255.255.255.0
ip ospf authentication-key Cisco

Verification:

R2#show ip ospf interface | i Serial|authentication
Serial1/3 is up, line protocol is up
Simple password authentication enabled
Serial1/1 is up, line protocol is up
Simple password authentication enabled

interface Serial1/1
ip ospf message-digest-key 1 md5 ccie

interface Serial1/2
ip ospf message-digest-key 1 md5 ccie

How do you configure a new MD5 password/key without interrupting traffic?

How can you verify it?

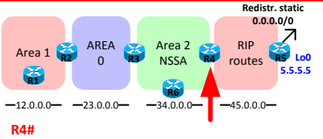
interface Serial1/1
ip ospf message-digest-key 1 md5 ccie
ip ospf message-digest-key 2 md5 NEW-PASS

interface Serial1/2
ip ospf message-digest-key 1 md5 ccie
ip ospf message-digest-key 2 md5 NEW-PASS

R2#show ip ospf interface ser 1/1
Message digest authentication enabled
Youngest key id is 2
Rollover in progress, 1 neighbor(s) using the old key(s):
key id 1

Once you see this:
R2#show ip ospf interface ser 1/1
Message digest authentication enabled
Youngest key id is 2

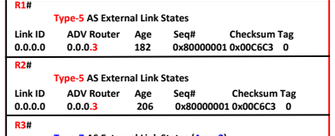
R1 and R2(config)#int ser 1/1
R1 and R2(config-if)#no ip ospf message-digest-key 1 md5 ccie



Where would you place the following command in order for R1 to see its effect?

area 2 nssa translate type7 suppress-fa

(show ip ospf database external 5.5.5.5)



R3#
router ospf 1
area 2 nssa translate type7 suppress-fa

show ip ospf database external 5.5.5.5

Without suppress-fa:
R1#
Advertising Router: 0.0.0.3
Forward Address: 34.0.0.4
Metric: 20

Using suppress-fa on R3:
R1#
Advertising Router: 0.0.0.3
Forward Address: 0.0.0.0
Metric: 20

How to verify OSPF authentication?

Type 2

Config

router ospf 1
router-id 0.0.0.2
area 0 authentication message-digest

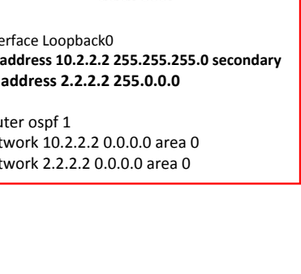
interface Serial1/3
ip address 23.1.1.2 255.255.255.0
ip ospf message-digest-key 1 md5 Cisco

Verification:

R2#show ip os interface | i Serial|authentication|key

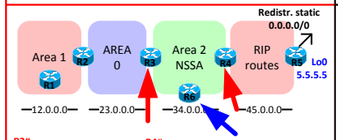
Serial1/3 is up, line protocol is up
Message digest authentication enabled
Youngest key id is 1

You are here:
And want to know all prefixes R4 is attached to.
What command would you use?



R1#show ip ospf database router adv-router 0.0.0.4
OSPF Router with ID (0.0.0.1) (Process ID 1)
Router Link States (Area 1)
LS age: 590
Options: (No TOS-capability, DC)
LS Type: Router Links
Link State ID: 0.0.0.4
Advertising Router: 0.0.0.4
LS Seq Number: 80000005
Checksum: 0xD919
Length: 120
Number of Links: 8
Link connected to: a **Stub Network**
(Link ID) Network/subnet number: 1.0.0.0
(Link Data) Network Mask: 255.255.255.0
Number of MTID metrics: 0
TOS 0 **Metrics: 1**
....

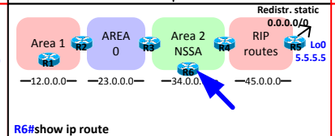
Stub Network, No other OSPF neigbor attached!



R3#
router ospf 1
area 2 nssa no-summary

R4#
router ospf 1
area 2 nssa default-information-originate

What will show up in R6 ospf database, routing table for 0.0.0.0 ?



R6#show ip route
O*IA 0.0.0.0/0 [110/11] via 34.0.0.3, 00:04:05, e0/0

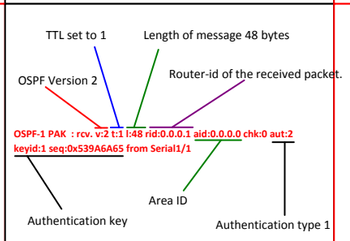
R6#show ip ospf database

Summary Net Link States (Area 2)

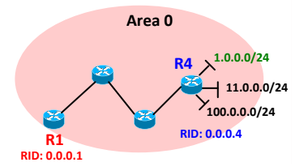
Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	0.0.0.3	280	0x80000001	0x00270C

Explain the output of the following command with Type 2 Auth:

debug ip ospf packet



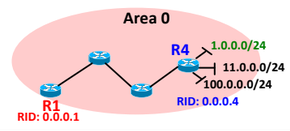
How can you filter out 1.0.0.0/24 on R1 located on R4 based on distance within the same OSPF area?

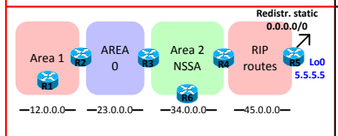


R1#
router ospf 1
distance 255 0.0.0.4 0.0.0.0 **99**

You can specify the Router-ID here of R4!!!

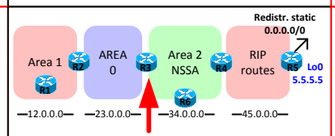
access-list 99 permit **1.0.0.0** 0.0.0.255





What is mandatory for the following command to work correctly ?

router ospf 1
area 2 nssa no-summary

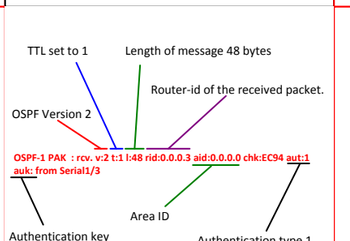


The router needs to have a minimum of one interface within Area 0 for "no-summary" to work!

router ospf 1
area 2 nssa no-summary

Explain the output of the following command with Type 1 Auth:

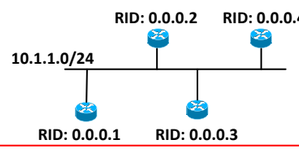
debug ip ospf packet



What will be expected output of

show ip ospf database network

On the DR of this network?



R4#show ip ospf database network

OSPF Router with ID (0.0.0.4) (Process ID 1)

Net Link States (Area 0)

Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 185
Options: (No TOS-capability, DC)
LS Type: Network Links
Link State ID: 10.1.1.4 (address of Designated Router)
Advertising Router: 0.0.0.4
LS Seq Number: 80000002
Checksum: 0x70A2
Length: 40
Network Mask: /24
Attached Router: 0.0.0.4
Attached Router: 0.0.0.1
Attached Router: 0.0.0.2
Attached Router: 0.0.0.3

All OSPF routers on that subnet

R4#
area 2 nssa default-information-originate

What will the output of the following command show on all Routers in regards to 0.0.0.0 ?

show ip ospf database

R1#
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.3	182	0x80000001	0x00C6C3	0

R2#
Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.3	206	0x80000001	0x00C6C3	0

R3#
Type-7 AS External Link States (Area 2)

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.4	222	0x80000001	0x002C53	0

Type-5 AS External Link States

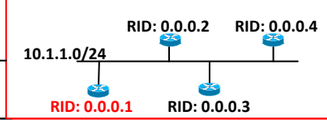
Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.3	221	0x80000001	0x00C6C3	0

R6#
Type-7 AS External Link States (Area 2)

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.4	250	0x80000001	0x002C53	0

What to expect of:

show ip ospf route



R1#show ip ospf route
OSPF Router with ID (0.0.0.1) (Process ID 1)
Base Topology (MTID 0)
Area BACKBONE(0)
Intra-area Route List
* 10.1.1.0/24, Intra, cost 1, area 0, **Connected**
via 10.1.1.1, FastEthernet0/0
* 1.0.0.0/8, Intra, cost 1, area 0, **Connected**
via 1.1.1.1, Loopback0
*> 2.0.0.0/8, Intra, cost 2, area 0
via 10.1.1.2, FastEthernet0/0
*> 3.0.0.0/8, Intra, cost 2, area 0
via 10.1.1.3, FastEthernet0/0
*> 4.0.0.0/8, Intra, cost 2, area 0
via 10.1.1.4, FastEthernet0/0

* connected, do not show a *> OSPF learned route

OSPF

Do not advertise the secondary address:

interface Loopback0
ip address 10.2.2.2 255.255.255.0 secondary
ip address 2.2.2.2 255.0.0.0

router ospf 1
network 10.2.2.2 0.0.0.0 area 0
network 2.2.2.2 0.0.0.0 area 0

interface Loopback0
ip address 10.2.2.2 255.255.255.0 secondary
ip address 2.2.2.2 255.0.0.0
ip ospf 1 area 0 secondaries none

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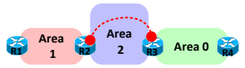
OSPF

What two solutions are available in this OSPF network to connect all Areas?



Option 1:

R2#
router ospf 1
area 2 virtual-link 0.0.0.3

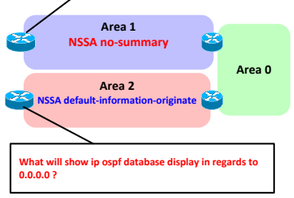
R3#
router ospf 1
area 2 virtual-link 0.0.0.2

Option 2:

R2#
interface Tunnel1
ip unnumbered Loopback0
ip ospf 1 area 0
tunnel source Serial1/x
tunnel destination 23.0.0.3

R3#
interface Tunnel1
ip unnumbered Loopback0
ip ospf 1 area 0
tunnel source Serial1/x
tunnel destination 23.0.0.2

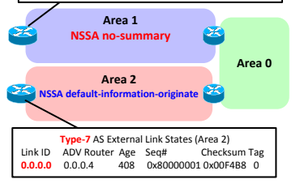
What will show ip ospf database display in regards to 0.0.0.0 ?



What will show ip ospf database display in regards to 0.0.0.0 ?

Summary Net Link States (Area 1) *(type 3)*

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	0.0.0.2	760	0x80000001	0x002D07



Type-7 AS External Link States (Area 2)

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	0.0.0.4	408	0x80000001	0x00F4B8	0

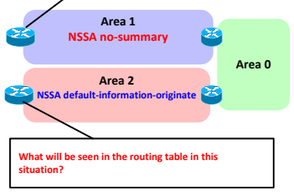
Important facts regarding

OSPF stub areas:

OSPF stub area:

- can NOT be a transit area (use GRE Tunnels)
- can NOT have an ASBR
- the backbone area can NOT be a stub
- External routes are not allowed into a stub
- A stub area can not have LSA Type 4's
- An ABR of a stub injects a default route via summary with a default cost of 1, which can be changed.
  area x default-cost <37>

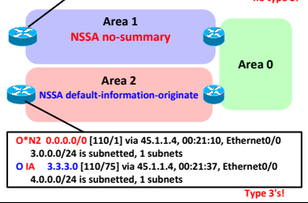
What will be seen in the routing table in this situation?



What will be seen in the routing table in this situation?

O*IA 0.0.0.0/0 [110/65] via 12.1.1.2, 00:26:43, Serial1/2
O 222.22.2.0/24 [110/65] via 12.1.1.2, 00:04:49, Ser1/2

no type 3!



O*N2 0.0.0.0/0 [110/1] via 45.1.1.4, 00:21:10, Ethernet0/0
3.0.0.0/24 is subnetted, 1 subnets
O IA 3.3.3.0 [110/75] via 45.1.1.4, 00:21:37, Ethernet0/0
4.0.0.0/24 is subnetted, 1 subnets

Type 3's!

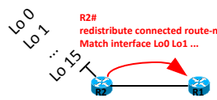
Important facts regarding

OSPF totally stub areas:

OSPF totally stub area

- can NOT be used as transit area (use GRE tunnels)
- can NOT have an ASBR
- backbone area can not be a totally stub area.
- external routes not allowed in totally stub area.
- default route (summary 3) injected, cost of default route can be changed.
  area x default-cost <z>
- do not get IA routes of other aereas.

Configure R1 to limit the number of non-self generated LSA's in its database to 10. R1 should generate a warning message if 50 % of this threshold is reached.



R2#
redistribute connected route-map RMP-OSPF-CON
Match interface Lo0 Lo1 ...

Verify current amounts of LSA in the entire domain:

show ip os database database-summary | I Non-self

Process 1 database summary

LSA Type	Count	Delete	Maxage
Router	3	0	0
...			
Non-self	3		
Total	4	0	0

router ospf 1
max-lsa 10 50 warning-only

Max 10 Non-self LSA's
Warning thresh. 50%

%OSPF-4-OSPF_MAX_LSA_THR: Threshold for maximum number of non self-generated LSA has been reached "ospf 1" - 8 LSAs
%OSPF-4-OSPF_MAX_LSA: Maximum number of non self-generated LSA has been exceeded "ospf 1" - 11 LSAs

show ip os database database-summary | I Non
Non-self 6

What alternative is there for the following config snip:

router ospf 1
no discard-route external

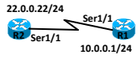
router ospf 1
no discard-route external

Alternative:

router ospf 1
discard-route external 255

Sets the admin distance of the external discard route to 255!

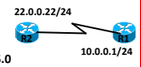
How can you bypass OSPF's sanity check in this situation -> to form an adjacency



show ip ospf neigbor
LIST IS EMPTY

R1#
int Lo1
ip address 10.0.0.1 255.255.255.0
int ser1/1
ip unnumbered Lo1
router ospf 1
network 10.0.0.1 0.0.0.0 area 0

R2#
int Lo1
ip address 22.0.0.22 255.255.255.0
int ser1/1
ip unnumbered Lo1
router ospf 1
network 22.0.0.22 0.0.0.0 area 0



%OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial1/1 from LOADING to FULL, Loading Done

Configure R1 such that it retransmits an LSA if no ACK is heard after 10 seconds:

R1 expects ACK for LSA Lo X within 5 seconds from R2

Verify current settings:

R1#show ip ospf interface fa0/0 | i Retransmit
Timer intervals configured, Hello 250 msec, Dead 1, Wait 1, Retransmit 5

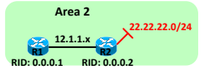
Configure:
conf t
int fa0/0
ip ospf retransmit-interval 10

Verify configuration

R1#show ip ospf interface fa0/0 | i Retransmit
Timer intervals configured, Hello 250 msec, Dead 1, Wait 1, Retransmit 10

OSPF filtering route-source

Configure R1 to filter out 22.22.22.0/24



R1#
distribute-list route-map RMP-NO-22-NET in

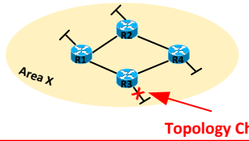
route-map RMP-NO-22-NET deny 10
match ip route-source 11

Route-map RMP-NO-22-NET permit 20

access-list 11 permit 0.0.0.2

OSPF router-id of R2

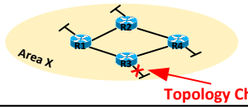
Configure R1 such that in case there is a topology change in the domain R1 only re-calculates the affected LSA type 1 and 2's in its database.



Topology Change

Have R1 only calculate the affected LSA 1 / LSA 2 recalculated.
Speeding up convergance and lowering the amount of needed CPU cycles!

R1#
conf t
router ospf 1
ispf



Topology Change

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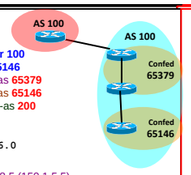
BGP

show ip bgp x.x.x.x y.y.y.y explained:

```
R1#
R1#show ip bgp 112.0.0.0 255.0.0.0
BGP routing table entry for 112.0.0.0/8, version 22
Paths: (2 available, best #2, table Default-IP-Routing-Table)
  Not advertised to any peer
  54 50 60
    54.1.1.254 (metric 2172416) from 155.1.146.6 (150.1.6.6)
      Origin IGP, metric 0, localpref 100, valid, internal
  54 50 60
    204.12.1.254 (metric 30720) from 155.1.0.4 (150.1.4.4)
      Origin IGP, metric 0, localpref 100, valid, internal, best
```

204.12.1.254 eBGP next-hop
155.1.0.4 Peering-IP
(150.1.4.4) router-id

iBGP Confederation




```
router bgp 65379
bgp confederation identifier 100
bgp confederation peers 65146
neighbor 155.1.37.3 remote-as 65379
neighbor 155.1.37.7 remote-as 65146
neighbor 155.1.44.44 remote-as 200

R1#show ip bgp 150.1.6.0
Local
  155.1.108.10 from 155.1.58.5 (150.1.5.5)
    Origin IGP, metric 0, localpref 100, valid, confed-internal
(65379 65146)
  155.1.146.4 (metric 2172416) from 155.1.0.3 (150.1.3.3)
    Origin IGP, metric 0, localpref 100, valid, confed-external
200
  192.10.1.254 from 192.10.1.254 (222.22.2.1)
    Origin incomplete, metric 0, localpref 100, valid, external
```

iBGP Synchronization

Disable RIBfailure marked routes from being automatically propagated:

By default BGP routes that have RIB-failure *are* advertised to neighbors.

This can be disabled by using:

```
bgp suppress-inactive
```

BGP Update Source Modification

```
router bgp 100
neighbor 150.1.4.4 update-source Loopbck0
```

iBGP Confederation default path decision:

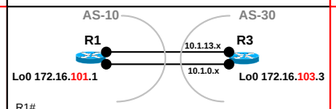
```
show ip bgp 150.1.7.0
...
(65379)
...
155.1.37.7 .. from 155.1.0.1 (150.1.3.3)
Origin ..., valid, confed-external

(65146 65379)
...
155.1.37.7 .. from 155.1.0.1 (150.1.1.1)
Origin ..., valid, confed-external, best
```

Lower Router-ID wins over confed-as path length by default!

BGP neighbor 172.16.103.3 disable-connected-check

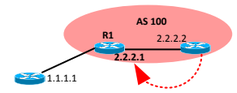
Command:




```
R1#
ip route 172.16.103.0 255.255.255.0 10.1.0.3
ip route 172.16.103.0 255.255.255.0 10.1.13.3
!
router bgp 10
 no synchronization
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor 172.16.103.3 remote-as 30
 neighbor 172.16.103.3 disable-connected-check
 neighbor 172.16.103.3 update-source Loopback0
 no auto-summary
```

BGP Next-Hop Processing – Next-Hop-Self:

```
R1#
router bgp 100
neighbor 2.2.2.2 next-hop-self
```

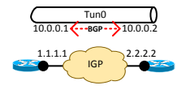


If next-hop is not set and 1.1.1.1 is not know the following could happen:

```
R2#show ip bgp 100.100.100.0
...
54 50 60, (Received from a RR-client)
1.1.1.1 (inaccessible) from 155.1.146.4 (150.1.4.4)
...
```

BGP over GRE

Run BGP Session across non-BGP capable router cloud




```
interface Tunnel0
 ip address 10.0.0.1 255.255.255.0
 tunnel source 1.1.1.1
 tunnel destination 2.2.2.2

router bgp 200
neighbor 10.0.0.2 remote-as 100
```

```
interface Tunnel0
 ip address 10.0.0.2 255.255.255.0
 tunnel source 2.2.2.2
 tunnel destination 1.1.1.1

router bgp 200
neighbor 10.0.0.1 remote-as 100
```

Transporting / Hiding a BGP next-hop via using a GRE tunnel. IGP does not need to know BGP next-hops.

Authenticating BGP Peerings

```
Router bgp 200
neighbor 192.10.1.254 password CISCO
```

Verify the established, autenticated BGP session:

```
show ip bgp neighbors 192.10.1.254 | include state|Flags
BGP state = Established, up for 00:01:19
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Flags: active open, nagle, md5
```

BGP Next-Hop Processing - Manual Modification

Set NHS for your coming from R6

```
router bgp 100
neighbor 1.1.1.1 route-map SET_NHS_FROM_R6 in

route-map SET_NHS_FROM_R6 permit 10
set ip next-hop 2.2.2.1
```

```
router bgp 100
neighbor 1.1.1.1 route-map SET_NHS_TO_R6 OUT

route-map SET_NHS_TO_R6 permit 10
set ip next-hop 2.2.2.1
```

Set NHS for routes being sent to R6

BGP Redistribute Internal

```
Router [ospf,eigrp,rip]
redistribute bgp
```

only eBGP prefixes will be redistributed by default to the other routing protocols!

```
bgp redistribute Internal
```

Will **enable iBGP prefix to be redistributed** into other routing protocols. -> Dangerous, as iBGP has no internal Loop prevention mechanism.

iBGP Route Reflection


```
R1#
Router bgp 200
neighbor 155.1.0.3 route-reflector-client
neighbor 155.1.0.4 route-reflector-client
```

```
R1#show ip bgp 150.1.2.0 255.255.255.0
...
Local, (Received from a RR-client)
...
```

RR's view

```
R2#show ip bgp 150.1.10.0 255.255.255.0
...
Originator: 204.12.1.10, Cluster list: 150.1.1.1
...
```

clients view

iBGP Synchronization

Route is not in IGP:

```
router bgp 100
Synchronization

R1#show ip bgp 112.0.0.0
...
Origin IGP, ...,.., valid, internal, not synchronized
...
```

Route not in IGP

Route needs to be visible in IGP before BGP is allowed to propagate the prefix.

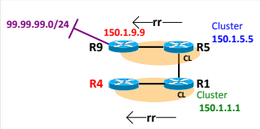
BGP Peer Groups

```
router bgp 100
neighbor IBGP_PEERS peer-group
neighbor IBGP_PEERS <commands>

neighbor 150.1.5.5 peer-group IBGP_PEERS

show ip bgp peer-group
...
BGP neighbor is IBGP_PEERS, peer-group internal,
members:
150.1.3.3 150.1.4.4 150.1.5.5 150.1.6.6
Index 0, Offset 0, Mask 0x0
Route-Reflector Client
Update messages formatted 0, replicated 0
Number of NLRIs in the update sent: max 0, min 0
```

Route Reflection with Clusters




```
R4#show ip bgp 99.99.99.0
BGP routing table entry for 99.99.99.0/24, version 16
Paths: (2 available, best #2, table Default-IP-Routing-Table)
  Not advertised to any peer
  Local
    155.1.79.9 (metric 2175488) from 155.1.58.5 (150.1.5.5)
      Origin IGP, metric 0, localpref 100, valid, internal
      Originator: 150.1.9.9, Cluster list: 150.1.1.1, 150.1.5.5
```

iBGP Synchronization

Route is in IGP:

```
router bgp 100
Synchronization

Rack1R1#show ip bgp 222.22.2.0
...
Paths: (1 available, best #1, table Default-IP-Routing-Table, RIBfailure(17))
...
Origin incomplete, metric 0, localpref 100, valid, internal, synchronized, best
```

Route is in IGP and reachable!

RIB-failure output is an informational message to let us know that although the BGP route is valid, it is not being installed in the routing table
-> route via an IGP route with a lower administrative distance

BGP Network Statement

```
Interface loop0
Ip address 99.9.9.9 255.255.255.0

ip route 150.0.0.0 255.252.0.0 Null0

router bgp 100

network 150.0.0.0 mask 255.252.0.0
network 99.9.9.0 mask 255.255.255.0
```

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http://www.flashcardguy.ch

BGP

BGP Auto-Summary

Create a summary, but do not use aggregate-address:

Router bgp 100
auto-summary

How to make BGP ignore the AS-Path length:

Router bgp x
bgp bestpath as-path ignore

BGP
DMZ Link Bandwidth

unequal cost load-balancing

Described:

Router bgp 200
maximum-paths ibgp
bgp dmzlink-bw (enable feature)
neighbor <IP> dmzlink-bw
neighbor <IP> send-community extended

load-balance based on the bandwidth of the links used to connect to the external BGP peers

bandwidth value is copied into a new extended community attribute

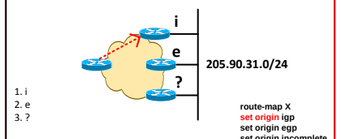
Internal routers need maximum-path activated and need to exchange ext-communities

Describe BGP path selection:

1) Ignore invalid paths (no valid next hop, not synchronized, looped).
2) Prefer path with the highest locally assigned weight value.
3) Prefer path with the highest Local Preference attribute value.
4) Prefer locally originated prefixes (i.e. originated via the network, aggregateaddress or redistribution commands).
5) Prefer path with the shortest AS_PATH attribute length
6) Prefer path with the lowest numerical value of the Origin code (IGP < EGP < Incomplete)
7) Prefer path with the lowest MED attribute value (provided that the first AS in the list is the same).
8) Prefer external BGP paths over Internal
9) Prefer path with the smallest IGP metric to reach the NEXT_HOP IP address
10) Prefer path originated from the router with the lowest BGP Router ID

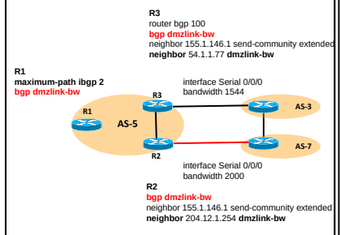
BGP - Origin

BGP origin type can be used for path selection:




```
BGP table version is 18, local router ID is 150.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i internal
r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
Network          Next Hop            Metric  LocPrf  Weight  Path
*>i205.90.31.0   155.1.45.5               0     100       0  200 254 i
*                155.1.38.7 0                              200 254 e
*                155.1.13.3 0                              200 254 ?
i
```

BGP
DMZ Link Bandwidth



BGP Bestpath Selection - Weight

neighbor <IP_Address> weight XX

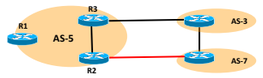
```
route-map SET_WEIGHT
math ip address ACCCESS_LIST
set weight 100

router bgp 100
neighbor 204.12.1.254 route-map
SET_WEIGHT in
```

BGP
MED

```
route-map TO_R3 permit 10
match as-path 1
set metric 1000
```

BGP -
DMZ Link Bandwidth

Show commands:



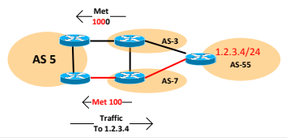
show ip bgp 112.0.0.0
...
54.1.1.254 (metric 256816) from 155.1.146.6 (150.1.6.6)
...
DMZ-Link Bw 250 kbytes
...
204.12.1.254 (metric 256016) from 155.1.146.4 (150.1.4.4)
...
DMZ-Link Bw 12500 kbytes

R1#show ip route 112.0.0.0
Routing entry for 112.0.0.0/8
Known via "bgp 100", distance 200, metric 0
...
204.12.1.254, from 155.1.146.4, 00:07:21 ago
Route metric is 0, **traffic share count is 48**
...
* 54.1.1.254, from 155.1.146.6, 00:07:21 ago
Route metric is 0, **traffic share count is 1**
...

BGP
Always Compare MED

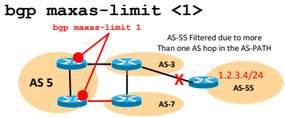
AS_PATH lengths must be the same.

Router bgp
bgp always-compare-med



BGP
Maximum AS Limit

Router bgp 100
bgp maxas-limit <1>



Sets the maximum number of AS elements allowed in the AS_PATH attribute

```
%BGP-6-ASPATH: Long AS path 200 254 received
from 155.1.146.1: More than configured MAXAS-
LIMIT
```

BGP
Local Preference

route-map SW1 permit 10
match as-path 1
set local-preference 200

router bgp 100
neighbor 1.1.1.1 route-map SW1 in

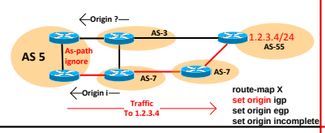
default local-preference <value>

BGP
AS-Path Ignore

bgp bestpath as-path ignore

Used in confederation scenarios, by ignoring as path confed routers start using the IGP costs.

By avoiding AS-Path Origin type could be used to prefer the path.



BGP
Backdoor

network <subnet> mask <netmask> backdoor

change the AD of a particaular eBGP prefix from 20 to 200.

Alternatively:

access-list **99** permit 100.200.0.0

router bgp 200
distance 55 <neighbor IP> 0.0.0.0 **99**

Set Admin distance for prefix 100.200.0.0 received from neighbor X to AD 55

BGP
AS-Path Prepending

route-map PREPEND
match ...
set as-path prepend 100 100

router bgp 100
neighbor 54.1.1.254 route-map PREPEND out

BGP
Router-IDs

all other attributes are equal (weight, LP, AP_PATH, Origin, MED, iBGP prefixes) including the IGP cost to reach the next-hops:

peer with the lowest router ID is preferred.

prefixes learned from different eBGP peers, prefer the older one, to minimize route flapping

changing a router's BGP router ID will hard reset all active BGP sessions.

Router bgp 20
Router-id X.X.X.X

BGP
Aggregation

R1
Router bgp 100
aggregate-address 10.0.0.0 255.255.252.0

R2#show ip bgp 10.0.0.0/22
...
Local, (**aggregated by 200 150.1.2.2**)
...
Origin IGP, localpref 100, weight 32768, valid, aggregated, local, **atomic-aggregate**, best

Usefull "sh ip bgp regexp"

Commands:

```
sh ip bgp regexp _54$
sh ip bgp regexp ^54$
```

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http://www.flashcardguy.ch

BGP

BGP Aggregate Summary Only

R1
Router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 summary-only

R2#show ip bgp 10.0.0.0/22
...
Local, (aggregated by 200 150.1.2.2)
...
Origin IGP, localpref 100, weight 32768, valid, aggregated, local, atomic-aggregate, best

BGP Communities

Command and prerequisites:

Neighbor <IP> send-community

ip bgp-community new-format

Communities can be set be out/ inbound route-maps or by the attribute map for locally generated summaries.

BGP Conditional Advertisement

Prefixes advertised to the peer

neighbor <IP> advertise-map MAP-1 non-exist MAP-2

neighbor <IP> advertise-map MAP-1 exist-map MAP-2

Prefixes which will be tracked in local BGP table.

If used with non-exist : MAP-1's prefix is advertised if MAP-2s prefix is NOT in BGP table.

Relies on BGP Scanner 60 sec!

If used with exist-map : MAP-1's prefix is advertised if MAP-2s prefix is in BGP table.

BGP Suppress Map

(suppress other more specific of summary, except of X.X.X.X)

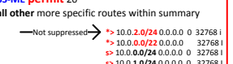
Similar to aggregation summary only, difference is, one can announce additional detailed routes, stated in the denied suppress map.

router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 **suppress-map SUPPRESS-ME**

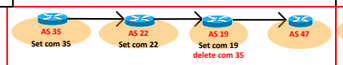
ip **prefix-list PFX-DONT-SUPPRESS-ME** seq 5 permit 10.0.2.0/24

route-map **SUPPRESS-ME deny** 10
match ip address prefix-list **PFX-DONT-SUPPRESS-ME**

route-map **SUPPRESS-ME permit** 20
remark : **suppress all other** more specific routes within summary



BGP Communities



Additive / delete comm-list example:

AS-35#
Route-map RMP-OUT
set community 35
Neighbor x.x route-map RMP-OUT out

AS-19#
ip community-list standard **DELETE** permit 35

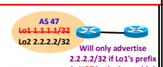
route-map RMP-OUT permit 10
set comm-list DELETE delete
set community 19 additive

AS-47#sh ip bgp 10.0.0.0

BGP routing table entry for 10.0.0.0/24, version 2
...
35 22 19
...
Community: 22 19

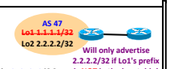
Community 35 is missing!

BGP Conditional Advertisement



Config using non-exist:

int lo1 (1.1.1.1/32)
int lo2 (2.2.2.2/32)



ip prefix-list **PFX-Lo1** seq 5 permit 1.1.1.1/32
ip prefix-list **PFX-Lo2** seq 5 permit 2.2.2.2/32

route-map **IF-NON-EXIST** permit 10
match ip address prefix-list PFX-Lo1
!
route-map **ADVERTISE** permit 10
match ip address prefix-list PFX-Lo2

router bgp 47
network 1.1.1.1 mask 255.255.255.255
network 2.2.2.2 mask 255.255.255.255

neighbor 155.1.146.6 **advertise-map ADVERTISE non-exist-map IF-NON-EXIST**

BGP Unsuppress Map

router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 summary-only
neighbor 155.1.146.6 **unsuppress-map DONT-SUPPRESS-ME**

ip prefix-list **PFX-DONT-SUPPRESS-ME** seq 5 permit **10.0.1.0/24**

route-map **DONT-SUPPRESS-ME** permit 10
match ip address prefix-list **PFX-DONT-SUPPRESS-ME**

remark : infinite deny any any of RMP blocks all
other more specific routes

BGP communities

Deleting more than one Community the easy way:

AS-35#
Route-map RMP-OUT
set community 35
Neighbor x.x route-map RMP-OUT out

AS-19#
ip community-list standard **DELETE** permit 35
ip community-list standard **DELETE** permit 22

route-map RMP-OUT permit 10
set comm-list DELETE delete
set community 19 additive

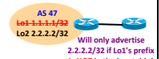
AS-47#sh ip bgp 10.0.0.0

BGP routing table entry for 10.0.0.0/24, version 2
...
35 22 19
...
Community: 19

Community 35 and 22 is missing!

BGP conditional advertisement

Checking status on a Advertise-map / exist / non-exist-map



Lo1 down:

R1#**show ip bgp neighbors** 155.1.146.6 **| i status**
Condition-map NON-EXIST, Advertise-map ADVERTISE, status: Advertise

Lo1 up:

R1#**show ip bgp neighbors** 155.1.146.6 **| i status**
Condition-map NON-EXIST, Advertise-map ADVERTISE, status: Withdraw

BGP Aggregation AS-Set

router bgp 100
aggregate-address 10.0.0.0 255.255.252.0
summary-only **as-set**

R1#show ip bgp

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 10.0.0.0/22	0.0.0.0	100		32768	{35,22,57,19}

Informational communities:

Action communities:

where the route was learned from?
continent, country, region...)
ISO 3166 country codes 3 digits

Informational communities:

How the route was learned?
transit, peer, customer, internal...)

1722:346
Continent
Country
region

Action communities

Do or do not export prefix to X
BGP attribute modification

BGP Conditional Route Injection

bgp inject-map:

router bgp 400
bgp inject-map INJECT-MAP **exist-map** EXIST-MAP

route-map **INJECT-MAP** permit 10
set ip address prefix-list **PFX-INJECT-THIS-PFX**

ip prefix-list **PFX-INJECT-THIS-PFX** seq 5 permit **10.0.3.0**/24
ip prefix-list **PFX-INJECT-THIS-PFX** seq 15 permit **10.0.1.55**/32

ip prefix-list **CHECK-FOR-EXISTING-BGP-PFX** seq 5 permit **10.0.0.0/22**

ip prefix-list **SOURCE-NEXT-HOP** seq 5 permit **155.1.146.1**/32

route-map **EXIST-MAP** permit 10
match ip address prefix-list **CHECK-FOR-EXISTING-BGP-PFX**
match ip route-source prefix-list SOURCE-NEXT-HOP ! mandatory

BGP Attribute-Map

sets BGP **attributes** for the **newly generated prefix**

Router bgp 100
aggregate-address 10.0.0.0 255.255.252.0
summary-only **attribute-map ATTRIBUTES**

Hint: change origin type of a prefix to artificially extend the AS path. **Set it to EGP <as-nr>**

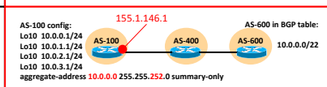
Route-map XXX
set origin **egp 22**

	Network	Next Hop	Metric	LocPrf	Weight	Path
*	10.0.0.0/22	155.1.146.4	0		0	300 e
*>		155.1.146.1	0		0	100 i
*>	10.0.0.0/22	155.1.146.4	0		0	300 e
*		155.1.146.1	0		0	100 22 e

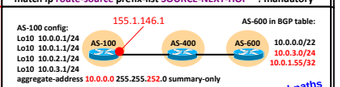
Well-known BGP communities:

R1(config-route-map)#**set community** ?

<1-4294967295> community number
aa:nn community number in aa:nn format
additive Add to the existing community
internet Internet (well-known community, all routers globaly)
local-AS Do not send outside local / **confederation** AS
no-advertise Do not advertise to any peer (well-known community)
no-export Do not export to next AS (well-known community)



BGP inject-map, what routes can be additionally announced?



Only more specific routes within the matched summary can be advertised, networks out of that range will not be propagated.

10.0.0.0/22 = summary

Routes within that block can be additionally advertised:

10.0.2.22/32

BGP Advertise Map

Removing AS/attributes from AS-SET:

ip prefix-list AS19_PREFIX permit **10.0.2.0/24**

route-map ADVERTISE_MAP deny 10
match ip address prefix-list **AS19_PREFIX**

route-map ADVERTISE_MAP **permit 100**
remark **allow all other AS-SET entries** attributes in summary

router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 **summary-only** **as-set**
advertise-map ADVERTISE_MAP

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 10.0.0.0/22	0.0.0.0	100		32768	{35,22,57} i

BGP Deleting Communities

Delete either community **22** or anything starting with **200:**

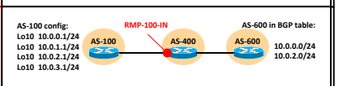
ip community-list **standard DELETE** permit **22**

ip community-list **expanded EXP-DELETE** permit **200:[0-9]+_**

Route-map DELETE-COM permit 10
Set comm-list **DELETE** delete

Route-map DELETE-COM permit 20
Set comm-list **EXP-DELETE** delete

BGP Filtering with Prefix-Lists



ip prefix-list DENY-SOME-NETS seq 5 **permit** 10.0.1.0/24
ip prefix-list DENY-SOME-NETS seq 10 **permit** 10.0.3.0/24

route-map RMP-100-IN **deny** 10
match ip address prefix DENY-SOME-NETS

route-map RMP-100-IN **permit** 20

router bgp 400
neighbor 155.1.146.1 route-map **RMP-100-IN in**

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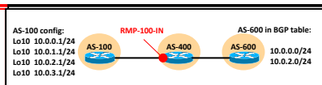
BGP

BGP Filtering Standard Access-Lists



access-list 100 permit ip **host 10.0.1.0** host 255.255.255.0
access-list 100 permit ip host 10.0.3.0 **host 255.255.255.0**

route-map RMP-100-IN **deny** 10
match ip address 100

route-map RMP-100-IN **permit** 20

router bgp 400
neighbor 155.1.146.1 route-map **RMP-100-IN in**

BGP Filtering Extended Access-Lists

BGP filtering: ACL extended: variable part:

permit ip 192.168.0.0 0.0.0.255 255.255.255.0 0.0.0.255

AND

matching the subnet Range
192.168.0.0 to
192.168.0.255

prefix length of / 24 or greater

10.0.0.X with /28 mask
permit ip 10.0.0.0 0.0.0.255 255.255.255.240 0.0.0.0

10.0.X.0 with /24 mask
`permit ip 10.0.0.0 0.0.255.0 255.255.255.0 0.0.0.0`

BGP Regular Expressions

^$	**localy originated prefix**
_254$	**pfx originated in AS 254**
^254_	**pfx received from adjacent neighbor**
_254_	**pfx was transiting AS 254**
^([0-9]+)_254	**pfx from AS-254 one AS hop away**
^254_([0-9]+)	**pfx of an AS connected to AS 254**
^(254_)+([0-9]+)	**same as above but allows 254 to prepend**
^254_([0-9]+_)+	**An AS connected to 254 can prepend**
^\(65100\)	**pfx from confederation peer 65100**

show ip bgp quote-regexp _101$|_100$
`ip as-path access-list 1 permit _54$`

BGP Filtering with Maximum Prefix

neighbor <IP> maximum-prefix <Number> [<Threshold%>] [warning-only]|[restart <minutes>]

router bgp 100
neighbor 54.1.1.254 **maximum-prefix** 20 80 **restart 3**

router bgp 300
neighbor 155.1.37.3 **maximum-prefix** 20 **warning-only**

SW1#show ip bgp neighbors 155.1.37.3 | include Maximum|Thresh
Maximum prefixes allowed 20 (warning-only)
Threshold for warning message 75%

BGP Default Routing

Router bgp 100
network 0.0.0.0 mask 0.0.0.0

---

default route is advertised if the route-map match conditions are satisfied

ip prefix-list **PFX-CHECK** permit 10.10.10.0/24

route-map **RMP-DEFAULT** permit 10
match ip address prefix-list **PFX-CHECK**

neighbor <IP> **default-originate route-map RMP-DEFAULT**

BGP Local AS

Router bgp 600
Neigbor 4.4.4.4 remote-as 400
neighbor 4.4.4.4 local-as 601 no-prepend

Router bgp 400
Neigbor 6.6.6.6 remote-as 601

R4#sh ip bgp
Network Next Hop Metric LocPrf Weight Path
*> 1.1.1.1/32 155.1.146.6 0 0 **601 600** i

AS 600 still visible!

BGP Local AS

No prepend replace-as

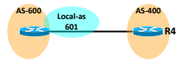
Router bgp 400
Neigbor 6.6.6.6 remote-as 601

Router bgp 600
Neigbor 4.4.4.4 remote-as 400
neighbor 4.4.4.4 local-as 601 no-prepend replace-as

R4#sh ip bgp
Network Next Hop Metric LocPrf Weight Path
*> 1.1.1.1/32 155.1.146.6 0 0 **601** i

AS 600 no longer visible!

BGP Local AS Replace-AS/Dual-AS

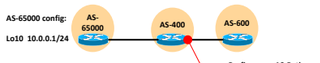


Router bgp 400
Neigbor 6.6.6.6 remote-as 600
or
Neigbor 6.6.6.6 remote-as 601

Router bgp 600
Neigbor 4.4.4.4 remote-as 400
neighbor 4.4.4.4 local-as 601 no-prepend replace-as dual-as

R4 could peer either with remote-as 600, the bgp process number or with the "created" local-as 601.

BGP Remove Private AS



Router bgp 400
Neighbor 6.6.6.6 remote-as 600
neighbor 6.6.6.6 **remove-private-as**

R4#sh ip bgp
Network Next Hop Metric LocPrf Weight Path
*> 10.0.0.0/24 155.1.146.6 0 0 **400** i

BGP Dampening

Have a route being dampened if it flaps 2 for 5 minutes:

router bgp 200
bgp dampening 4 750 2000 16

Bgp dampening HL RL SL MS

bgp dampening
Half_Life ReuseLimit SuppressLimit
MaximumSuppressTime

show ip bg dampening flap-statistics
show ip bg dampening dampened-path

BGP Dampening

Show outputs:

sh ip bgp 1.1.1.1/32
...
400 (**suppressed due to dampening**) (**history entry**)
...
Dampinfo: penalty 3556, flapped 4 times in 00:04:41, reuse in 00:00:53

Flapped 1x, but not yet dampened

Network Next Hop Metric LocPrf Weight Path
h 1.1.1.1/32 155.1.146.1 0 400 i
d 1.1.1.1/32 155.1.146.1 0 400 i

Flapped several times, is dampened

BGP Dampening calculation:

Routes flaps twice in a row, they should only advertise after 10 minutes of stability:

Maximum penalty = reuse-limit *2 ^ (maximum suppress time/half-life tim

2000 = 750 * 2 ^ (10 minutes / half-life time)
2000/750 = 2 ^ (10 / half-life)
8/3 = 2 ^ (10 / half-life)
using basic exponential equation, take log of both side

log (8/3) = log [2 ^ (10 / half-life)]
0.4259 = 10 log 2 / half-life
0.4295 = 3.0102 / half-life
half-life = 7.067 (approximately 7)

BGP Fast Fallover

router bgp 200
bgp dampening route-map DAMPENING

route-map DAMPENING permit 10
match as-path 100
set dampening 4 750 2000 16

route-map DAMPENING **permit 90**
catch-all others!

show ip bgp dampening parameters

debug ip bgp dampening

BGP Timers Tuning

Router bgp 100
timers bgp <keepalive> <holdtime>
timers bgp 60 180

bgp scan-interval <5-60> — time it takes for the IGP update to be redistributed into BGP
bgp scan-time import <5-60> — For VPNv4 pfxs
debug ip bgp keepalive

batches all new prefixes and delays the sending of an update packet to the peer until the next advertisementinterval timer expires:
set to 0 advertises immediately

`neighbor <IP> advertisement-interval <seconds>`

BGP Fast Fallover

if line protocol to eBGP speaker goes down, dont wait for holddown timer, tear session down. Enabled by default.

bgp fast-external-fallover

Informs BGP about line-proto down

same feature but for shared ip segments enabled by neighbor:

neighbor <IP> fall-over

BGP Outbound Route Filtering (ORF)

neighbor <IP> capability orf prefix-list {send | receive | both}

R1#
ip prefix-list ORF seq 3 **deny 6.6.6.6/32**
ip prefix-list ORF seq 10 permit 0.0.0.0/0 le 32

router bgp 400
neighbor 155.1.146.6 **capability orf prefix-list both**
neighbor 155.1.146.6 prefix-list **ORF in**

R2#
sh ip bgp neighbors 155.1.146.4 **advertised-routes**
*> **1.1.1.1/32** 0.0.0.0 0 32768 i

BGP Outbound Route Filtering (ORF)

Show commands:

debug ip bgp rib-filter

R1(config)#no ip route 99.99.99.99 255.255.255.255 Null0

*Jul 16 16:46:19.538: BGP- ATF: EVENT 99.99.99.99/32 RIB update DOWN
*Jul 16 16:46:19.538: BGP- ATF: EVENT 99.0.0.0/8 RIB update DOWN

R1(config)#no ip route 99.99.99.99 255.255.255.255 Null0

*Jul 16 16:46:30.470: BGP- ATF: EVENT 99.99.99.99/32 RIB update UP

R6#show ip bgp neighbors 155.1.146.4 received prefix-filter
Address family: IPv4 Unicast
ip prefix-list 155.1.146.4: 3 entries
seq 3 deny 6.6.6.6/32
seq 10 permit 0.0.0.0/0 le 32

Config ---------- Force neighbor to update filter: **clear ip bgp * x.x.x.x out**

R1#
ip prefix-list ORF seq 3 **deny 6.6.6.6/32**
ip prefix-list ORF seq 10 permit 0.0.0.0/0 le 32

router bgp 400
neighbor 155.1.146.6 **capability orf prefix-list both**
neighbor 155.1.146.6 prefix-list **ORF in**

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BGP

BGP Soft Reconfiguration

Router bgp 100
neighbor <IP> soft-reconfiguration inbound

sh ip bgp neighbors 155.1.146.6 received-routes
*** 6.6.6.6/32 155.1.146.6 0 0 600 i**
***> 1.1.1.1/32 155.1.146.6 0 0 600 i**

sh ip bgp neighbors 155.1.146.6 routes
***> 1.1.1.1/32 155.1.146.6 0 0 600 i**

BGP multipath

BGP Multipath	BGP address family command
eBGP	
iBGP	
eiBGP	

BGP multipath

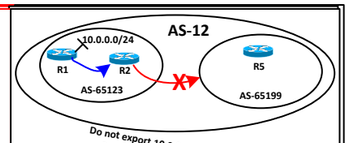
BGP Multipath	BGP address family command
eBGP	**maximum-path n**
iBGP	**maximum-path ibgp n**
eiBGP	**maximum-path eibgp n**

Weight, LP, AS-Path, Origin, MED need to be the same.
Default multipath = 1

BGP community

Local-as

explained



R1:
router bgp 65123
bgp confederation identifier 12
neighbor x.x.x.x send-community
network 10.0.0.0 mask 255.255.255.0 route-map SET-COM

route-map SET-COM permit 10
set community local-as

BGP Next-Hop Trigger

bgp nexthop trigger delay <seconds>

As soon as any change that affects an existing NEXT_HOP occurs, the watch process notifies the BGP router Process

`bgp nexthop trigger delay <seconds>`
Schedules the next BGP table scan after a change happened to a next-hop after <seconds> of it being detected.

BGP SOO

Configuration:

neighbor 1.1.1.1 soo 10:12

neighbor 1.1.1.1 route-map RMP-X in

route-map RMP-X permit 10
set extcommunity 10:12

BGP 4-Byte Autonomous System Numbers

```
Router# show ip bgp summary
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/
Down  Statd
192.168.1.2     4 65536       7       7        1    0    0 00:03:04     0
192.168.3.2     4 65550       4       4        1    0    0 00:00:15     0
```

router bgp X
bgp asnotation dot

asplain:
65536 to 4294967295

```
Router# show ip bgp summary
BGP table version is 1, main routing table version 1
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/
Down  Statd
192.168.1.2     4   1.0       9       9        1    0    0 00:04:13     0
192.168.3.2     4  1.14       6       6        1    0    0 00:01:24     0
```

show ip bgp regexp ^1\.0$ (ASN 1.0 / 65536)

BGP TTL Security

neighbor <IP> ttl-security hops <hop-count>

BGP packets will be tolerated with a TTL no lower than (255 – 2 hops) = 253

R1/R3#
neighbor <IP> ttl-security hops 2

R5#show ip bgp neighbors 1.1.1.1| inc TTL
Mininum incoming TTL 253, Outgoing TTL 255

BGP scan interval

VPN performance tuning

`bgp scan-interval`
general scanning interval

advertisement-interval
periodic "batching" of events:
BGP waits for the timer to expire and accumulates the updates

scan-time import 15
process to import the MP-BGP VPNv4 prefixes into the local VRF table

router bgp 100
address-family vpnv4 unicast
scan-time import 15
neighbor 150.1.5.5 **advertisement-interval 0**
bgp scan import 5

BGP

BFD for IPv4 and IPv6

interface X
bfd interval <msec> **min_rx** <msec> **multiplier** <interval-multiplier>

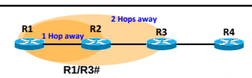
bfd interval 50 min_rx 50 multiplier 3 ! = 150 msec holddown

router bgp 65000
neighbor 2001:DB8:5:1::2 **fall-over bfd**
neighbor 1.2.3.4 **fall-over bfd**

show bfd neighbors

BGP TTL Security

Debugging:



R1/R3#
neighbor <IP> ttl-security hops 2

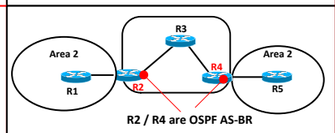
Debug ip packet detail DUMP //do not use in production!

```
*Feb 10 12:15:37.485: IP: s=155.1.146.4 (GigabitEthernet0/0.146),
d=155.1.146.6 (GigabitEthernet0/0.146), len 61, rcvd 3
*Feb 10 12:15:37.485:    TCP src=47218, dst=179, seq=1061966907,
ack=369930400, win=16384 ACK PSH
3F200C00:                0026 08578960          .&.W9`
3F200C10: 00260B57 BA610800 45C0003D 00150000  .&.W:a..E@.=....
3F200C20: FE0661D8 9B019204 9B019206 B8720083  ~.aX.......8r.3
3F200C30: 3F4C543B 160CB0A0 50184000 FF360000  ?LT;..0 P.@..6..
3F200C40: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF  ................
3F200C50:
```

FE Hex = 254 packet has arrived with a TTL of 254 from 155.1.146.4

2nd Rule of

IGP / BGP synchronization



R2 / R4 are OSPF AS-BR

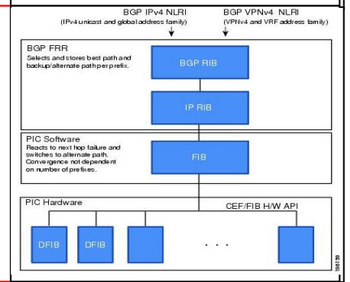
R2:
OSPF RID: 2.2.2.2
BGP RID: 2.2.2.2

2nd rule of BGP synchronization!

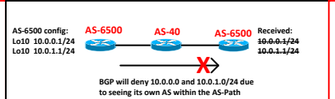
OSPF and BGP IDs have to match on R2 in order for R4 to advertise learned prefixes originated from R1 to R5

BGP PIC Edge and BGP FRR

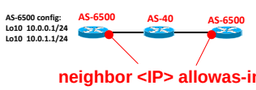
Explained:



BGP AllowAS in



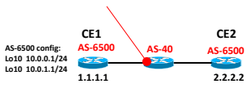
debug ip bgp updates
rcv UPDATE about 7.7.7.7/32 -- **DENIED due** to: AS-PATH **contains our own AS**;



neighbor <IP> allowas-in

BGP as-override

router bgp X
address-family ipv4 unicast vrf x
neighbor 1.1.1.1 as-override
neighbor 2.2.2.2 as-override



CE1:
AS-path for 20.0.0.0/24: 40

CE2:
AS-path for 10.0.0.0/24: 40

PE hides CE AS number behind AS-40

BGP info:

- idle
- connect
- active (3 way handshake)
- open sent (capabilities)
- open confirm
- open

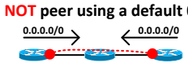
Keep alives

router bgp X
neigh 1.1.1.1 remote-as 200 (reachability to peer)

neighbor transport-mode

OpenSent:
- ASN Number
- Holddown
- Router-ID
- Options (AFI/SAFI)
- Open

BGP can NOT peer using a default 0/0 route!



BGP Neighbor capabilities:

AFI Adress Family Identifier (2 Octet)
SAFI Subsequent Address Family Identifier (1 Octet)

AFI:

0	Reserved
1	IPv4
2	IPv6
11	IPX
12	AppleTalk

debug ip bgp afi/safi

SAFI:

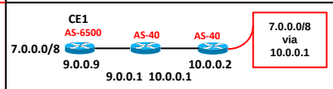
1	unicast forwarding
2	multicast forwarding
3	both, unicast and multicast forwarding
4	IPv4 label forwarding
128	labeled VPN forwarding

Alternative to

neighbor x.x.x.x set-next-hop-self

and

neighbor x.x.x.x route-map OUT
Route-map OUT permit 10
Set ip next-hop-self



route-map PEER-ADDRESS permit 10
set ip next-hop peer-address

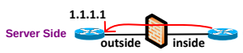
If 9.0.0.0 would not be in the RT of Router B, then 7.0.0.0 would be inaccessible.

BGP neighbor transport connection-mode

bgp neighbor transport connection-mode [active / passive]

Client Side **Server side**

TCP SYN to 1.1.1.1:179



Watch out for stateful firewalls or Router ACLs with keyword established

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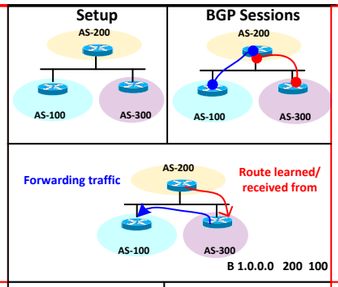
BGP

BGP next-hop

default



bgp bestpath med missing-as-worst

bgp bestpath med confed

bgp bestpath med missing-as-worst

consider a missing MED as having a value of infinity, making the path without a MED value the least desirable path.

bgp bestpath med confed

Enable Path/MED comparison between different Sub-Ases within a confederation.

- comparison between MEDs is made only if there are no external autonomous systems in the path
- external autonomous system in the path, then the external MED is passed transparently through the confederation

bgp route-map priority

```
router bgp 50000
 bgp route-map priority
 address-family ipv4 unicast vrf inside
  bgp route-map priority
```

BGP
4 Byte ASN calculation

explained

2 Byte ASN Range:	4 Byte ASN Range:
0 to 65535	0 to 4294967295

2 Byte **max** ASN **65535** = **0.65535** 4 Byte ASN Format

65536 = 1.0
65537 = 1.1

Example calculation using **ASN 140000**

140000 / **65535** = 2.1 (gives the factor)

2x 65535 = 131070

140000 - 131070 = **8930**

Final **4 Byte ASN** Nr: **2.8930**

bgp bestpath med confed

path= 65000 65004, med=2
path= 65001 65004, med=3
path= 65002 65004, med=4
path= 65003 22, med=1

Which path will be used?

Used due to lowest MED

path= 65000 65004, med=2
path= 65001 65004, med=3
path= 65002 65004, med=4
path= 65003 **22**, med=1

Has lower MED, but it is not involved in the MED comparison because there is an external autonomous system is in this path

bgp bestpath med confed

BGP router-id

bgp router-id { **ip-address** | **vrf auto-assign** }

```
Router bgp 45000
bgp router-id 1.1.1.1
```

```
router bgp 45000
 bgp router-id vrf auto-assign
```

```
router bgp 45000
 address-family ipv4 vrf VRF2
  bgp router-id auto-assign
```

BGP
4 Byte ASN:
Data entities that carry ASNs

- The AS_PATH attribute; (AS**4**_PATH)
- The AGGREGATOR attribute; (AS**4**_AGGREGATOR)
- The COMUNITES attribute; (4 Byte EXT_COMM)
- **The Open message** (New capability)

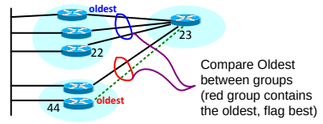
- Neighbor is either New_BGP or Old_BGP implementation (Capability).
- New to old BGP speaker uses reserved 2-byte ASN, 23456, called AS_TRANS and no OLD ASN SHOULD USE THIS ASN!
- AS4_PATH new optional path attribute, unlike "historic" AS-PATH attribute which is mandatory

BGP
bgp deterministic med

(ensures MED gets compared where AS paths are the same)

bgp deterministic-med

Groups the same AS path together, checks the oldest path within the group. Them compares the oldest path towards AS 22 with the oldest path of the group going to AS 44. The oldest path between the two group wins.
The oldest path is always displayed at the bottom of show bgp!



BGP RPKi

bgp rpki server tcp 192.168.1.1 port 1033 refresh 600

(Origin AS Validation)

```
router bgp X
bgp rpki server tcp 192.168.1.1 port 1033 refresh 600
```

show ip bgp rpki servers
Displays the current state of communication with the RPKI servers.

show ip bgp rpki table
cached list of prefix/AS pairs.

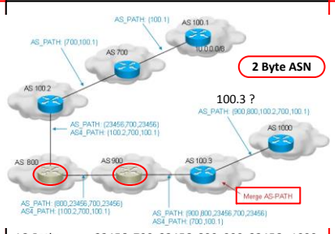
bgp bestpath prefix-validate
invalid prefixed are allowed to be used as the best path, even if valid prefixes are available, or disables the checking of prefixes.

clear ip bgp rpki server
Purges SOVC records downloaded from the specified server

debug ip bgp event rpki
neighbor announce rpki state

4 Byte – 2 Byte BGP

ASN operation



AS-Path:	23456	700	23456	800	900	23456	1000	
AS-Path new:	100.1		100.2			100.3		
Merged:	100.1	700	100.2	800	900	100.3	1000	

BGP
bgp bestpath compare-router-id

Do not use the oldest path as the best

NEWEST PATH } Compare 1st
OLDER PATH } Compare 2nd
OLDEST PATH

bgp bestpath compare-router-id (will select lowest RID)

Making bgp **NOT compare down to the oldest path.**

bgp update-delay

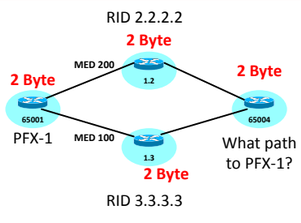
Delay the first update with prefixes for X seconds

bgp update-delay <seconds>

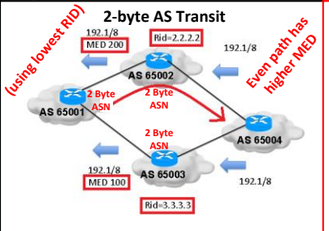
Could be used in to initialize learned perfixes learned older or newer depending how much you delay on which router.

Command can be used with:

bgp graceful-restart



bgp deterministic-med
no bgp always-compare-med



bgp deterministic-med
no bgp always-compare-med

BGP Dynamic Neighbors

(Up to 5 optional AS numbers)

```
router bgp
bgp listen limit <max-number>
bgp listen range 10.0.0.0/24 peer-group GROUP
neighbor GROUP ebgp-multihop <ttl>
neighbor GROUP remote-as 22 alternative-as 44
```

debug ip bgp range
show ip bgp peer-group X

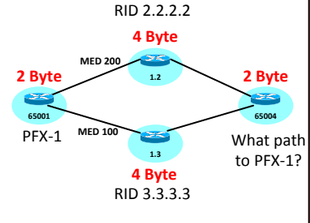
bgp slow-peer detection [threshold seconds]
oldest message in a peers queue can be lagging behind the current time before the peer is determined to be a slow peer

neighbor slow-peer detection clear ip bgp slow

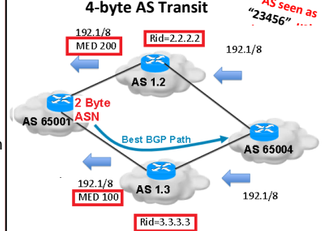
bgp slow-peer split-update-group dynamic [permanent]

BGP table-map

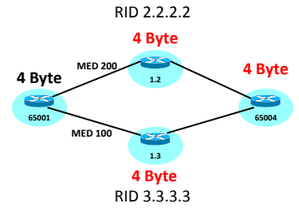
```
router bgp 500
table-map buckets

ip as-path access-list 99 permit _10_
ip as-path access-list 77 permit _11_

route-map buckets permit 10
match as-path 99
set traffic-index 1

route-map buckets permit 20
match as-path 77
set traffic-index 2

route-map buckets permit 80
set traffic-index 7

Interface fa0/x
bgp-policy accounting input source
```



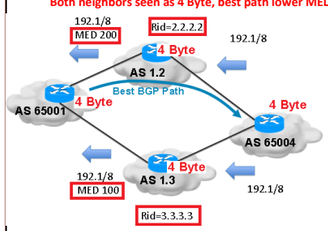
bgp deterministic-med
no bgp always-compare-med



bgp deterministic-med
no bgp always-compare-med



bgp deterministic-med
no bgp always-compare-med



bgp deterministic-med
no bgp always-compare-med

BGP BMP Server

```
router bgp 65
bmp initial-refresh delay 30

show ip bgp bmp server neighbors

neighbor bmp-activate
```

```
Device# show ip bgp bmp server neighbors

Number of BMP neighbors configured: 10
BMP Refresh not in progress, refresh not scheduled
Initial Refresh Delay configured, refresh value 30s
BMP buffer size configured, buffer size 2048 MB, buffer size bytes used 0 MB

Neighbor        PriQ    MsgQ    CfgSvr#         ActSvr#         RM Sent
30.1.1.1        0       0       1  2            1  2            16
2001:DB8::2001  0       0       1  2            1  2            15
40.1.1.1        0       0       1  2            1  2            26
```

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BGP

BGP additional path

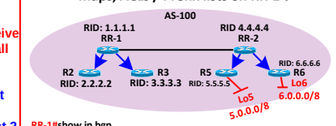
(BGP Add path)

```
router bgp 100
address-family ipv4 unicast
bgp  additional-paths select all
neighbor 192.168.1.2 additional-paths send receive
neighbor 192.168.1.2 advertise additional-path all

 address-family ipv4 unicast
  bgp additional-path select all best 3 group-best
  neighbor 1.1.1.1 route-map ADD-PATH out
  neighbor 1.1.1.1 advertise additional-paths best 2

route-map ADD-PATH permit 10
 match additional-paths advertise-set best 2
 set metric 888
```

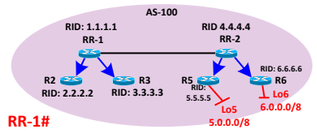
How can you filter out any originated prefixes originated by R5 and R6 without using Route-maps, ACLs / Prefix lists on RR-1 ?



RR-1#**show ip bgp**

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.0.0.0	0.0.0.0	0		32768	i
*>i 2.0.0.0	12.1.1.2	0	100	0	i
*>i 3.0.0.0	13.1.1.3	0	100	0	i
*>i 4.0.0.0	14.1.1.4	0	100	0	i
*>i 5.0.0.0	45.1.1.5	0	100	0	i
*>i 6.0.0.0	46.1.1.6	0	100	0	i

Filter them out



RR-1#

```
router bgp 100
bgp cluster-id 4.4.4.4
```

RR-1#**show ip bgp**

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.0.0.0	0.0.0.0	0		32768	i
*>i 2.0.0.0	12.1.1.2	0	100	0	i
*>i 3.0.0.0	13.1.1.3	0	100	0	i
*>i 4.0.0.0	14.1.1.4	0	100	0	i

BGP regex

Utilizing (\1):

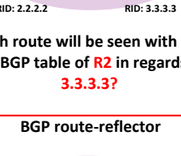
(\1) stores, what ever was discovered as directly attached neigbor AS!

*** allows the prepend of one more instance of ANY prepended number.**

show ip bgp regexp ^([0-9]+)(_\1)+$

+ only allows 200 200, the prepended number needs to be the same!

How do you configure eBGP multipath?



Weight, LP, AS-Path, Origin, MED need to be the same.

```
router bgp 50
bgp bestpath as-path multipath-relax
maximum-paths 2
 neighbor 2.2.13.3 remote-as 100
 neighbor 2.2.16.6 remote-as 200
```

Router#**show bgp**

Network	Next Hop	Metric LocPrf Weight Path
*> 1.2.3.4/32	2.2.16.6	0 200 888 i
*m	2.2.13.3	0 100 888 I

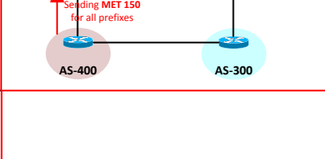
Router#**show ip route bgp**

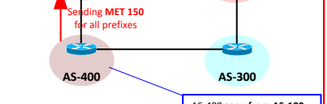
1.0.0.0/32 is subnetted, 1 subnets

B 1.2.3.4 **[20/0] via 2.2.16.6, 00:01:46**
[20/0] via 2.2.13.3, 00:01:46

Keyword BGP Backdoor:

Configure R3 and R2 so that traffic from Loopback to loopback takes the ethernet interfaces.
Use two different configuration on both sides!





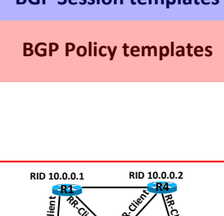
BGP Backdoor, two solutions:

1. R3#
router bgp 300
network 2.0.0.0 mask 255.255.255.0 **backdoor**

2. R2#
router bgp 200
distance 91 12.1.1.1 0.0.0.0 **88**

access-list 88 permit **3.0.0.0**

How will the config look in regards to the BGP confederation ?



R1#
router bgp **65511**
bgp confederation identifier 900
neigbor R2.R2.R2.R2 remote-as 65511

Confed peer not configured!

R2#
router bgp **65511**
bgp confederation identifier 900
bgp confederation peers 65522
neigbor R1.R1.R1.R1 remote-as 65511
neigbor R3.R3.R3.R3 remote-as 65522

R3#
router bgp **65522**
bgp confederation identifier 900
bgp confederation peers 65511
neigbor R2.R2.R2.R2 remote-as 65511
neigbor R4.R4.R4.R4 remote-as 65522

Confederation peers only configured where necessary!

Which of the following prefixes have been originated locally?

Where these networks learned by eBGP or iBGP?

R3#**show ip bgp**
....

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i 1.0.0.0	10.1.1.1	0	100	0	i
*>i 2.0.0.0	10.1.1.2	0	100	0	i
*> 3.0.0.0	0.0.0.0	0		32768	i
*>i 4.0.0.0	10.1.1.4	0	100	0	i

R3#**show ip bgp**
BGP table version is 17, local router ID is 192.168.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i 1.0.0.0	10.1.1.1	0	100	0	i
*>i 2.0.0.0	10.1.1.2	0	100	0	i
*> 3.0.0.0	0.0.0.0	0		32768	i
*>i 4.0.0.0	10.1.1.4	0	100	0	I

Prefixes learned by iBGP, due to Local Pref visible in the output!

What are the values for the following well-known BGP communities?

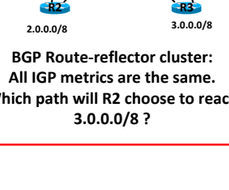
Internet
no-export
no-advertise
local-as

Wellknown BGP community range:

4294**901760** – 4294**967295**

Internet	does not have a value
no-export	4294967041
no-advertise	4294967042
local-as	4294967043

How will a show ip bgp look from router R1 in this BGP confederation?



R1#**show ip bgp**

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.0.0.0	0.0.0.0	0		32768	i
*> 2.0.0.0	12.1.1.2	0	100	0 (65511)	i
*> 3.0.0.0	23.1.1.3	0	100	0 (65522)	i
*> 4.0.0.0	34.1.1.4	0	100	0 (65522)	i
*> 5.0.0.0	45.1.1.5	0	100	0 (65522 65533)	i
*> 6.0.0.0	45.1.1.6	0	100	0 (65522 65533)	123 i

Where these networks learned by eBGP or iBGP?

R2#**show ip bgp**
....

Network	Next Hop	Metric	LocPrf	Weight	Path
* 1.0.0.0	10.1.1.1			0	300 100 i
*	10.1.1.1			0	400 100 i
*>	10.1.1.1	0		0	100 i
*> 2.0.0.0	0.0.0.0	0		32768	i
* 3.0.0.0	10.1.1.3			0	400 300 i
*	10.1.1.3			0	100 300 i
*>	10.1.1.3	0		0	300 i
* 4.0.0.0	10.1.1.4			0	100 400 i
*	10.1.1.4			0	300 400 i
*>	10.1.1.4	0		0	400 i

Routes where learned from eBGP identified by a zero Local Preference field!
The Metric of 0 only shows up from Peers where that peer originates that prefix!

R2#**show ip bgp**
....

Network	Next Hop	Metric	LocPrf	Weight	Path
* 1.0.0.0	10.1.1.1			0	300 100 i
*	10.1.1.1			0	400 100 i
*>	10.1.1.1	0		0	100 i
*> 2.0.0.0	0.0.0.0	0		32768	i
* 3.0.0.0	10.1.1.3			0	400 300 i
*	10.1.1.3			0	100 300 i
*>	10.1.1.3	0		0	300 i
* 4.0.0.0	10.1.1.4			0	100 400 i
*	10.1.1.4			0	300 400 i
*>	10.1.1.4	0		0	400 i

What to keep in mind with BGP in the CCIE lab / real world?

Use something like the following to **be as specific as possible:**

```
ip prefix-list PFX-2 permit 2.2.2.0/24

ip as-path access-list 500 permit ^200$

route-map RMP-2-IN permit 10
match ip address prefix-list PFX-2
match as-path 500
SET  /  DO what ever

route-map RMP-2-IN permit 20
```

show ip bgp template peer-session

R2#**show ip bgp template peer-session**
Template:COMMON, index:1
Local policies:0x12, Inherited polices:0x0
***Inherited by Template IBGP, index= 2**
Locally configured session commands:
version 4
password is configured
Inherited session commands:

Template:IBGP, index:2
Local policies:0x81, Inherited polices:0x12
This template inherits:
COMMON index:1 flags:0x0
Locally configured session commands:
update-source Loopback0
Inherited session commands:
version 4
password is configured

```
router bgp 100
network 10.0.0.0 mask 255.0.0.0
template peer-session ONE
version 4
password cisco
template peer-session TWO
update-source loopback 0
inherite peer-session ONE
```


Which route will be seen with *> in the BGP table of R2 in regards to 3.3.3.3?

R2#**show ip bgp**

* i 3.0.0.0	13.1.1.3	0	100	0	i
*>i	13.1.1.3	0	100	0	I

R2#**show ip bgp 3.3.3.3**
BGP routing table entry for 3.0.0.0/8, version 4
Paths: (2 available, **best #2**, table default)
Not advertised to any peer
Refresh Epoch 1
Local
13.1.1.3 (metric 128) from 12.1.1.1 **(1.1.1.1)**
Origin IGP, metric 0, localpref 100, valid, internal
Originator: 3.3.3.3, **Cluster list: 1.1.1.1**
Refresh Epoch 2
Local
13.1.1.3 (metric 128) from 13.1.1.3 **(3.3.3.3)**
Origin IGP, metric 0, localpref 100, valid, internal, **best**

How can you influence AS-100 to use the path with the lowest metric in this situation?

AS-400 **seen from AS-100:**

(metric 100) 200 300 400
(metric 150) 400

bgp always-compare-med
bgp bestpath as-path ignore

clear ip bgp * (hard clear the session!!)

BGP Session templates

BGP Policy templates

Policy Templates

advertisement-interval
allowas-in
as-override
capability
default-originate
distribute-list
dmzlink-bw
filter-list
maximum-prefix
next-hop-self
next-hop-unchanged
prefix-list
remove-private-as
route-map
route-reflector-client
send-community
send-label
soft-reconfiguration
soo
unsuppress-map
weight

Session templates

allowas-in
description
disable-connected-check
ebgp-multihop
fall-over
local-as
password
remote-as
shutdown
timers
translate-update
transport
ttl-security
update-source
version

BGP route-reflector

Output of show ip bgp 33.33.33.0

On R2 and the RR:

R2#**show ip bgp 33.33.33.0**
BGP routing table entry for 33.33.33.0/24, version 10
Paths: (1 available, best #1, table default)
Not advertised to any peer
Refresh Epoch 1
Local
13.1.1.3 (metric 128) from 12.1.1.1 (1.1.1.1)
Origin IGP, metric 0, localpref 100, valid, internal, best
Originator: 3.3.3.3, Cluster list: 1.1.1.1

RR#**show ip bgp 33.33.33.0**
BGP routing table entry for 33.33.33.0/24, version 11
Paths: (1 available, best #1, table default)
Advertised to update-groups:
2
Refresh Epoch 2
Local, (Received from a RR-client)
13.1.1.3 from 13.1.1.3 (3.3.3.3)
Origin IGP, metric 0, localpref 100, valid, internal, best

What are 3 different examples of filtering methods in BGP:

```
router bgp 100
neigbor 1.1.1.1 distribute-list 88 in

access-list 88 deny 2.0.0.0 0.0.0.0
access-list 88 permit any
```

```
router bgp 100
neigbor 1.1.1.1 prefix-list PFX-1 in

ip prefix-list PFX-1 deny 2.0.0.0/24
ip prefix-list PFX-1 permit 0.0.0.0/0 le 32
```

```
router bgp 100
neigbor 1.1.1.1 filter-list 77 in

ip as-path access-list 77 deny _300$
ip as-path access-list 77 permit .*
```

show ip bgp regex ....'
show ip bgp filter-list <1-500>

BGP Route-reflector cluster:
All IGP metrics are the same.
Which path will R2 choose to reach 3.0.0.0/8 ?

13th Prefer the path that comes from the **lowest neighbor address**

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BGP

BGP Inject-map
Inject ANY prefix into BGP

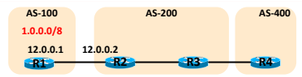
R1 sends a default route to R2

Inject network 99.99.99.0/24 which is NOT configured on R2, into R2s BGP table.
R3 will see the route but will not be able to reach it.

R1 sends a default route to R2

R2 has ALL routes in table due the default route, R2 can inject ANY route specified by the INJECT route-map into BGP!

```
R2#
router bgp 200
bgp inject-map INJECT exist-map EXIST
neigbor 12.0.0.1 remote-as 100
neigbor 13.0.0.3 remote-as 300

route-map INJECT permit 10
SET ip address prefix INJECT-THIS-NETWORK

route-map EXIST
match ip address prefix DEFAULT
match ip route-source prefix R1-NEXT-HOP

ip prefix-list DEFAULT permit 0.0.0.0/0
ip prefix-list INJECT-THIS-NETWORK 99.99.99.0/24
ip prefix-list R1-NEXT-HOP permit 12.0.0.1/32
```

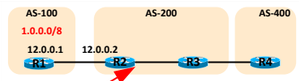


R1#
neigbor 12.1.1.2 send-community
neigbor 12.1.1.2 route-map RMP-SET-COM

route-map RMP-SET-COM
match ip address 1
set community no-export

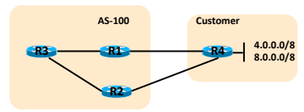
access-list 1 permit 1.0.0.0 0.0.0.255

Ensure that 1.0.0.0/8 is in R4 routing table, do NOT create/modify existing route-maps:



R2#
Router bgp 200
no neigbor 23.1.1.3 send-community

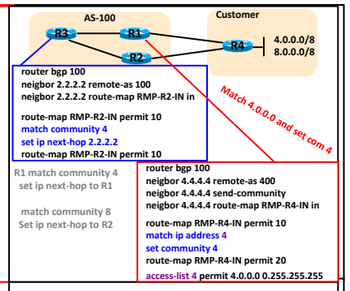
By disabling communities from R2 to R3, the community "no-export" set by R1 will be removed. Therefore R2 will advertise 1.0.0.0/8 to R4



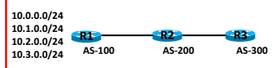
BGP communites / tags

Ensure R3 takes takes path via R1 towards 4.0.0.0/8
And R2 towards 8.0.0.0/8

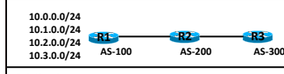
Use communities to accomplish this task:



BGP Aggretagtion



Configure two solutions on how to aggretage the R1 networks on R2 towards R3.

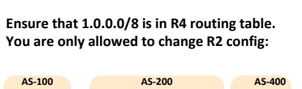


Solution 1

```
R2#
router bgp 200
aggregate-address 10.0.0.0 255.255.0.0 summary-only
```

Solution 2

```
R2#
ip route 10.0.0.0 255.255.0.0 null 0

router bgp 200
network 10.0.0.0 mask 255.255.0.0
```

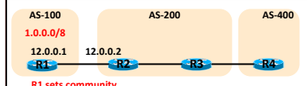


R1#
neigbor 12.1.1.2 send-community
neigbor 12.1.1.2 route-map RMP-SET-COM

route-map RMP-SET-COM
match ip address 1
set community no-export

access-list 1 permit 1.0.0.0 0.255.255.255

Ensure that 1.0.0.0/8 is in R4 routing table.
You are only allowed to change R2 config:



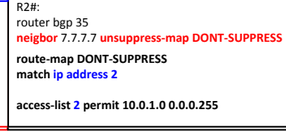
R1 sets community no-export

```
R2#
router bgp 200
neigbor 12.1.1.1 send-community
neigbor 12.1.1.1 route-map RMP-R1-IN in

route-map RMP-R1-IN
match ip address 1
set community internet

access-list 1 permit 1.0.0.0 0.255.255.255
```

R2#
show ip bgp community no-advertise

```
R2#
router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 summary-only as-set
```

Easy way of finding why the summary is not advertised from R2 to R1 when using aggregate-address and as-set!



R3#show ip bgp community no-advertise
...

Network	Next Hop	Metric	LocPrf	Weight	Path
s> 10.0.2.0/24	35.1.1.5	0	0		19 i
*> 10.0.0.0/22	0.0.0.0		100	32768	{22,57,19} i

Give two solutions on how to fix the missing summary on R1


```
R2#
router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 summary-only as-set
```


Solution 1

Change outbound route-map of AS-19 NOT to set community no-advertise.

Solution 2

```
R2#
router bgp 35
aggregate-address 10.0.0.0 255.255.252.0 summary-only as-set
attribute-map ATTR-MAP

route-map ATTR-MAP permit 10
set community internet
```

What do the following commands do?

```
router bgp 300
 bgp log-neighbor-changes
 aggregate-address 10.1.0.0 255.255.252.0 as-set summary-only
 attribute-map ATTR-MAP advertise-map ADVERTISE-MAP
```

Includes all AS numbers of all specific routes of the summary.

Will only send the summary address and suppress the more specific routes

```
router bgp 300
 bgp log-neighbor-changes
 aggregate-address 10.1.0.0 255.255.252.0 as-set summary-only
 attribute-map ATTR-MAP advertise-map ADVERTISE-MAP
```

Sets attributes such as communities etc

```
route-map ATTR-MAP permit 10
 set community internet
```

Can be used to filter out either single prefixes and their attached attributes (no-export with AS-SET!) or entire AS numbers out of the summary (with or without no-advertise / no-export attributes)

```
route-map ADVERTISE-MAP permit 10
 match as-path 400    (if you only want to have AS 400 in AS-SET)
 or
 match ip address prefix-list PFX-MATCH-ONLY-THIS-INTO-AS-SET
```



```
R2#
router bgp 100
aggregate-address 10.0.0.0 255.255.252.0 summary-only as-set
```

Unsuppress 10.0.1.0/24 to R7 but not to R1

R2#:
router bgp 35
neigbor 7.7.7.7 unsuppress-map DONT-SUPPRESS

route-map DONT-SUPPRESS
match ip address 2

access-list 2 permit 10.0.1.0 0.0.0.255

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Multicast

show ip pim neighbor:

R5#**show ip pim neighbor**
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority, S - State Refresh Capable

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
155.1.45.4	Serial0/1/0	00:01:38/00:01:36	v2	1 / S
155.1.58.8	GigabitEthernet0/0	00:01:11/00:01:32	v2	1 / DR S

ip igmp join-group:

ip igmp static-group:

ip igmp join-group

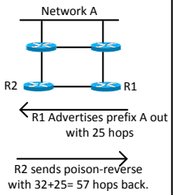
Simulates a router acting as a client which is attached/joining a group. Will answer to pings to the group.

(*, 224.1.1.1), 03:50:11/**stopped,**
RP 0.0.0.0, flags: DC

ip igmp static-group

Will make sure the router is accepting the group and is forwarding traffic for that group but it will NOT answer ICMPs for that group. Can be rate-limited only on Serial interfaces.

DVMRP explained:



DVMRP:
- Dense-Mode (S,G)
- Infinity 32 hops

Show ip pim interface

R5#**show ip pim interface**

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
155.1.45.5	Serial0/1/0	v2/D	1	30	1	0.0.0.0
155.1.58.5	GigabitEthernet0/0	v2/**D**	1	30	1	155.1.58.8
155.1.62.3	GigabitEthernet0/1	v2/**S**	1	30	1	155.1.62.1
155.1.88.2	GigabitEthernet0/2	v2/**SD**	1	30	1	155.1.88.4

Dense-Mode
Sparse-Mode
Sparse-**D**ense-Mode

Show ip igmp group:

Group is known for:

155.1.58.5 was the last "client" requesting that group

R5#**show ip igmp group**
IGMP Connected Group Membership

Group Address	Interface	Uptime	Expires	**Last Reporter**
224.99.99.99	Gi0/0	03:04:17	00:02:49	155.1.58.5
224.0.1.40	Gi0/0	04:10:06	00:02:46	155.1.58.8

IGMPv1:

Hosts leave a group quietly
Querier is eleted via DR
Time-out = 3x query interval 3x 60 = 180 seconds

The difference from IGMPv1 and v2 can be seen in the Maximum-Response-Time field which is always set to Zero in Version 1.

Where as Version 2 it's a non-zero value.

Multicast Test setup:

R4#
int fa0/x
ip igmp join-group 224.11.22.33
R3#
ping 224.11.22.33 rep 100

Or use a IP SLA for a constant multicast stream.
Only Group Members should respond to the sent ping

Multicast

Source Tree:

Shared Tree:

Source Tree (S,G) known as SPT

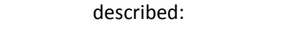
Shared Tree (*,G) via RP known as RTP

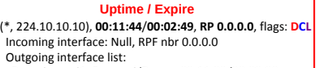
IGMPv2:

Non Zero Maximum-Response-Time field.
Group specific joins and leaves
Querier election when router starts by sending 224.0.0.1 general-query.
Lowest IP is querier.

Show ip mroute described:

DENSE-MODE





DENSE-MODE example

SW4#sh ip mroute
RP is always 0.0 in DM

Uptime / Expire

(*, 224.10.10.10), **00:11:44/00:02:49**, **RP 0.0.0.0**, flags: **DCL**
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Port-channel1, Forward/Dense, 00:11:33/00:00:00
Vlan10, Forward/Dense, 00:11:44/00:00:00

D: Dense Mode
C: Directly connected
L: router itself is a member

IGMPv3

Join / Prunes include the source of the group:

Join (192.168.77.22, 224.1.1.1)

Prune (192.168.59.32, 224.1.1.1)

PIM Dense-Mode:

Depends on unicast routing table (RPF check)

RPF check towards source, checks AdminDistance/Metric If several path exist, interface with highest IP is used.

Neighbor discovery via 224.0.0.13, Hello Period 30 sec

DR election in PIMv1 Dense-Mode, Highest IP wins.

Join/Prune Prune override Graft Assert-Message

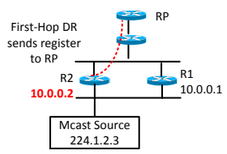
No flags set
WC,RP flags set

Show ip igmp interface X/X:

R5#**sh ip igmp interface** gi0/0
GigabitEthernet0/0 is up, line protocol is up
Internet address is 155.1.58.5/24
IGMP is **enabled** on interface
Current IGMP **host version** is **2**
Current IGMP **router version** is **2**
IGMP **query interval** is **60** seconds
IGMP **querier timeout** is **120** seconds
IGMP **max query response time** is **10** seconds
Last member query count is 2
Last member query response interval is 1000 ms
Inbound **IGMP access group** is not set
IGMP activity: **2 joins, 0 leaves**
Multicast routing is enabled on interface
Multicast **TTL threshold** is 0
Multicast designated router (**DR**) **is** 155.1.58.8
IGMP **querying router is** 155.1.58.5 (this system)
Multicast **groups joined** by this system (number of users):
224.0.1.40(1) 224.99.99.99(1)

PIM Spare Mode Register Messages

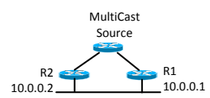
PIM Sparse-Mode Register



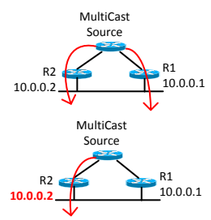
DR Encapsulates Register-Message in a Unicast to the RP.
RP then sends (S,G) join to the source.
-> forces a RPT to SPT switchover

PIM Assert message

Explained:

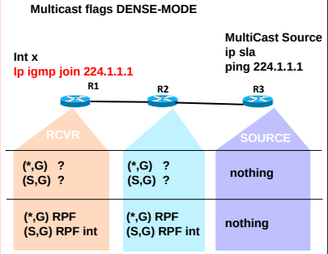


PIM Assert message

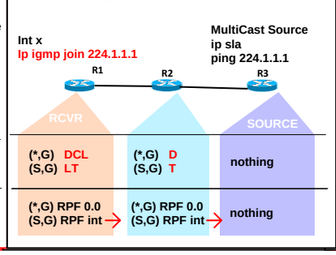


Higher IP wins, if both have the same metric

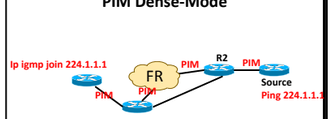
Multicast flags DENSE-MODE



Multicast flags DENSE-MODE

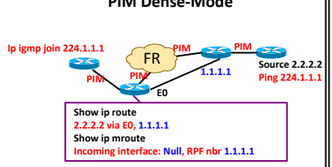


PIM Dense-Mode



Which router should be checked for the RPF failure in this PIM DM scenario?

PIM Dense-Mode

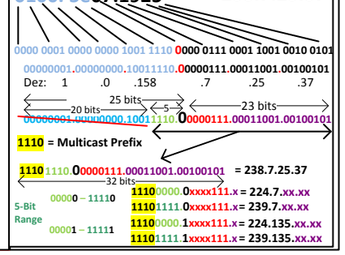


The unicast table is using E0 to reach 2.2.2.2 which is a Non-PIM enabled interface/route to the source!
→ Results in a RPF failure

MAC multicast address conversion:

Convert the mac to the corresponding MultiCast IP address:

0100.5e07.1925



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Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

Colin

http://www.flashcardguy.ch

Multicast

PIMv2 Messages:

0 Hello
1 Register
2 Register-Stop
3 Join/Prune
(Join WC/RP flag set. Prune has none set)
4 Bootstrap
5 Assert
6 Graft (PIM DM only)
7 Graft-Ack (PIM only)
8 Candidate-RP-Advertisement

Explain the command

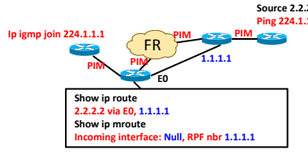
Ip pim sparse-dense-mode:

ip pim sparse-dense-mode

Will perform in Sparse mode for all groups where there is an Group/RP binding known / existing.

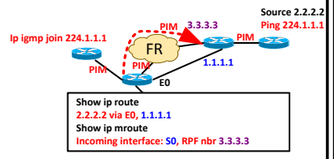
For all others it will flood and prune using IP PIM Dense-Mode.

PIM Dense-Mode



How do you correct this RPF failure scenario?

PIM Dense-Mode



Create a static mroute:

Ip mroute 2.2.2.2 255.255.255.255 3.3.3.3

Show ip mroute

Dense-Mode (*,G)

Explained:

(***, 224.0.1.40**), 01:55:45/00:02:24, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing **i**nterface **l**ist:
Serial0/1, **Forward**/Dense, 01:49:38/**00:00:00**
Serial0/0, Forward/Dense, 01:52:38/00:00:00

In (*,G) the interface appears in the **Oil** in two cases:
1. PIM neighbor detected (Hello)
2. Group Member is joined on that interface

In Dense-Mode: Traffic is NEVER forwarded according to *,G, for traffic to be forwarded there has to be a S,G! OiL copied into S,G entry to start the flood/prune of packets.
Dense-Mode
Directly **C**onnected member
Local flag, Router is member of this group

Difference between

(*,G) in PIM Dense-Mode

And

(*,G) in PIM Sparse-Mode

Dense-Mode:

Traffic is never forwarded according to (*,G), a separate (S,G) needs to be created to forward traffic. OiL is copied from (*,G) to (S,G) which triggers flood and prune behavior.

Sparse-Mode:

(*,G) is used for forwarding multicast traffic.
(*,G) is a result of a explicit join of a PIM neighbor or a directly connected Host.
The incoming interface of (*,G) always points to the RP.

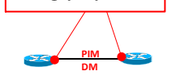
How to troubleshoot

Multicast problems using

Debug ip mpacket:

Conf t
Int x
no ip mroute-cache
End

debug ip mpacket



s=155.1.146.6 (Vlan58) d=224.10.10.10 (Po1) id=19, ttl=252, prot=1, len=100(100), **mforward**

MOSPF explained:

DR originates group membership LSA's

(S,G) whereas S refers to the source subnet not the source ip!

Each time there is a topology change MOPF must flush the entire forwarding chache!

IP PIM Sparse Mode

Flags:

IP PIM Sparse Mode Flags

S indicates sparse-mode
C directly connected member for this group attached
L router itself is a member of the group
P causes to prune to be sent to the upstream RPF neighbor
T (S,G) only: traffic is being forwarded
X Proxy-Join Timer is running
J (*,G) traffic rate is exceeding the SPT-threshold, will switch over to (S,G).
J (S,G) too little traffic, will switch back to (*,G)
R Prune (*,G) traffic to the RP and start direct (S,G) traffic

Explain:

multicast rpf backoff <min-delay ms> <max-delay ms>

delay their RPF interface re-computation after topology change:

specifies the amount of milliseconds to wait after the topology change to re-calculate RPF interfaces

`multicast rpf backoff <min-delay ms> <max-delay ms>`

<min-delay> gets doubled after every consequent topology change but never gets higher than specified in the **<max-delay ms>**

PIM Dense-Mode

(*,G) OiL explained

On show ip mroute:

(*, 224.0.1.40), 01:55:45/00:02:24, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1, Forward/Dense, 01:49:38/00:00:00
Serial0/0, Forward/Dense, 01:52:38/00:00:00

Interfaces seen in *,G entry are either interfaces going to joined group members, or are interfaces on which PIM has detected a PIM neigbor via Hello.

IP PIM Dense Mode Flags

IP PIM Dense-Mode flags

D Dense Mode
C directly connected Member attached
L router itself is a member to this group
P OiL is Null and a Prune is sent upstream towards the RPF interface
T Traffic is forwarding via (S,G)
J Used internally, tells (*,G) to create a (S,G)

How can you tune the Multicast RPF computation?

ip multicast rpf interval <in seconds>

PIM Dense-Mode

(*,G) and (S,G)

Show ip mroute explained:

(***, 224.1.1.40**), 01:55:45/00:02:24, RP 0.0.0.0, flags: **D**
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1, **Forward**/Dense, 01:49:38/**00:00:00**
Serial0/0, **Forward**/Dense, 01:52:38/**00:00:00**

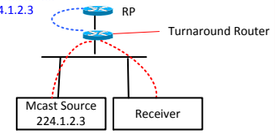
(**172.16.15.22, 224.1.1.40**), 01:55:45/00:02:24, RP 0.0.0.0, flags: T
Incoming interface: Serial0/1 RPF nbr 192.168.26.48
Outgoing interface list:
Serial0/1, **Forward**/Dense, 01:49:38/**00:00:00**
Serial0/0, **Prune**/Dense, 01:52:38/**00:02:33**

Forward expire timer is always 00:00:00 as its still forwarding.
Prune expire timer is counting, once it expires it moves to forward until its pruned again by the downstream router.

IP PIM Sparse-Mode

Turnaround Router explained:

Periodic (S,G) proxi joins to the RP for 224.1.2.3



Flags **seen on Turnaround router** are:

(*,G) S
OiL Enet0
(192.168.1.1,224.1.2.3) PXT
OiL Null

Debugging IP multicast traffic

Using:
no ip mroute-chache
debug ip mpackets

Finding RPF failures:

s=155.1.146.6 (Serial0/0/0) d=224.10.10.10 id=21, ttl=253, prot=1, len=104(100), **RPF lookup failed for source**

s=155.1.146.6 (Serial0/0/0) d=224.10.10.10 id=21, ttl=253, prot=1, len=104(100), **not RPF interface**

Configuring IP PIM Sparse-Mode

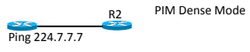
Statically:

ip multicast-routing

interface X
ip pim sparse-mode

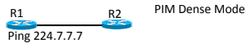
ip pim rp-address X.X.X.X

RP address tells the router where to send the (*,G) joins to.



Show ip mroute output in

Dense-Mode timing out:



Times out second, while (S,G) entry is already gone. (another 3 minutes later)

(*, 224.7.7.7), 00:00:51/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Port-channel1, Forward/Dense, 00:00:51/00:00:00

Times out first after 3 minutes

(155.1.108.10, 224.7.7.7), 00:00:51/00:02:08, flags: PT
Incoming interface: Port-channel1, RPF nbr 0.0.0.0
Outgoing interface list: Null

IP PIM Sparse-Mode

Router manually joined

R4#
int fa0/x
ip igmp join-group 224.10.10.10

R4#


int fa0/x
ip igmp join-group 224.10.10.10

R4#
(*, 224.10.10.10), 00:09:33/00:02:11, RP 0.0.0.0, flags: SJCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Vlan10, Forward/Sparse, 00:09:33/00:02:11

Sparse-Mode
J reached threshold, will switchover to S,G
Connected
L Router is member of group

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

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Thanks for appreciating my efforts

Colin

http://www.flashcardguy.ch

Multicast

Explain the following command:

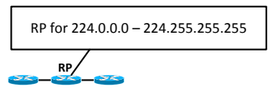
ip pim rp-address <IP> <ACL> <override>

ip pim rp-address x.x.x.x ACL override

Sets the RP address for groups specified in the Access-Lists

Keyword **override** will priorise static configuration versus dynamically learned Group/RP mappings!

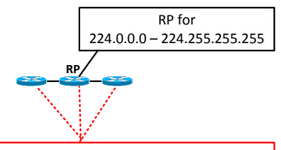
PIM Sparse-Dense-Mode



Setup config so that Routers MultiCast in Sparse-Mode for any groups within 224.0.0.0 - 224.255.255.255,

All others should be using dense-mode

PIM Sparse-Dense-Mode



ip pim rp-address 150.1.5.5 SPARSE_GROUPS

ip access-list standard SPARSE_GROUPS
permit 224.0.0.0 0.255.255.255

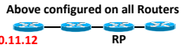
PIM
Accept RP

Allows only groups specified from RP

ip pim accept-rp 150.1.5.5 ALLOWED_GRP

ip access-list standard ALLOWED_GRP
permit 224.10.10.10
permit 224.110.110.110

Above configured on all Routers



%PIM-6-INVALID_RP_JOIN: Received (*, **224.10.11.12**) Join from 0.0.0.0 for invalid RP 150.1.5.5

Explain:

ip pim spt-threshold

ip pim spt-threshold <bandwith in kilobits/s>

Will switchover from (*,G) to (S,G) entry if the bandwith specified is reached.

Ip pim spt-threshold infinity

Will never switch to from a (*,G) to (S,G)

PIM Assert messages over NBMA networks:

Dangerous!

xxxxxx

Forcing a group to revert to Dense-Mode Operation in a Sparse-Dense-Mode setup for specific groups:

ip pim sparse-dense-mode

Setting the range for Sparse Mode:

ip pim rp-address 150.1.5.5 SPARSE_GROUPS

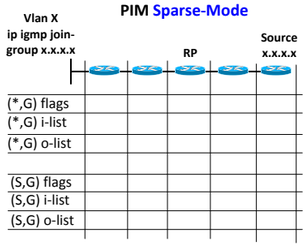
ip access-list standard SPARSE_GROUPS
permit 224.0.0.0 0.255.255.255

Ip pim accept-rp x.x.x.x ALLOWED_GRP

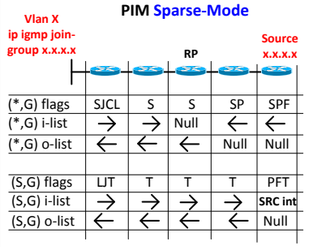
Ip access-list standard ALLOWED_GRP
DENY 224.10.11.12

Disabling the allowed Group to RP mapping **results in Dense-Mode** operation for **Group 224.10.11.12**

PIM Sparse-Mode



PIM Sparse-Mode



Multicast with different routing domains within the same MultiCast Domain!

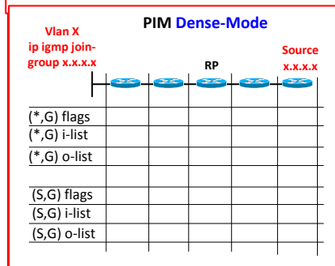
xxxxx

PIM
DR Election

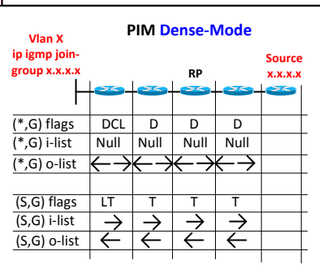
interface FastEthernet0/0
ip pim dr-priority 0

interface FastEthernet0/0
ip pim dr-priority 100

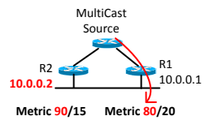
PIM Dense-Mode



PIM Dense-Mode

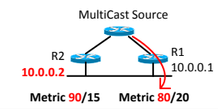


Troubleshooting PIM assert winners:




```
debug ip pim

PIM(0): Received v2 Assert on
FastEthernet0/0 from 155.1.146.4
PIM(0): Assert metric to source
155.1.108.10 is [90/2174976]
PIM(0): We win, our metric [80/20]
```



PIM
DR Election

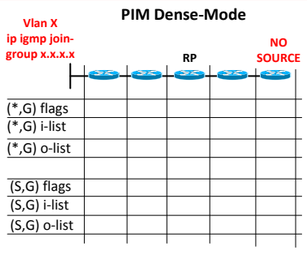
Verification:

```
show ip pim interface fastEthernet 0/0
detail
...
PIM: enabled
PIM version: 2, mode: sparse-dense
PIM DR: 155.1.146.1 (this system)
PIM neighbor count: 2
…
```

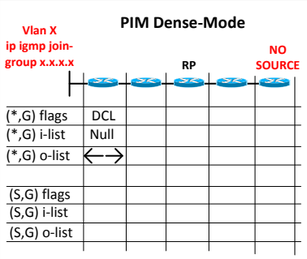
R6#**show ip pim neighbor**

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
1.1.1.1	Gi0/0.146	00:27:04/00:01:19	v2	**255/ DR** S
2.2.2.2	Gi0/0.146	02:44:56/00:01:43	v2	1 / S

PIM Dense-Mode



PIM Dense-Mode



How to identify the **PIM Assert winner** in a **show ip mroute** output:

```
(*, 239.6.6.6),00:02:05/stopped,RP 0.0.0.0, flags: DC
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
FastEthernet0/0, Forward/Sparse-Dense, 00:02:05/
00:00:00
Serial0/0.1, Forward/Sparse-Dense, 00:02:05/00:00:00

(155.1.108.10, 239.6.6.6),00:00:22/00:02:46, flags: T
Incoming interface: Serial0/0.1, RPF nbr 155.1.0.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse-Dense, 00:00:24/
00:00:00, A
```

PIM
Accept Register

(registering the source)

Source: Source 2.2.2.2 — RP

ping 224.10.10.10 — Denies Source 2.2.2.2 For (S,G)

RP Config:
ip pim accept-register route-map ACCEPT_REGISTER

route-map ACCEPT_REGISTER **deny** 10
match ip address **SOURCES**

ip access-list extended **SOURCES**
permit ip **host 2.2.2.2** any
deny ip any any

ip pim register-source Lo 0

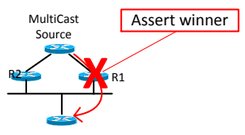
%PIM-4-INVALID_SRC_REG: Received Register from 155.1.0.1 for (**2.2.2.2**, 224.10.10.10), **not willing to be RP**

How to figure out if PIM Sparse or Dense mode is used on an interface configured with IP PIM SPARSE-DENSE-MODE

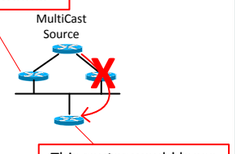
(*, 239.0.0.1), 00:00:10/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1/0, Forward/Sparse-Dense, 00:00:10/00:00:00
FastEthernet0/1, Forward/Sparse-Dense, 00:00:10/
00:00:00
(155.1.146.6, 239.0.0.1), 00:00:10/00:02:55, flags: T
Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1/0, Forward/Sparse-Dense, 00:00:12/00:00:00

(*, 239.0.0.1), 00:00:10/stopped, RP 0.0.0.0, flags: **D**
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1/0, Forward/**Sparse-Dense**, 00:00:10/00:00:00
FastEthernet0/1, Forward/**Sparse-Dense**, 00:00:10/
00:00:00
(155.1.146.6, 239.0.0.1), 00:00:10/00:02:55, flags: T
Incoming interface: FastEthernet0/1, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/1/0, Forward/**Sparse-Dense**, 00:00:12/**00:00:00**

What happens when an Assert winner stops operation?

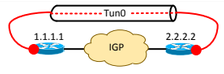


The Assert looser needs to time-out the Assert winner!



This router would loose traffic for 3 minutes

Multicast
Tunneling



interface Tunnel 0
ip unnumbered Loopback0
tunnel source Loopback0
tunnel destination 2.2.2.2
ip pim sparse-dense-mode

interface Tunnel 0
ip unnumbered Loopback0
tunnel source Loopback0
tunnel destination 1.1.1.1
ip pim sparse-dense-mode

ip mroute 0.0.0.0 0.0.0.0 tunnel 0

Use different IGP for tunnel, or make sure tunnel SRC/DST not learned through the tunnel!

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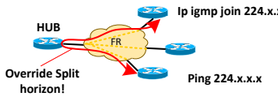
Multicast

PIM NBMA Mode

(sparse-mode only)



HUB:
interface Serial 0/0
ip pim nbma-mode
Ip pim sparse-mode
frame-relay map ip x.x.x.x 501 broadcast

Configuring a Auto-RP

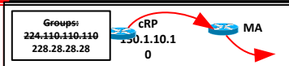
Candidate RP

And

Mapping Agent:

```
interface Loopback0
ip pim sparse-dense-mode

cRP:
ip pim send-rp-announce Loopback 0 scope 10
MA:
ip pim send-rp-discovery loopback 0 scope 10

R5#show ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is an RP-mapping agent (Loopback0)

Group(s) 224.0.0.0/4
  RP 150.1.5.5 (?), v2v1
    Info source: 150.1.5.5 (?), elected via Auto-RP
         Uptime: 00:02:33, expires: 00:02:26
```

Auto-RP - Filtering Candidate RPs

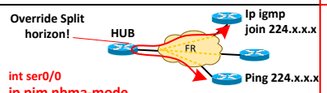



```
ip access-list standard RP_LIST
permit 150.1.10.10

ip access-list standard GROUP_LIST
deny 224.110.110.110
permit any

ip pim rp-announce-filter RP_LIST
group-list GROUP_LIST
```

PIM NBMA Mode

(sparse-mode only)

Show ip mroute output:




```
int ser0/0
ip pim nbma-mode
Frame-relay map xx  broadcast
Ip pim sparse-mode
```

Show ip mroute
(*, 224.110.110.110), 00:17:47/00:03:28, RP 150.1.5.5, flags: S
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial0/0/0, **155.1.0.3**, Forward/Sparse-Dense, 00:16:48/00:03:28
IP is visible instead of only the interface! -> override

How to change the ? From the output below?

R5#show ip pim rp mapping
...
Group(s) 224.0.0.0/4
RP 150.1.5.5 **(?)**, v2v1
Info source: 150.1.5.5 **(?)**, elected via Auto-RP
Uptime: 00:02:33, expires: 00:02:26

```
conf t
ip host Router5 150.1.5.5
end

R5#show ip pim rp mapping
...

Group(s) 224.0.0.0/4
  RP 150.1.5.5 (Router5), v2v1
    Info source: 150.1.5.5 (Router5), elected via Auto-RP
         Uptime: 00:07:34, expires: 00:02:21
```

Debug ip pim auto-rp output

Disallowing group 224.110.110.110:

debug ip pim auto-rp

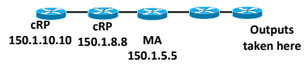
```
Auto-RP(0): Received RP-announce, from
150.1.10.10, RP_cnt 1, ht 181
Auto-RP(0): Filtered -224.110.110.110/32 for RP
150.1.10.10
Auto-RP(0): Update (232.0.0.0/5, RP:150.1.10.10),
PIMv2 v1
```

How do you configure a MultiCast cRP, Candidate RP?

MultiCast Candidate RP:

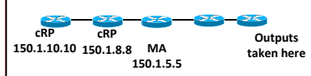
ip pim send-rp-announce <Interface> scope <TTL> group-list <Std-ACL> interval <seconds>

Router will start sending traffic destined to: 224.0.1.39 UDP 496
Served to groups speciefied in the group-list. Denied group-list entries will be served in Dense-Mode. TTL can be used for admin scoping
Requires: `pim sparse-dense-mode`



Auto-RP (*,G) and (S,G)

Show outputs



(*, 224.0.1.**39**), 00:00:27/stopped, RP 0.0.0.0, flags: **D**

(150.1.**8.8**, 224.0.1.**39**), 00:00:27/00:02:32, flags: **PT**

(150.1.**10.10**, 224.0.**1.39**), 00:00:13/00:02:46, flags: **PT**

(*, 224.0.1.**40**), 00:02:47/stopped, RP 0.0.0.0, flags: **DCL**

(150.1.**5.5**, 224.0.**1.40**), 00:02:03/00:00:56, flags: **L**

Auto-RP Listener

interface x/x
ip pim sparse-mode

ip pim autorp listener

Only 224.0.1.39 and 224.0.1.40 are flooded in **dense-mode**
All other possible denied groups are never flooded in dense-mode

How to configure a MultiCast MA Mapping Agent?

`MultiCast Mapping Agent`

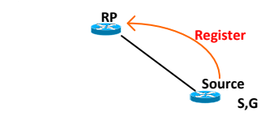
`ip pim send-rp-discovery <Interface> scope <TTL> interval <Seconds>`

Listens to 224.0.1.39 udp 496
Sends to 224.0.1.40 udp 496

Requires: `pim sparse-dense-mode`

What are reasons why the RP does not have a S,G entry in its mroute table?

S,G not seen on RP!



S,G not seen on RP!

Source IP not in RPs routing table!

Show ip pim autorp

Once with ip pim **sparse-dense-mode**:

Once with **ip pim sparse-mode** and **ip pim autorp listener**:

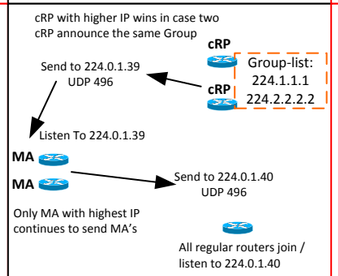
```
Transit interfaces:
ip pim sparse-dense-mode

SW4#show ip pim autorp
AutoRP Information:
  AutoRP is enabled.

PIM AutoRP Statistics: Sent/Received
  RP Announce: 810/334, RP Discovery: 342/417
```

Transit interfaces: **ip pim sparse-mode** *ip pim autorp listener*

```
SW4#sh ip pim autorp
AutoRP Information:
  AutoRP is enabled.
  AutoRP groups over sparse mode interface is enabled

PIM AutoRP Statistics: Sent/Received
  RP Announce: 816/340, RP Discovery: 345/421
```

Auto RP

Explained as picture:



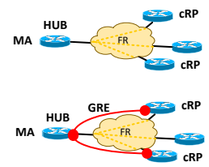
How can one verify a group is **running in dense-mode** in combination with

Auto-RP:

```
SW4#show ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
Group(s) 224.0.0.0/5
  RP 150.1.8.8 (?), v2v1
    Info source: 150.1.5.5 (?), elected via Auto-RP
         Uptime: 00:51:39, expires: 00:02:36
Group(s) (-)224.14.14.14/32
  RP 150.1.10.10 (?), v2v1
    Info source: 150.1.5.5 (?), elected via Auto-RP
         Uptime: 00:00:22, expires: 00:02:37
ip pim send-rp-announce Loopback0 scope 10 group-list
GROUPS
ip access-list standard GROUP
 deny   224.110.110.110
 permit 224.0.0.0 7.255.255.255
```

(-) Shows that group 224.14.14.14 runs in Dense-Mode due to denied group-list

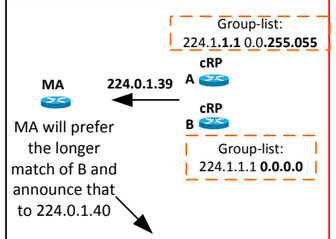
Auto-RP and RP/MA Placement



I did not get the point here, basically how to connect the MA with the cRPs over a NBMA

Auto RP and group-lists and more specifics:

Diagram:



Explain:

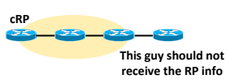
ip pim rp-announce-filter rp-list <access-list> group-list <accesslist>

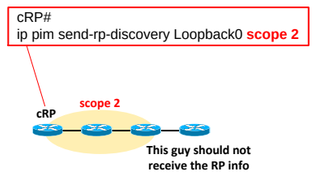
List of allowed RPs

ip pim rp-announce-filter rp-list <access-list> group-list <accesslist>

List of allowed groups, per allowed RP

Filtering Auto-RP Messages





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Multicast

Multicast Boundary

Acl:

filtering control plane traffic (IGMP,PIM,AutoRP) and data plane not relying on TTL.

ip multicast boundary <access-list> [filter-autorp]

standard ACL:
ingress IGMP/PIM, forwards group traffic if it has a match

permit 224.10.10.10

extended ACL:

specifies multicast source and group

interface FastEthernet 0/0
ip multicast boundary PERMITTED_GROUPS filter-autorp

ip access-list standard PERMITTED_GROUPS
deny 232.0.0.0 7.255.255.255
permit any

BSR Multiple RP Candidates

Distribute all odd / even multicast groups between two RPs using 31 bits:

BSR: **ip pim bsr-candidate Loopback0 31**

Router1: `ip pim rp-candidate Loopback0`

Router2: `ip pim rp-candidate Loopback0`

```
Router2#show ip pim rp-hash 239.1.1.1
...
PIMv2 Hash Value (mask 255.255.255.254)
RP 150.1.10.10, via bootstrap, priority
0, hash value 989207280
…
Router2#show ip pim rp-hash 239.1.1.2
PIMv2 Hash Value (mask 255.255.255.254)
RP 150.1.8.8, via bootstrap, priority 0,
hash value 1364246456
```

IGMP Timers

Interface X
ip igmp query-interval <seconds>

ip igmp querier-timeout <seconds>

ip igmp query-max-response-time <seconds>

ip igmp last-member-query-count <2 sec>

ip igmp last-member-query-interval <msec>

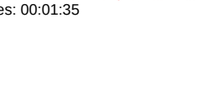
ip igmp immediate-leave group-list <ACL>

PIM Bootstrap Router

PIMv2 RP

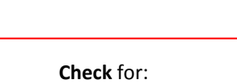
ip pim rp-candidate <PIM-Enabled-Interface> group-list <Standard-ACL> priority <0-255>

Lower priority is preferred

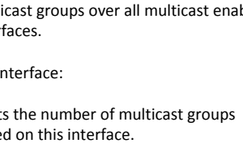


BSR floods RP/group info via PIM messages hop by hop, NOT Dense-Mode

Filtering BSR Messages



Stop BSR flooding here



Checking IGMP timers:

show ip igmp interface Fa0/0

…
IGMP **query interval is** 20 seconds
IGMP **querier timeout is** 40 seconds
IGMP **max query response time** is 4 seconds
Last member query count is 2
Last member query response interval is 1000 ms
…

PIM Bootstrap Router

PIMv2 BSR

If both prios's are the same, higher IP is used

ip pim bsr-candidate <Interface-Name> hash-mask-length priority

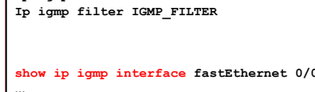
Hash is used to loadbalance to different RPs

Higher priority is preferred

ip pim rp-candidate Loopback0
ip pim bsr-candidate Loopback0

Stub Multicast Routing & IGMP Helper

ip igmp helper-address 1.1.1.1



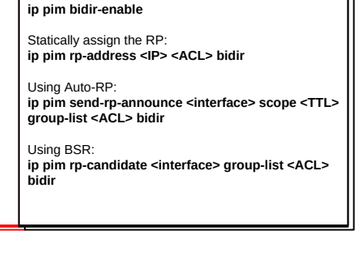
Forwards join/prune messages to 1.1.1.1 without creating (*,G)(S,G) entries locally

Keeps track for Stub Router behind low bandwith link, only sends 2.2.2.2 groups requested by the clients

access-list **33** deny 2.2.2.2
access-list **33** permit any

Int ser0/0
ip pim sparse-mode
ip pim neighbor-filter 33

Multicast Helper Map



ip forward-protocol udp 5000
ip access-list extended TRAFFIC
permit udp any any eq 5000
interface FastEthernet 0/0
ip multicast helper-map broadcast 224.1.2.3 TRAFFIC

ip forward-protocol udp 5000
ip access-list extended TRAFFIC
permit udp any any eq 5000
interface FastEthernet 0/0
ip directed-broadcast
ip broadcast-address 155.1.37.255
interface Serial 0/0
ip multicast helper-map 224.1.2.3 155.1.37.255 TRAFFIC

debug ip pim bsr:

debug ip pim bsr

PIM-BSR(0): RP-set for 224.0.0.0/4
PIM-BSR(0): RP(1) 150.1.5.5, holdtime 150 sec priority 0
PIM-BSR(0): **Bootstrap message for** 150.1.5.5 **originated**
PIM-BSR(0): Build v2 Candidate-RP advertisement for 150.1.5.5 priority
0, holdtime 150
PIM-BSR(0): Candidate RP's group prefix 224.0.0.0/4
PIM-BSR(0): Send Candidate RP Advertisement to 150.1.5.5

When RPF check **fails**:
PIM-BSR(0): **bootstrap from non-RPF neighbor** 155.1.146.6

IGMP Filtering

ip igmp access-group <ACL>

Standard ACL:
`permit 239.1.1.0 0.0.0.255`
`allow all groups within 239.1.1.0/24 to be joined.`

Extended ACL:
`permit ip <srcip> <src-mask> <group-ip> <group-mask>`
Allows to specify source and group

Multicast Rate Limiting

```
ip multicast rate-limit {in | out} group-list <acl>  source-list <acl> <limit>
```

`limit` is specified in Kilobits per second

ip multicast rate-limit out group-list 100 128
ip multicast rate-limit out 512 Aggregate max flow Over all is 512

If limit is "forgotten" it results in ALL multicast traffic being dropped!

show commands:

Show ip mroute
(155.1.146.6, 239.1.1.100), 00:00:04/00:02:57, flags: LJT
Incoming interface: Serial1/0.1, RPF nbr 155.1.0.5
Outgoing interface list:
FastEthernet0/0, Forward/Dense, 00:00:04/00:00:00, **limit 256 kbps**

How to check that the RP/Group mapping has been learned by BSR?

R1#show ip pim rp mapping
PIM Group-to-RP Mappings
Group(s) 224.0.0.0/4
RP 150.1.5.5 (?), v2
Info source: 150.1.5.5 (?), **via bootstrap**, **priority 0**, holdtime 150
Uptime: 00:05:23, expires: 00:02:06

ip igmp limit <N>

Explained:

Used globaly:

Allows only the configured count of multicast groups over all multicast enabled interfaces.

Per Interface:

Limits the number of multicast groups joined on this interface.

Check for:

Ip igmp limit

And

Ip igmp access-group

With a show command:

```
Interface fa0/0
Ip igmp limit 10
Ip igmp filter IGMP_FILTER


show ip igmp interface fastEthernet 0/0
...
Inbound IGMP access group is IGMP_FILTER
...
Interface IGMP State Limit : 1 active out of 10 max
...
```

Bidirectional PIM

Shared tree (*,G):

Enable PIM Bidir an all routers:
ip pim bidir-enable

Statically assign the RP:
ip pim rp-address <IP> <ACL> bidir

Using Auto-RP:
ip pim send-rp-announce <interface> scope <TTL> group-list <ACL> bidir

Using BSR:
ip pim rp-candidate <interface> group-list <ACL> bidir

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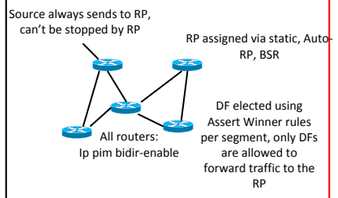
Multicast

Bidirectional PIM



Establish a DVMRP connection:

```
ip dvmrp interoperability

access-list 40 permit 155.1.0.0 0.0.255.255

interface FastEthernet0/1
ip dvmrp metric 1 list 40 eigrp 100

interface tunnel 0
ip unnumbered Loopback0
ip pim dense-mode
tunnel source Loopback0
tunnel destination 204.12.1.100
tunnel mode dvmrp
```

Show ip msdp peer

Output:

```
SW1#show ip msdp peer
MSDP Peer 150.1.5.5 (?), AS 200 (configured AS)
  Connection status:
    State: Listen, Resets: 0, Connection source: Loopback0 (150.1.7.7)
    Uptime(Downtime): 00:00:12, Messages sent/received: 0/0
    Output messages discarded: 0
    Connection and counters cleared 00:00:12 ago
  SA Filtering:
    Input (S,G) filter: none, route-map: none
    Input RP filter: none, route-map: none
    Output (S,G) filter: none, route-map: none
    Output RP filter: none, route-map: none
  SA-Requests:
    Input filter: none
  Peer ttl threshold: 0
  SAs learned from this peer: 0
  Input queue size: 0, Output queue size: 0
```

Bidirectional PIM

Identify DFs and the RP with show ip mroute

```
DF routers will show:
(*, 238.1.1.1), 00:08:15/00:02:59, RP 150.1.5.5, flags: BCL
Bidir-Upstream: Serial0/0.1, RPF nbr 155.1.0.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:08:15/00:02:40
Serial0/0.1, Bidir-Upstream/Sparse, 00:08:15/00:00:00

The RP will NOT show Bidir-Upstream !
```

Verify DVMRP packet generation:

```
R2#debug ip dvmrp detail
DVMRP(0): Building Report for FastEthernet0/1
DVMRP(0): Report 155.1.146.0/24, metric 32
DVMRP(0): Report 155.1.10.0/24, metric 1
DVMRP(0): Report 155.1.8.0/24, metric 1
DVMRP(0): Report 150.1.5.0/24, metric 1
DVMRP(0): Report 150.1.10.0/24, metric 1
DVMRP(0): Report 150.1.8.0/24, metric 1
DVMRP(0): Delay Report on FastEthernet0/1
DVMRP(0): 12 unicast, 0 MBGP, 0 DVMRP routes advertised
DVMRP(0): Send Report on FastEthernet0/1 to 224.0.0.4
```

show ip msdp summary

Output:

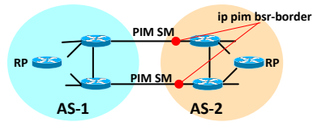
```
SW1#show ip msdp summary
MSDP Peer Status Summary
Peer Address     AS  State   Uptime/  Reset SA    Peer Name
                                  Downtime Count Count
150.1.5.5        200 Up      00:00:57 0     0     ?
150.1.8.8        200 Up      00:01:35 0     0     ?
```

Source Specific Multicast

```
Specify groups that should use SSM:

ip pim ssm range default | range <Standard-ACL>

Default = 232.0.0.0/8

Interface X
ip igmp version 3

Interface Y
ip igmp version 3
ip igmp join 232.2.2.2 source 2.2.2.2
```

Multicast BGP Extension

```
router bgp 2
address-family ipv4 multicast
neighbor 1.1.1.1 activate
```




```
router bgp 1
address-family ipv4 multicast
neighbor 2.2.2.2 activate
```

debug ip msdp detail

While pinging 239.1.1.1:

```
start_index = 0, mroute_cache_index = 0, Qlen = 0
Sent entire mroute table, mroute_cache_index = 0, Qlen = 0
start_index = 0, sa_cache_index = 0, Qlen = 0
Sent entire sa-cache, sa_cache_index = 0, Qlen = 0
Received 120-byte TCP segment from 150.1.5.5
Append 120 bytes to 0-byte msg 26 from 150.1.5.5, qs 1
WAVL Insert SA Source 155.1.10.10 Group 239.1.1.1 RP 150.1.5.5 Successful
Forward decapsulated SA data for (155.1.10.10, 239.1.1.1) on Vlan79
Received 120-byte TCP segment from 150.1.5.5
Append 120 bytes to 0-byte msg 27 from 150.1.5.5, qs 1
WAVL Insert SA Source 155.1.108.10 Group 239.1.1.1 RP 150.1.5.5 Successful
Forward decapsulated SA data for (155.1.108.10, 239.1.1.1) on Vlan79
....
```

Source Specific Multicast

Show ip igmp groups x.x.x.x detail

```
show ip igmp groups 232.6.6.6 detail
Flags: L - Local, U - User, SG - Static Group, VG - Virtual Group,
SS - Static Source, VS - Virtual Source,
Ac - Group accounted towards access control limit
Interface: FastEthernet0/0
Group: 232.6.6.6
Flags: SSM
Uptime: 00:26:06
Group mode: INCLUDE
Last reporter: 155.1.146.6
Group source list: (C - Cisco Src Report, U - URD, R - Remote, S -
Static,
V - Virtual, M - SSM Mapping, L - Local,
Ac - Channel accounted towards access control
limit)
Source Address Uptime v3 Exp CSR Exp Fwd Flags
150.1.10.10 00:26:06 00:02:54 stopped Yes R
```

Show ip bgp ipv4 multicast summary

Output:

```
R6#show ip bgp ipv4 multicast summary
....
....
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
150.1.7.7       4   100      57      43        21    0    0 00:00:29        16
155.1.146.4     4   200      29      49        21    0    0 00:01:18         2
```

show ip pim rp-hash 239.1.1.1

Output:

```
R4#show ip pim rp-hash 239.1.1.1
  RP 150.1.5.5 (?), v2
    Info source: 150.1.10.10 (?), via bootstrap, priority 0, holdtime 150
         Uptime: 02:35:01, expires: 00:02:24
  PIMv2 Hash Value (mask 0.0.0.0)
    RP 150.1.5.5, via bootstrap, priority 0, hash value 623125189
    RP 150.1.8.8, via bootstrap, priority 0, hash value 613026582
```

Lowest hash is selected, if both are the same, highest RP IP wins.

Source Specific Multicast

Show ip igmp groups x.x.x.x detail

```
Rack1R1#show ip mroute 232.6.6.6 150.1.10.10
IP Multicast Routing Table

(150.1.10.10, 232.6.6.6), 00:26:09/00:02:26, flags: sTI
Incoming interface: Serial0/0.1, RPF nbr 155.1.0.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:26:09/00:02:26
```

MultiCast MSDP

ip msdp peer

ip msdp sa-limit x.x.x.x <nr>

```
ip msdp peer
ip msdp originator-id

ip msdp peer 2.2.2.2 connect-source Loop0 remote-as 2

ip msdp [vrf X] sa-limit {peer-address} sa-limit

%MSDP-4-SA_LIMIT: RP <RP address> for <mroute> exceeded sa-limit of
```

mtrace source group:

Once successful

Once failing, due to the group not joined

Successful:

```
SW3#mtrace 150.1.10.10 224.44.44.44
...
-2  155.1.79.7 PIM/MBGP  [150.1.10.0/24]
-3  155.1.37.3 PIM/MBGP  [150.1.10.0/24]
-4  155.1.0.5 [AS 200] PIM Reached RP/Core
[150.1.10.0/24]
```

Failed:

```
SW3#mtrace 150.1.10.10 239.1.1.4
...
..
-6  155.1.108.10 [AS 200] PIM  [150.1.10.0/24]
-7  150.1.10.10
```

PIM Reached RP/Core is missing!

DVMRP Interoperability

Globally enable:
ip dvmrp interoperability

PIM needs to be enabled!

Per interface:
ip dvmrp unicast-routing

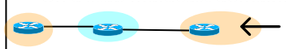
DVMRP summarizes groups by default, to disable summary:
no ip dvmrp auto-summary

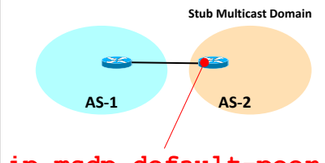
By default will only advertise directly connecteds

Redistribute static subnets:
Interface X
ip dvmrp metric <hops> list <access-list> protocol <process-id>

MultiCast MSDP

On a stub multicast domain:






```
ip msdp default-peer
```

ip msdp default-peer 10.1.1.1 prefix-list site-a

mtrace 150.1.10.10 239.1.1.1

Output:

```
SW3#mtrace 150.1.10.10 239.1.1.1
Type escape sequence to abort.
Mtrace from 150.1.10.10 to 155.1.79.9 via group 239.1.1.1
From source (?) to destination (?)
Querying full reverse path...
 0  155.1.79.9
-1  155.1.79.9 PIM/MBGP  [150.1.10.0/24]
-2  155.1.79.7 PIM/MBGP Reached RP/Core
[150.1.10.0/24]
-3  155.1.37.3 PIM/MBGP  [150.1.10.0/24]
-4  155.1.0.5 [AS 200] PIM Reached RP/Core
[150.1.10.0/24]
-5  155.1.58.8 [AS 200] PIM  [150.1.10.0/24]
-6  155.1.108.10 [AS 200] PIM  [150.1.10.0/24]
```

Multicast

Anycast RP

intra-domain solution

- PIM Joins are being sent to the closest RP
- Groups of RPs use the same IP address.
- To maintain consistent source information configure MSDP sessions.

1. Use the same IP address on all routers as the candidate RP IP address. (Propagate via Auto-RP or BSR)

OR

2. Using different IP addresses on every router. source MSDP sessions and link all candidate RPs in a mesh.
   Manually specify the MSDP originator ID to be different on every RP

Anycast RP

intra-domain solution

Config:

R1#
interface **loopback 0**
ip address **9.9.9.9** 255.255.255.255
interface loopback 1
ip address **1.1.1.1** 255.255.255.255
ip msdp **peer 2.2.2.2** connect-source loopback 1
ip msdp originator-id loopback1
ip pim **rp-address 9.9.9.9**

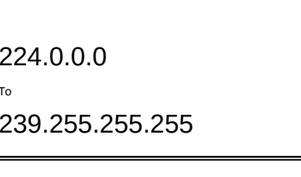
R2#
interface **loopback 0**
ip address **9.9.9.9** 255.255.255.255
interface loopback 1
ip address **2.2.2.2** 255.255.255.255
ip msdp **peer 1.1.1.1** connect-source loopback 1
ip msdp originator-id loopback1
ip pim **rp-address 9.9.9.9**

Anycast RP

intra-domain solution

Diagram:

AnyCast RP



Routers will use closest AnyCast RP

`show ip msdp sa-cache`

Output:

R5#show ip msdp sa-cache
MSDP Source-Active Cache - 3 entries
(150.1.10.10, 239.1.1.1), RP 150.1.8.8, MBGP/AS 200, 00:00:26/00:05:34, Peer 150.1.8.8

(155.1.10.10, 239.1.1.1), RP 150.1.8.8, MBGP/AS 200, 00:00:26/00:05:34, Peer 150.1.8.8

(155.1.108.10, 239.1.1.1), RP 150.1.8.8, MBGP/AS 200, 00:00:25/00:05:34, Peer 150.1.8.8

Catalyst Multicast VLAN Registration

(MVR)

Int Gi0/2
mvr type receiver
Switchport access **vlan 20**

Int Gi0/1
mvr type source
Switchport access **vlan 10**

mvr vlan 10
mvr
mvr group 224.9.9.9

Int vlan [10,20]
Ip address x.x.x.x
ip pim sparse-dense-mode

no ip multicast-routing distributed !!

Catalyst IGMP Profiles

Switches allow filtering of IGMP messages sent by directly connected hosts to multicast routers similar to the `ip igmp accessgroup`

applies ingress to layer 2 ports only

ip igmp profile 1
permit
range 232.0.0.0 232.255.255.255

interface FastEthernet 0/4
ip igmp filter 1

Catalyst IGMP Snooping

IGMP snooping is enabled by default on Catalyst multi-layer switches

to disable IGMP snooping globally:
`no ip igmp snooping`

or disable per vlan
`no ip igmp snooping vlan <VLAN-ID>`

Statically configure a port to a router:
`ip igmp snooping vlan <vlan-id> mrouter interface <interface-id>`

switchports with **only one host** attached, can immediately leave the group if a leave is heard:
ip igmp snooping vlan <vlan-id> immediate-leave

`show ip igmp snooping vlan 146`

Output:

SW1#show ip igmp snooping vlan 146
Global IGMP Snooping configuration:

IGMP snooping : Enabled
IGMPv3 snooping (minimal) : Enabled
Report suppression : Enabled
TCN solicit query : Disabled
TCN flood query count : 2
Last Member Query Interval : 1000
Vlan 146:

IGMP snooping : Enabled
IGMPv2 immediate leave : Enabled
Explicit host tracking : Enabled
Multicast router learning mode : pim-dvmrp
Last Member Query Interval : 1000
CGMP interoperability mode : IGMP_ONLY

`show ip igmp snooping mrouter vlan <nr>`

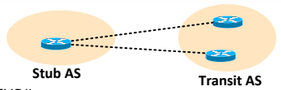
`show ip igmp snooping groups vlan <nr>`

Output:

```
Rack1SW1#show ip igmp snooping mrouter vlan 146
Vlan ports
---- -----
146 Fa0/1(dynamic), Fa0/19(dynamic)
```

```
SW4#show ip igmp snooping groups vlan 146
Vlan Group Version Port List
------------------------------------------
146 239.1.1.100 v2 Fa0/4, Fa0/13, Fa0/16
```

MSDP default-peer



STUB#
ip msdp peer 1.2.3.4 connect-source Lo0
ip msdp peer 9.8.7.6 connect-source Lo0
ip msdp default-peer 1.2.3.4
ip msdp default-peer 9.8.7.6

Active default peer is the first in the config.
SAs are not accepted from 9.8.7.6 unless 1.2.3.4 fails. (accepts only a single peer)

Ethernet MAC address range for multicast

IP Address range for MultiCast

01:00:5E:00:00:00
To
01:00:5E:7F:FF:FF

224.0.0.0
To
239.255.255.255

Limiting multicasts IPv4 boundaries:

ip multicast threshold <TTL-value>

---

ip multicast boundary **10**

accesslist **10** deny 224.x.x.x 0.0.0.0

CGMP messages:

Type	GDA	USA	Function
Join			
Join			
Leave			
Leave			
Leave			
Leave			

Type	GDA	USA	Function
Join	0	Router MAC	Identify Router Port
Join	Group MAC	Member MAC	Adds member
Leave	Group MAC	Member MAC	Removes member
Leave	Group MAC	0	Removes Group
Leave	0	Router MAC	Removes all groups Affected switch
Leave	0	0	Removes all groups all switches

Protocol	Implicit Join	Explicit Join
DVMRP		
MOSPF		
PIM-DM		
PIM-SM		
CBT		

Protocol	Implicit Join	Explicit Join
DVMRP		
MOSPF	X	X
PIM-DM		
PIM-SM	X	X
CBT		X
	Sender originates	Hosts join via IGMP

Protocol	Source-Based-Tree (S,G) RPT	Shared-Tree (*,G) SPT
DVMRP		
MOSPF		
PIM-DM		
PIM-SM		
CBT		

Protocol	Source-Based-Tree (S,G) RPT	Shared-Tree (*,G) SPT
DVMRP	X	
MOSPF	X	
PIM-DM	X	
PIM-SM		X
CBT		X

PIMv2 DM messages:

0 Hello
3 Join/Prune
6 Graft
7 Graft-Ack
5 Assert

PIMv2 SM messages:

0 Hello
4 Bootstrap
8 Candidate-RP-Advertisement
3 Join/Prune
5 Assert
1 Register
2 Register-Stop

What dangers are there using the following command:

RTR(config)#ip pim send-rp-discovery Loopback0 scope 5

RTR(config)#ip pim send-rp-discovery Loopback0 scope 5
No PIM interface ignored in accepted command.
RTR(config)#
Results in:

Ip pim send-rp-discovery scope 5

MAPPING AGENT, WILL NOT WORK, Loopback 0 has to be enabled with PIM first!!!!

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

Colin

http://www.flashcardguy.ch

Multicast

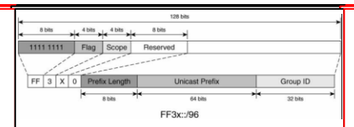
Explain two ways on how to perform RP load balancing for multicast groups?

1. use group lists:

2. use hash values:

Unicast-Prefix based Multicast Address

Similar to GLOB under IPv4:



IPv6 Unicast Address:

2001:100:abc:1::/64

Global Multicast Address:

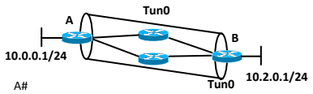
FF3E:0040:**2001:100:abc:1**:11FE:11EE

What types of Multicast RP assignments are there?

- **Static RP**
- **Bootstrap Router (BSR)**
- **Auto-RP**
- **Anycast-RP**
- **Phantom RP**
- **Embedded RP**

Explain how to Load Balance MultiCast traffic over an Equal cost path?

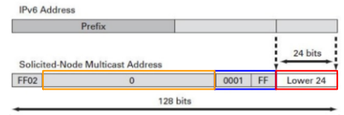
MultiCast Load balance over equal cost Path



A#
int Tun0
ip addr 1.1.1.1 255.255.255.0
ip pim sparse-dense-mode
tunnel source lo0
tunnel destination x.x.x.x

Ip mroute 2.2.2.2 255.255.255.255 **tunnel0**

IPv6 Solicited-Node Multicast Address:



—24bits—

2001:100:abc:1:0:0:aa**bb:ccdd**/64

FF02::1:FF**bb:ccdd**

Multicast Vlan Registration

MVR

Show commands:

show commands:

show mvr

show mvr interface

show mvr members

show ip igmp groups

mvr mode dynamic
Only forwards traffic if receivers are attached on receiver side

Explain mrinfo's output:

Router# **mrinfo**
192.1.7.37 (b.x.com) [version cisco 11.1] [flags: PMSA]:
192.1.7.37 -> 192.1.7.34 (s.x.com) [1/0/pim]
192.1.7.37 -> 192.1.7.47 (d.x.com) [1/0/pim/querier/leaf]
192.1.7.37 -> 192.1.7.44 (d2.x.com) [1/0/pim]
131.9.26.10 -> 131.9.26.9 (su.bbnplanet.net) [1/32/pim]

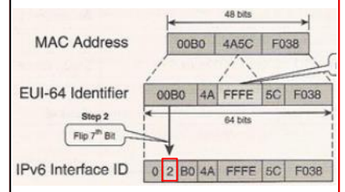
P = prune-capable
M = mtrace-capable
S = SNMP-capable
A = Auto-RP-capable

Router# **mrinfo**
192.1.7.37 (b.x.com) [version cisco 11.1] [flags: PMSA]:
192.1.7.37 -> 192.1.7.34 (s.x.com) [1/0/pim]
192.1.7.37 -> 192.1.7.47 (d.x.com) [1/0/pim/querier/leaf]
192.1.7.37 -> 192.1.7.44 (d2.x.com) [1/0/pim]
131.9.26.10 -> 131.9.26.9 (su.bbnplanet.net) [1/32/pim]

Metric/no TTL threshold set(0)/Protocol/Role/Type

IPv6

EUI-64 Interface ID generation:



Show ip mroute active

Output:

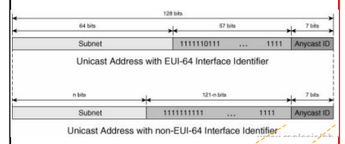
```
Router# show ip mroute active
Active IP Multicast Sources - sending >= 4 kbps

Group: 239.1.2.3, (?)
   Source: 10.0.0.1 (?)
     Rate: 20 pps/4 kbps(1sec), 4 kbps(last 30 secs), 4 kbps(life avg)
```

Explain the following output of mtrace:

R6#**mtrace** 10.0.12.1
Type escape sequence to abort.
Mtrace from 10.0.12.1 to 10.0.56.6 via RPF
From source (?) to destination (?)
Querying full reverse path...
0 10.0.56.6
-1 10.0.56.6 PIM [10.0.12.0/24]
-2 10.0.56.5 PIM [10.0.12.0/24]
-3 10.0.45.4 PIM/Static [10.0.12.1/32]
-4 10.0.45.4 None No route
-5 10.0.12.1

R6#**mtrace** 10.0.12.1
Type escape sequence to abort.
Mtrace from 10.0.12.1 to 10.0.56.6 via RPF
From source (?) to destination (?)
Querying full reverse path...
0 10.0.56.6
-1 10.0.56.6 PIM [10.0.12.0/24]
-2 10.0.56.5 PIM [10.0.12.0/24]
-3 10.0.45.4 **PIM/Static** [10.0.12.1/32] ! static mroute
-4 10.0.45.4 **None No route** ! Intentionally disabled PIM, ! -> RPF fails

IPv6 AnyCast Address format:



AnyCast ID field can take following values:

00 - 7D, 7F

7E is reserved for MIPv6

show ip pim interface count

output

```
Router# show ip pim interface count

State: * - Fast Switched, D - Distributed Fast Switched
       H - Hardware Switching Enabled
Address          Interface                FS Mpackets In/Out
172.31.100.2     GigabitEthernet0/0/0     *    4122/0
10.1.0.1         GigabitEthernet1/0/0     *    0/3193
```

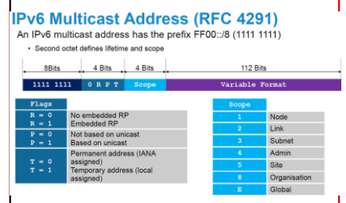
Explain the mstat syntax:

mstat 1.1.1.1 2.2.2.2 224.9.9.9

source destination group

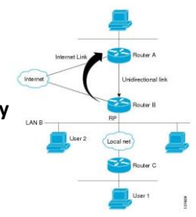
mstat 1.1.1.1 2.2.2.2 224.9.9.9

IPv6 Multicast Address format:



FF00::/8

IGMP Proxy



Upstream UDL Device for IGMP UDLR

Interface fa0/x
Ip pim dense-mode
ip igmp unidirectional-link

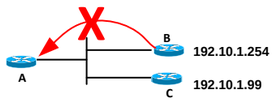
show ip igmp udlr
show ip igmp interface

Downstream UDL Device for IGMP UDLR

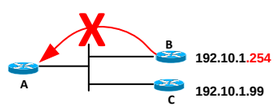
Interface **fa0/1**
Ip pim dense-mode
ip igmp unidirectional-link

interface loopback 0
Ip pim dense-mode
ip igmp helper-address udl fa0/1
ip igmp proxy-service

Interface fa0/2
Ip pim dense-mode
ip igmp mroute-proxy loopback 0
Request IGMP reports sent back to Lo0 for all groups in mroute table forwarded to fa0/2



Do not allow router B to build a PIM adjacency with Router A: (config on RTR A)



interface Fa0/0
ip pim neighbor-filter 75

access-list 75 deny 192.10.1.254
access-list 75 permit any

Scope Hex	Scope Binary	Description

Fill in the blanks

IPv6 Multicast Scope and values:

Scope Hex	Scope Binary	Description
1	0001	**Interface-local**
2	0010	**Link-local**
3	0011	**Subnet-local**
4	0100	**Admin-local**
5	0101	**Site-local**
8	1000	**Organizational-local**
E	1110	**Global-local**

Multicast Service Reflection

"Multicast NAT"

interface Vif1
ip pim sparse-mode
ip service reflect Ethernet 0 destination 224.1.1.0 to 10.3.3.0 mask-len 24 source 10.1.1.2

To be continued....

Found under **Implementing Multicast Service Reflection**

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Multicast

ECMP Multicast Load Splitting based on: S,G S,G next-hop	**ip multicast multipath** *Based on source address* **ip multicast multipath s-g-hash basic** Source and group address S-G-Hash algorithm. **ip multicast multipath s-g-hash next-hop-based** source, group, and next-hop address using the next-hop-based algorithm Alternative **- Tunnel interface (static mroutes)**				
Multicast CAC **Multicast Limit**	**ip multicast limit out acl-basic 75** **ip multicast limit out acl-premium 25** **ip multicast limit out acl-gold 25** **ip multicast limit out ACL <kbps permitted>** **debug ip mrouting limits** [group-address] **show ip multicast limit** type number **clear ip multicast limit**				
What info does the following command provide: **show ip multicast:**	R2#**show ip multicast** Multicast Routing: **disabled** Multicast **Multipath**: **disabled** Multicast Route limit: **No limit** Multicast **Fallback group mode**: Sparse Number of **multicast boundaries** configured with filter-autorp option: 0				

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IPv6

IPv6
interface serial 0/0/0

Frame map / show frame-relay map output:

interface Serial0/0/0
encapsulation frame-relay
ipv6 address **FE80::5 link-local**
frame-relay map ipv6 FE80::1 501 broadcast

R5#**show frame-relay map**
Serial0/0/0 (up): **ipv6** FE80::2 dlci 502(0x1F6,0x7C60), static, broadcast,
CISCO, status defined, active

IPv6 Auto-Configuration

Announce prefix via ND RA, but **hosts** are **not allowed to use it for autoconfig:**

ipv6 nd prefix fc00:1:0:58::/64 14400 14400 **no-autoconfig**

Lifetime set to 4 hours

Announce prefix via ND RA, hosts are **allowed to use it:**

ipv6 nd prefix fc00:1:0:85::/64 14400 14400

`ipv6 nd prefix:`

manipulates the IPv6 network prefixes included into RA. By default, all prefixes are included.

Ping ipv6 xx.x.x

On 12.2-24T:

R4#**ping ipv6 FE80::5**
Output Interface: serial0/0/0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to FE80::5, timeout is 2 seconds:
Packet sent with a source address of FE80::4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
R4#

IPv6 ULA address config:

interface FastEthernet 0/0
ipv6 address **fc00**:1:0:58::5/64
ipv6 address fc00:1:0:85::5/64

IPv6
Auto-Configuration:

Explain its function:

With auto-configuration, an IPv6 host may automatically learn the IPv6 prefixes assigned to the local segment, as well as determine the default routers on that segment.

Client:
ipv6 address autoconfig default

Router:
ipv6 nd ...

IPv6

Unique Local Address

ULA format:

FC00 (7 bits)
Unique ID (41 bits)
Link ID (16 bits)
Interface ID (64 bits).

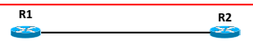
IPv6 ND RA:

advertise itself as the

default router every 40 seconds
Lifetime interval 60 seconds:

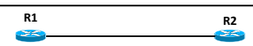
ipv6 address fc00:1:0:85::5/64
ipv6 nd prefix fc00:1:0:85::/64 14400 14400

`ipv6 nd ra-interval 40`
`ipv6 nd ra-lifetime 60`



R2#
interface FastEthernet 0/0
ipv6 address fc00:1:0:85::5/64
ipv6 nd prefix fc00:1:0:85::/64 14400 14400
ipv6 nd ra-interval 40
ipv6 nd ra-lifetime 60
no ipv6 nd suppress-ra

On R2:
show ipv6 int gi0/0 prefix:



show ipv6 int gi0/0 prefix:

Shows R2 **announced prefixes via ND RA**'s:

R2#show ipv6 int gi0/0 prefix
IPv6 Prefix Advertisements GigabitEthernet0/0
Codes: **A** - **Address**, **P** - **Prefix-Advertisement**, O - Pool
U - Per-user prefix, D - Default
N - Not advertised, C - Calendar

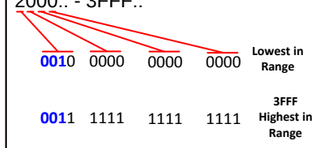
default [LA] Valid lifetime 2592000, preferred lifetime 604800
AP FC00:1:0:58::/64 [L] Valid lifetime 14400, preferred lifetime 14400
AP FC00:1:0:85::/64 [LA] Valid lifetime 14400, preferred lifetime 14400

IPv6
Global Aggregatable Addressing

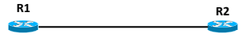
1/8th of the total IPv6 address space is currently allocated: 2001::/16

binary prefix 001 (2000::/3)

2000:: - 3FFF::



R1 learns its IPv6 address automatically and use R2 as its default gateway

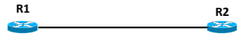


R1-Client#
interface fa0/1

R2#
interface FastEthernet 0/0

Fill in the blanks:

R1 learns its IPv6 address automatically and use R2 as its default gateway



R1-Client#
interface fa0/1
ipv6 address autoconfig default

R2#
interface FastEthernet 0/0
ipv6 address fc00:1:0:85::5/64
ipv6 nd prefix fc00:1:0:85::/64 14400 14400
ipv6 nd ra-interval 40
ipv6 nd ra-lifetime 60
no ipv6 nd suppress-ra

RIPng

Config:

ipv6 unicast-routing

interface FastEthernet 0/0
ipv6 address fc00:1:0:1::1/64
ipv6 rip RIPNG enable

IPv6
EUI-64 Addressing

interface FastEthernet 0/0.146
ipv6 address 2001:1:0:146::**/64 eui-64**

Results in:

2001:1:0:146:213:7FFF:FE7F:62A0

0000 0010 0000 0001
Flipping the 2nd bit!

FFFE is inserted

MAC: 0013 7F7F 62A0

Use:
show ipv6 interface

`ipv6 nd ra-interval:`

specifies the periodic interval to send RAs.

show ipv6 route rip

Output:

R6#**show ipv6 route rip**
IPv6 Routing Table - 10 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
U - Per-user Static route
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS
O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1,
ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

R FC00:1:0:1::/64 [120/2]
via FE80::213:7FFF:FE7F:62A0, Gi0/0.146
R FC00:1:0:4::/64 [**120/2**]
via FE80::226:BFF:FE57:BA61, Gi0/0.146

show ipv6 interface

of EUI-64 address:

R1#**show ipv6 interface**
FastEthernet0/0 is up, line protocol is up
IPv6 is enabled, link-local address is
FE80::213:7FFF:FE7F:62A0
Global unicast address(es):
2001:1:0:146:213:7FFF:FE7F:62A0,
subnet is 2001:1:0:146::/64 [EUI]
Joined group address(es):
FF02::1
FF02::2
FF02::1:FF7F:62A0
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
Hosts use stateless autoconfig for addresses.

`ipv6 nd ra-lifetime:`

specifies the validity interval of the router's IPv6 address

Output of

debug ipv6 rip

R6#debug ipv6 rip
RIP Routing Protocol debugging is on
Rack1R6#
RIPng: **response received** from FE80::20D:65FF:FE84:6560 on FastEthernet0/0.146 for RIPNG
src=FE80::20D:65FF:FE84:6560 (Fa0/0.146) **dst=FF02::9**
sport=521, dport=521, length=52
command=2, version=1, mbz=0, #rte=2
tag=0, metric=1, prefix=2001:1:0:146::/64
tag=0, metric=1, prefix=FC00:1:0:1::/64

Sending multicast update on Loopback100 for RIPNG
src=FE80::20C:85FF:FEC1:FC60
dst=FF02::9 (Loopback100)
sport=521, dport=521, length=92
command=2, version=1, mbz=0, #rte=4
tag=0, metric=1, prefix=2001:1:0:146::/64

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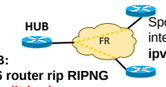
IPv6

RIPng over NBMA



HUB:
ipv6 router rip RIPNG
no split-horizon

interface Serial 0/0/0
ipv6 rip RIPNG enable

Do not forget to use the `broadcast` keyword with the **IPv6 mapping statements** on DLCIs

NBMA networks the **next-hop** is always going to be a **link-local address**

RIPng Default Routing

interface g0/0.146
ipv6 rip RIPNG **default-information originate metric 5**

IPv6 Summarization

FC00:1:0:5::/64
FC00:1:0:8::/64

FC00:1:0:5::/64
FC00:1:0:8::/64

0000 0000 0000 0**0101** = 5
0000 0000 0000 0**1000** = 8

FC00:1::/60

Shifting 4 bits, to the left ending up with a /60 as summary

Show ipv6 rip database

Output:

R5#**show ipv6 rip database**
RIP **process "RIPNG"**, local RIB
2001:1:0:146::/64, metric 2, **installed**
Serial0/0/0/FE80::1, expires in 179 secs
Serial0/0/0/FE80::4, expires in 157 secs
2001:1:0:1234::/64, **metric 2**
Serial0/0/0/FE80::1, expires in 179 secs
Serial0/0/0/FE80::4, expires in 157 secs
FC00:1:0:1::/64, metric 2, **installed**
Serial0/0/0/FE80::1, expires in 179 secs

In routing table

EIGRPv6 Enable process:

```
ipv6 router eigrp <AS-Nr>
no shutdown
```

EIGRPv6 Summarization

With **IPv6 EIGRP** it is **not possible** to configure a **leak-map** to leak more specifics!

```
interface Serial 0/0/0
ipv6 summary-address eigrp 100 FC00:1::/60
```

RIPng Summarization

Interface fa0/x
ipv6 rip RIPNG enable
ipv6 rip RIPNG **summary-address** FC00:1::**/61**

EIGRPv6 authentication config:

key chain EIGRPV6
key 1
key-string CISCO

interface FastEthernet 0/1
ipv6 eigrp 100
ipv6 authentication mode eigrp 100 md5
ipv6 authentication key-chain eigrp 100 **EIGRPV6**

Ipv6 router eigrp 100
No shutdown

EIGRPv6 Prefix Filtering

Distribute-Lists

Blocking prefix to enter routing table

ipv6 prefix-list PFX-1 seq 10 deny FC00:1:0:6::/64
Ipv6 prefix-list PFX-1 seq 20 permit ::/0 le 128

ipv6 router eigrp 100
distribute-list prefix-list PFX-1 in

RIPng Prefix Filtering

Denying a prefix in, allowing all others:

ipv6 prefix-list PFX deny fc00:1:0:6::/64
ipv6 prefix-list PFX permit ::/0 le 128

ipv6 router rip RIPNG
distribute-list prefix-list PFX in

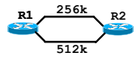
Explain:

```
ipv6 split-horizon eigrp 100
```

```
no ipv6 next-hop-self eigrp
```

EIGRPv6 Metric Manipulation

EIGRPv6 can only implement equal cost loadbalancing due to CEF IPv6 limitations.



ipv6 router eigrp 100
metric weight 0 0 0 **1** 0 0
variance 3

interface Serial 0/0
delay 2000

interface Serial 0/1
delay 1000

Manipulate path metrics to adjust for unequal load balancing settings

RIPng Metric Manipulation

Offset-list

Interface serial 0/0/0
ipv6 rip RIPNG enable
ipv6 rip RIPNG metric-offset 2

You only need link local addresses for RIP to work!

EIGRPv6

Usefull show commands to troubleshoot

```
show ipv6 eigrp 100 interfaces
```

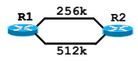
```
show ipv6 protocols
```

```
show ipv6 eigrp neighbors
```

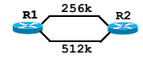
```
show ipv6 eigrp interfaces
detail fastEthernet X
```

(gives clues about autentiation type / used key-chain)

EIGRPv6 checking unequal load balancing



ipv6 router eigrp 100
metric weight 0 0 0 **1** 0 0
variance 3



interface Serial 0/0
delay 2000

interface Serial 0/1
delay 1000

```
show ipv6 route FC00:1::/60
```

```
show ipv6 eigrp topology FC00:1::/60
Topology should have 2 entries
```

```
show ipv6 eigrp topology FC00:1::/60
Check that CEF equally allocates the 16
buckets
```

IPv6 router rip outputs after applying offset-lists:

Previous:

After:

show ipv6 route FC00:1:0:1::/64

?

show ipv6 route FC00:1:0:1::/64

?

IPv6 router rip outputs after applying offset-lists:

Previous:

After:

show ipv6 route FC00:1:0:1::/64

R FC00:1:0:1::/64 [120/2]
via FE80::1, **Serial0/0**

R FC00:1:0:1::/64 [120/2]
via FE80::22, **Serial0/1**

show ipv6 route FC00:1:0:1::/64

R FC00:1:0:1::/64 [120/2]
via FE80::1, **Serial0/0**

Make sure that RIP only uses one path, while serial0/1 is used as a backup connection, if serial0/0 fails.

Interface serial 0/1
ipv6 rip RIPNG enable
ipv6 rip RIPNG metric-offset 2

Show ipv6 cef <prefix> internal

Output:

Rack1R4#**show ipv6 cef FC00:1::/60 internal**
FC00:1::/60, epoch 0, RIB[I], refcount 4, per-destination sharing
sources: RIB
feature space:
IPRM: 0x00038000
ifnums:
Serial0/0/0(5): FE80::5
Serial0/1/0(6): FE80::213:1AFF:FE68:804C
path 65E7BFC8, path list 65F9332C, share 1/1, type attached nexthop, for IPv6
nexthop FE80::5 Serial0/0/0, adjacency IPV6 adj out of Serial0/0/0, addr FE80::5 65E7AAE0
path 65E7BC28, path list 65F9332C, share 1/1, type attached nexthop, for IPv6
nexthop FE80::213:1AFF:FE68:804C Serial0/1/0, adjacency IPV6 adj out of Serial0/1/0 65E79E60
output chain:
loadinfo 6655FD68, per-session, 2 choices, flags 0005, 8 locks
flags: Per-session, for-rx-IPv6
16 hash buckets
< 0 > IPV6 adj out of Serial0/0/0, addr FE80::5 65E7AAE0
< 1 > IPV6 adj out of Serial0/1/0 65E79E60
.....
Subblocks:
None

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IPv6

EIGRPv6 Default Routing

using redistribution

using summarization

Redistribution:
EIGRP an external route with an AD of 170.
Allows metric manipulations!

Summarization:
summarize all routes, no leak-map!
Metric is calculated, not changeable

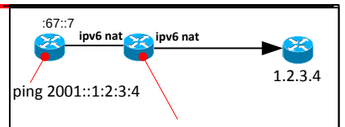
```
interface Fa0/1
ipv6 summary-address eigrp 100 ::/0 5
```

Show ipv6 route ospf

C / L / S / R / B …. :

```
show ipv6 route codes:
C   - Connected
L   - Local
S   - Static
R   - RIP
B   - BGP
U   - Per-user Static route
I1  - ISIS L1
I2  - ISIS L2
IA  - ISIS interarea
IS  - ISIS summary
O   - OSPF intra
OI  - OSPF inter,
OE1 - OSPF ext 1
OE2 - OSPF ext 2
ON1 - OSPF NSSA ext 1
ON2 - OSPF NSSA ext 2
```

debug ipv6 nat detailed



debug ipv6 nat detailed

NOT GOOD:
IPv6 NAT: Dropping v6tov4 packet

GOOD:
ipv6nat_find_entry_v4tov6:

IPv6 autoconfiguration

Administrative Distance

For default routes:

Ipv6 autoconfiguration has a Admin Distance of 1 and could overwrite any routing protocol speaking for an injected default route!

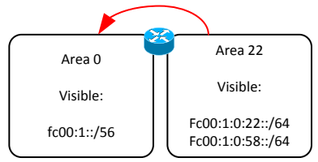
```
SW2#show ipv6 route
IPv6 Routing Table - Default - 12 entries

S ::/0 [1/0]
via FE80::213:1AFF:FE68:B04C, Vlan58
```

EIGRPv6 was configured, but autoconfigs default route was used instead!

OSPFv3 Summarization

ipv6 router ospf 1
area 22 range fc00:1::/56



IPv6 address types:

Unspecified Address:	**0:0:0:0:0:0:0:0**
Loopback:	**0:0:0:0:0:0:0:1**
IPv4-compatible-IPv6 addr:	**0:0:0:0:0:0:IPv4**
IPv4-mapped IPv6 addr:	**0:0:0:0:0:FFFF:IPv4**

OSPFv3

Basic config:

ipv6 unicast-routing

ipv6 router ospf 1
router-id 150.1.7.7

interface Vlan 67
ipv6 ospf hello-interval 1
ipv6 ospf 1 area 0

IPv6 Redistribution

redistribute <protocol> will not redistribute the locally connected

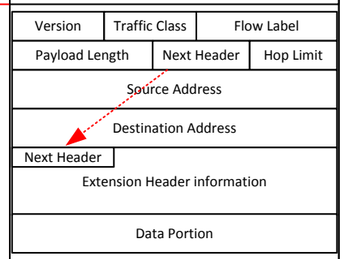
```
ipv6 router ospf 1
redistribute rip RIPNG metric 8
redistribute eigrp 100 metric 8
redistribute connected metric 8
```

```
ipv6 router rip RIPNG
redistribute eigrp 100 include-connected metric 8
redistribute ospf 1 include-connected metric 8
```

```
ipv6 router eigrp 100
redistribute rip RIPNG include-connected metric 1000 0 255 1 1500
redistribute ospf 1 include-connected metric 1000 0 255 1 1500
```

IPv6 Packet header

Image:



OSPFv3 Virtual Links

ipv6 router ospf 1
area 37 virtual-link 150.1.7.7

```
SW1#show ipv6 ospf interface fastEthernet 0/3
FastEthernet0/3 is up, line protocol is up (connected)
Link Local Address FE80::212:1FF:FE31:41, Interface ID 1021
Area 37, Process ID 1, Instance ID 0, Router ID 150.1.7.7
Network Type POINT_TO_POINT, Cost: 1
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:01
Index 1/1/2, flood queue length 0
Next 0x0(0)/0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
Adjacent with neighbor 150.1.3.3
Suppress hello for 0 neighbor(s)
```

show ipv6 ospf interface fa0/3

Output:

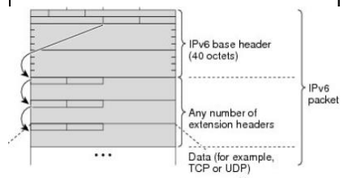
IPv6 Filtering

ipv6 access-list FILTER_OUT
permit tcp fc00:1:0:67::/64 any eq 80
permit tcp fc00:1:0:67::/64 any range 20 21
permit udp fc00:1:0:67::/64 any eq 43

interface Serial 1/0
ipv6 traffic-filter FILTER_OUT **out**

IPv6 packet extension header

Image:

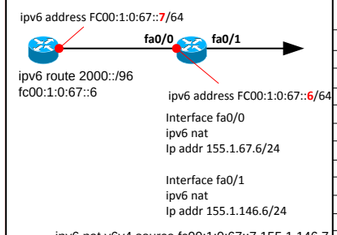


IPv6 packet extension header

Order	Header Type	Next Header Code
1		-
2		0
3		60
4		43
5		44
6		51
7		50
8		60
9		135
		59
Upr L		6
Upr L		17
Upr L		58

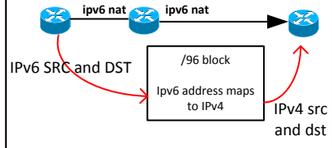
Order	Header Type	Next Header Code
1	Basic IPv6 header	-
2	Hop-by-Hop Options	0
3	Destination options (with routing options)	60
4	Routing header	43
5	Fragment header	44
6	Authentication header	51
7	Encapsulation Security Payload header	50
8	Destination Options	60
9	Mobility header	135
	No next header	59
Upr L	TCP	6
Upr L	UDP	17
Upr L	ICMPv6	58

IPv6 NAT-PT



IPv6 NAT-PT

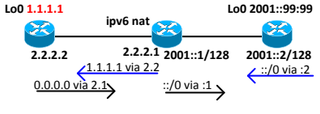
Drawing / rules

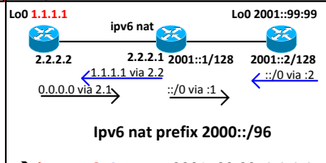


1) Rules to translate IPv4 source addrs to IPv6 addrs
2) Rules to translate IPv6 source addrs to IPv4 addrs
3) The /96 prefix to map the IPv4 address space to

Explain IPv6 NAT-PT

NAT statements:





Ipv6 nat prefix 2000::/96

➔ **ip nat v6v4 source** 2001::99:99 **1.1.1.1**
➔ **ip nat v4v6 source** 2.2.2.2 2000::960B:202

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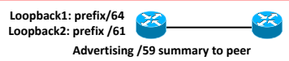
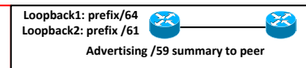
IPv6

IPv6 MP-BGP:





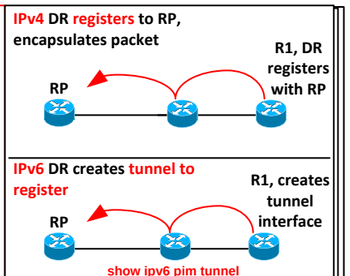

```
interface Loopback 101
ipv6 address 2003:1:0:1::1/64

interface Loopback 102
ipv6 address 2003:1:0:11::11/61

router bgp 100
address-family ipv6 unicast
neighbor 2001:1:0:1234::5 remote-as 500
neighbor 2001:1:0:1234::5 activate
network 2003:1:0:1::/64
network 2003:1:0:10::/61
aggregate-address 2003:1::/59 summary-only
```

Show ipv6 pim interface

Output:

```
R5#show ipv6 pim interface
Interface                PIM  Nbr     Hello  DR
                              Count   Intvl  Prior
VoIP-Null0               off  0       30     1
  Address: ::
  DR    : not elected
GigabitEthernet0/0  on   0       30     1
  Address: FE80::221:A0FF:FE9A:F4C0
  DR    : this system
GigabitEthernet0/1  off  0       30     1
  Address: ::
  DR    : not elected
```

What is the difference between a DR registering with an RP in IPv4 and IPv6?



Router bgp XXX
`bgp default ipv4-unicast:`

`bgp default ipv4-Unicast`

means that all unicast IPv4 peers are automatically "activated"

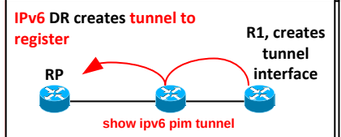
Show ipv6 pim neighbor

Output:

```
R5#show ipv6 pim neighbor
PIM Neighbor Table
Mode: B - Bidir Capable, G - GenID Capable
Neighbor Address  Interface        Uptime    Expires   Mode DR pri

FE80::1           Serial0/0/0      00:06:21  00:01:19 B G   1
FE80::3           Serial0/0/0      00:06:21  00:01:20 B G   1
FE80::4           Serial0/1/0      00:06:21  00:01:17 B G   1
```

Show ipv6 pim tunnel:

Output:




```
R5#show ipv6 pim tunnel
Tunnel0*
  Type  : PIM Encap
  RP    : Embedded RP Tunnel
  Source: 2001::5
```

IPv6 PIM and MLD

Flooding scope details:

PIM supports only Sparse-Mode operation

flooding scope enforcement must be configured administratively using multicast filtering

As soon as
`ipv6 multicast-routing` is entered PIM becomes active
To disable IPv6 pim use:
`no ipv6 pim`

IPv6 PIM BSR

Announcing itself as RP candidate:

Announcing itself as BSR:

BSR only announcing a static list of cRPs:

Router **announce itself as a RP** via the BSR:

`ipv6 pim bsr candidate rp <IPv6 Address>`

Announce itself as BSR:

`ipv6 pim bsr candidate bsr <IPv6 Address>`

BSR only announcing a **static list of cRPs**:
`ipv6 pim bsr announced rp <IPv6 Address>`

What is the difference between a IPv6 unicast and a Multicast route:

Using:

Network 2001::1/64
Next-Hop FE80::1

```
Ipv6  route  2001::1/64  Gi0/0   FE80::1

Ipv6  route  2001::1/64  Gi0/0   FE80::1   multicast
```

Route only usable by multicast

IPv6 MLD details

IPv6	IPv4
MLDv1	= IGMP...
MLDv2	= IGMP...

Multicast Listener Discovery protocol, based on ICMPv6, replaced IGMP.
Message types are:
Query, Report, Done

IPv6	IPv4
MLDv1	**= IGMPv2**
MLDv2	**= IGMPv3**

Usefull MLD commands:

show ipv6 pim group

Show ipv6 pim topology

Show ipv6 pim interface

Show ipv6 mfib

Show ipv6 pim bsr election

Output:

To find the successful BSR candidate:

```
R4#show ipv6 pim bsr election
PIMv2 BSR information

BSR Election Information
  Scope Range List: ff00::/8
  This system is the Bootstrap Router (BSR)
  BSR Address: FC00:1:0:4::4
  Uptime: 00:00:02, BSR Priority: 100, Hash mask length: 126
    RPF: FE80::226:BFF:FE57:BA60,Loopback100
    BS Timer: 00:00:57
  This system is candidate BSR
     Candidate BSR address: FC00:1:0:4::4, priority: 100, hash mask length: 126
```

MLD:

Limit maximum of groups a member can join:

Change mld querry interval

Mld time-out

Response time

```
ipv6 mld limit

ipv6 mld queryinterval

ipv6 mld query-timeout

ipv6 mld query-max-reponsetime
```

Joining a group via MLD:

interface FastEthernet 0/0
ipv6 mld join-group
ff76:0640:2001:CC1E::8

How can you display the mappings of RPs to the multicast group ranges in IPv6?

```
R4#show ipv6 pim range-list
Static SSM Exp: never Learnt from : ::
  FF33::/32 Up: 00:51:08
  FF34::/32 Up: 00:51:08
  FF35::/32 Up: 00:51:08
  FF36::/32 Up: 00:51:08
  FF37::/32 Up: 00:51:08
  FF38::/32 Up: 00:51:08
  FF39::/32 Up: 00:51:08
  FF3A::/32 Up: 00:51:08
  FF3B::/32 Up: 00:51:08
  FF3C::/32 Up: 00:51:08
  FF3D::/32 Up: 00:51:08
  FF3E::/32 Up: 00:51:08
  FF3F::/32 Up: 00:51:08
BSR SM RP: FC00:1:0:6::6 Exp: 00:02:13 Learnt from : FC00:1:0:4::4
  FF00::/8 Up: 00:01:16
```

MLDv1 filtering:

Group based filtering:

SSM source/group based filtering:

```
Ipv6 access-list ACL-X
{permit|deny} ipv6 <part1> <part2>

Filter MLDv1, group based, set <part1> to any:

MLDv1:
ipv6 access-list MLDv1_FILER
permit ipv6 any ff08::/64
----------------------------------------------------------------

Filter MLDv1, SSM based, source/group:

MLDv2:
ipv6 access-list MLDv1_FILER
permit ipv6 2000::25 ff08::/64
```

source / group

IPv6 SSM

Join a group ff36::8
Only sourced from 2001::25

config

IPv6 SSM, join group ff36::8 but only sourced from 2001::25

interface FastEthernet 0/0
ipv6 mld join-group ff36::8 2001::25

IPv6 Embedded RP

Using 2002:6666::6 as the RP address

FF7x:y40:2002:6666::1 or FF7e:640:2002:6666::1

Only the RP needs to know that he is serving as RP, all other routers will figure out based on the Embedded IPv6 address!

FF7E:0640:2002:6666::1

On the RP: conf t: ipv6 pim rp-address 2002:6666::6

FF	Multicast
FF7	Embedded RP IPv6
FF7E	Global scope
FF7E:0	must be 0
FF7E:06	Last digit of "rp-address"

FF7E:0640 Prefix length of IPv6 addr 40 Hex = 64 decimal

FF7E:0640:2002:6666::1111:1111 Multicast Group

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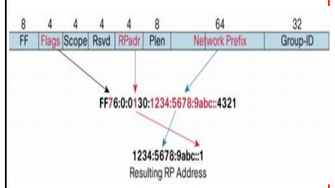
IPv6

IPv6 Embedded RP address format:



IPv6 ISATAP Tunneling

Show interface tun X

Output:

```
R4#show interface tunnel 345
Tunnel345 is up, line protocol is up
  Hardware is Tunnel
  MTU 1514 bytes, BW 9 Kbit/sec, DLY 500000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 150.1.4.4 (Loopback0), destination UNKNOWN
  Tunnel protocol/transport IPv6 ISATAP

  Fast tunneling enabled
  Tunnel transmit bandwidth 8000 (kbps)
  Tunnel receive bandwidth 8000 (kbps)
....
```

OSPFv3

Clearing process/redistr./ spf:

```
clear ospfv3 <process-ID> force-spf

clear ospfv3 <process-ID> process

clear ospfv3 <process-ID> redistribution

clear ipv6 ospf  <process-ID> [ process, force-spf, redistr ]
```

What is the difference between the following two tunnel configs:

Interface Tunnel 88
Tunnel mode ipv6ip

Interface Tunnel 26
(no mode specified)

Protocol 41

```
interface tunnel 88
tunnel source Loopback0
tunnel destination 1.1.1.1
ipv6 address 2001:2::2/64
tunnel mode ipv6ip
```

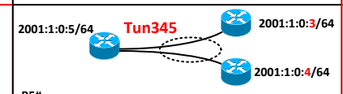
```
interface tunnel 88
tunnel source Loopback0
tunnel destination 2.2.2.2
ipv6 address 2001:2::6/64
tunnel mode ipv6ip
```

Protocol 47

```
interface tunnel 26
tunnel source Loopback0
tunnel destination 1.1.1.1
ipv6 address 2001:1::2/64
```

```
interface tunnel 26
tunnel source Loopback0
tunnel destination 2.2.2.2
ipv6 address 2001:1::6/64
```

IPv6 ISATAP Tunneling




```
R5#
interface Tunnel345
ipv6 address 2001:1:0:345::/64 eui-64
tunnel source Loopback0
tunnel mode ipv6ip isatap
!
interface Loopback100
ipv6 address 2001:1:0:5::5/64
!
ipv6 route 2001:1:0:4::/64 2001:1:0:345:0:5efe:9601:404
ipv6 route 2001:1:0:3::/64 2001:1:0:345:0:5efe:9601:303
```

BFD Support for EIGRP IPv6

```
interface fa0/x
bfd interval 50 min_rx 50 multiplier 3


router eigrp NAME
 address-family ipv6 autonomous-system 88
 af-interface default
 bfd
```

Based on what can you filter the establishement of IP tunnels utilizing Access-Lists?

Protocol 41: (ipv6ip)
access-list 100 [permit|deny] 41 any any

```
interface tunnel 88
...
ipv6 address 2001:2::2/64
tunnel mode ipv6ip
```

Protocol 47: (GRE)
access-list 100 [permit|deny] 47 any any

```
interface tunnel 26
...
ipv6 address 2001:1::2/64
```

IPv6 ISATAP Tunneling

Addressing format:

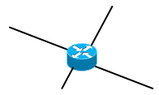
ISATAP Addressing:

EUI-64 = 0000 (16 bits) + 5EFE (16 bits) + IPv4 Address (32 bits):

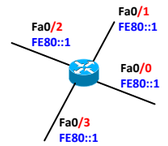
IPv6 Prefix **2001:1:0:345**::/64 will have:

2001:1:0:345:0:**5efe**:**9601**:**0303**/64
150.1. 3.3

Assigning FE80::1 the same Link-local address to several Interfaces:



How do you ping other FE80 addresses?



Automatic 6to4 Tunneling

Automatic 6to4 Tunneling are Multipoint by design:

No Tunnel destination configured

```
interface Tunnel 345
tunnel source Loopback0
tunnel mode ipv6ip 6to4
ipv6 address 2002:9601:303::3/64

ipv6 route 2002::/16 Tunnel 345

(route destination through tun)
```

Automatic 6to4 Tunneling:

General info about 6to4:

- 6to4 tunnels are multipoint by design

- router extracts the IPv4 address embedded in the IPv6 address

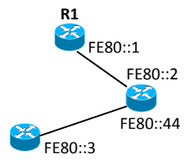
- need to use the 16-bit prefix 2002,

- only static routing is possible, (usually 2002::/16)

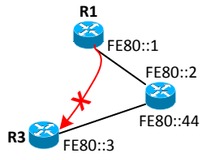
2002 (16 bits): IPv4 address (32 bits):
Subnet ID(16 bits): Interface ID (64 bits)

150.1.3.3 = 2002:**9601**:**303**::/48
150.1.3.3

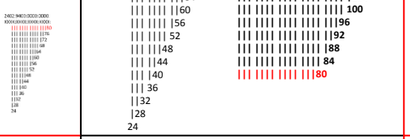
Will R1 be able to ping FE80::3 ?



R1 can NOT ping R3's FE80::3
Link local address!



IPv6 Subnet Reference Prefix Lengths:



Automatic 6to4 Tunneling:

Show interface tunnel:

```
R4#show interfaces tunnel 345
Tunnel345 is up, line protocol is up
  Hardware is Tunnel
  MTU 1514 bytes, BW 9 Kbit/sec, DLY 500000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 150.1.4.4 (Loopback0), destination UNKNOWN
  Tunnel protocol/transport IPv6 6to4

  Fast tunneling enabled
  Tunnel transmit bandwidth 8000 (kbps)
  Tunnel receive bandwidth 8000 (kbps)
...
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
....
     0 output buffer failures, 0 output buffers swapped out
```

What will the outputs show in regards to joined multicast groups?

```
interface Ethernet0/0
 mac-address 0000.7799.8888
 ipv6 enable
```

```
ipv6 unicast-routing

interface Ethernet0/0
 mac-address 0000.7799.8888
 ipv6 enable
```

Config 1:

```
interface Ethernet0/0
 mac-address 0000.7799.8888
 ipv6 enable
```

Config 2:

```
ipv6 unicast-routing

interface Ethernet0/0
 mac-address 0000.7799.8888
 ipv6 enable
```

show ipv6 interface **Output 1**

```
Ethernet0/0 is up, ....
  IPv6 is enabled, link-local addr..  FE80::200:77FF:FE99:8888
  Joined group address(es):
    FF02::1
    FF02::1:FF99:8888
```

show ipv6 interface **Output 2**

```
  IPv6 is enabled, link-local addr..  FE80::200:77FF:FE99:8888
  Joined group address(es):
    FF02::1
    FF02::2          <- ipv6 unicast-routing enabled, adds group FF02::2 !
    FF02::1:FF99:8888
```

Example of /48 allocations:

```
2402:9400:10::/48
2402:9400:11::/48
......
2402:9400:1F::/48
2402:9400:20::/48
2402:9400:21::/48
2402:9400:22::/48
......
2402:9400:2F::/48
2402:9400:30::/48
```

Leave your IPv6 calculator at home:

```
2402:9400:1234:1234::/?
2402:9400:1234:123X::/?
2402:9400:1234:12XX::/?
2402:9400:1234:1XXX::/?
2402:9400:1234:XXXX::/?
2402:9400:123X:XXXX::/?
2402:9400:12XX:XXXX::/?
```

```
2402:9400:1234:1234::/64
2402:9400:1234:123X::/60
2402:9400:1234:12XX::/56
2402:9400:1234:1XXX::/52
2402:9400:1234:XXXX::/48
2402:9400:123X:XXXX::/44
2402:9400:12XX:XXXX::/40
```

IPv6 Multicast addresses:

IPv6 RIP:
IPv6 EIGRP
IPv6 OSPF:
mDNS:

IPv6 Multicast addresses:

IPv6 RIP:	FF02::9	(224.0.0.9)
IPv6 EIGRP	FF02::10	(224.0.0.10)
IPv6 OSPF:	FF02::5	(224.0.0.5)
After DR election	FF02::6 appears	(224.0.0.6)
mDNS:	FF02::B	send to FF02::B, if there is something it will reply

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IPv6

IPv6 SLAAC Configuration:

ICMPv6-ND: Setup RA from FE80::1 to FF02::1 on e0/0
ICMPv6-ND: MTU = 1500
ICMPv6-ND: prefix = 2001:12:1::/64 onlink autoconfig
ICMPv6-ND: 2592000/604800 (valid/preferred)

R1#
ipv6 unicast-routing
int ser1/2
ipv6 address 2001::1/64
ipv6 enable
clock rate 64000

R1 — R2

Acquire network portion from Router

R2#
int ser1/2
ipv6 enable
ipv6 address autoconfig default

Configure int Looback 0 with IPv6 addr: 1:1:1:1::/64 using the mac address of the first LAN interface:

conf t
interface Loobback 0
ipv6 addr 2:2:2:2::/64 eui-64

Will instruct the router to use the first LAN interface in regards to the MAC address!

What will the following command display:

show ipv6 interface e0/x

R1 — e0/0 — e0/1 — SW1

R1#
interface Ethernet0/0
ipv6 address FE80::9 link-local

interface Ethernet0/1
ipv6 address FE80::9 link-local

SW1#
interface e0/0
switchport access vlan 10

interface e0/1
switchport access vlan 10

R1#
interface Ethernet0/0
ipv6 address FE80::9 link-local

interface Ethernet0/1
ipv6 address FE80::9 link-local

show ipv6 interface e0/0
ND DAD is enabled, number of DAD attempts: 1

show ipv6 interface e0/1
IPv6 is stalled, link-local address is FE80::9 [DUP]

show logging
%IPV6_ND-6-DUPLICATE_INFO: DAD attempt detected for FE80::9 on e0/0
%IPV6_ND-4-DUPLICATE: Duplicate address FE80::9 on e0/0

~~IPv6 SLAAC~~

And options via DHCP

ipv6 unicast-routing

int e0/0
ipv6 address 2001::1/64
ipv6 enable
ipv6 nd other-config-flag

ipv6 dhcp pool TEST
address prefix 99::/64
dns-server 2000::1
domain-name its-a-bit-buggy.com

ipv6 unicast-routing
int e0/0
ipv6 enable
ipv6 address autoconfig default

What is the correct FE80::x address ?

interface loopback0
ipv6 address 2:2:2:2:/64

MAC of first LAN interface:
aabb.cc00.0200

interface Loopback 0
ipv6 address x:x:x:x::/64 eui-64

MAC of first LAN interface: AABB.CC00.0200
AA = 1010 1010
AA flipped 7th bit = 1010 1000
HEX = A 8
Finally: FE80::A8BB:CCFF:FE00:0200
FFFE inserted

What to expect of

show ipv6 eigrp 100 interfaces detail serail 2/x

R5#show ipv6 eigrp 100 interfaces detail serial 2/1
EIGRP-IPv6 Interfaces for AS(100)
Xmit Queue PeerQ Mean Pacing Time
Multicast Pending
Interface Peers Un/Reliable Un/Reliable SRTT Un/Reliable
Flow Timer Routes
Se2/1 1 0/0 0/0 14 0/15 71 0
Hello-interval is 5, Hold-time is 15
Split-horizon is enabled
Next xmit serial <none>
Packetized sent/expedited: 12/0
Hello's sent/expedited: 159/3
Un/reliable mcasts: 0/0 Un/reliable ucasts: 12/15
Mcast exceptions: 0 CR packets: 0 ACKs suppressed: 1
Retransmissions sent: 1 Out-of-sequence rcvd: 1
Topology-ids on interface - 0
Authentication mode is not set

IPv6 over DMVPN (IPv4)

E0/0 9.9.1.1 — E0/0 9.9.3.3 — E0/0 9.9.2.2

NBMA (public) address
R1: 9.9.1.1 R2: 9.9.2.2
R3: 9.9.3.3

HUB#
int tunnel 1
ipv6 address 123::1/64
tunnel source e0/0
tunnel mode gre multipoint
ipv6 nhrp network-id 111
ipv6 nhrp map 123::2/64 9.9.2.2
ipv6 nhrp map 123::3/64 9.9.3.3
ipv6 nhrp multicast dynamic

(instead of mcast dynamic use static)
ipv6 nhrp map multicast 9.9.2.2
ipv6 nhrp map multicast 9.9.3.3

SPOKE
int tunnel 1
ipv6 address 123::2/64
tunnel source e0/0
tunnel mode gre multipoint
ipv6 nhrp network-id 222
ipv6 nhrp map 123::1/64 9.9.1.1
ipv6 nhrp nhs 123::1

Spoke registers its NBMA (public IP) to R1, the nhs Next-hop resolution server, Which is mapped to NBMA 9.9.1.1 (IPv4)

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

interface Ethernet0/0
mac-address 0000.0000.1111
ipv6 address FE80::1 link-local
ipv6 address 2001::1/64

ipv6 route FEED:BEEF::2/128 ???????

Which address do you use for static routing? Using public IP's

R1 — R2

R1#ping FEED:BEEF::2

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

interface Ethernet0/0
ipv6 address FE80::2 link-local
ipv6 address 2001::2/64

ipv6 route FEED:BEEF::1/128 ?????

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

interface Ethernet0/0
mac-address 0000.0000.1111
ipv6 address FE80::1 link-local
ipv6 address 2001::1/64

ipv6 route FEED:BEEF::2/128 2001::2

R1 — R2

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

interface Ethernet0/0
ipv6 address FE80::2 link-local
ipv6 address 2001::2/64

ipv6 route FEED:BEEF::1/128 2001::1

Full IPv6 EIGRP authentication

Config:

Use a key of "Cisco"
EIGRP 100

R3#
key chain KEY
key 1
key-string Cisco

interface Serial1/x
ipv6 address FE80::3 link-local
ipv6 eigrp 100
ipv6 authentication mode eigrp 100 md5
ipv6 authentication key-chain eigrp 100 KEY

ipv6 router eigrp 100
eigrp router-id 0.0.0.3
no shut

Verify:
show ipv6 eigrp 100 interfaces detail serial 1/x
Authentication mode is md5, key-chain is "KEY"

IPv6 over DMVPN (IPv4)

Using link-local address space

E0/0 9.9.1.1 — E0/0 9.9.3.3 — E0/0 9.9.2.2

HUB#
int tunnel 1
ipv6 address FE80::1/64
tunnel source e0/0
tunnel mode gre multipoint
ipv6 nhrp network-id 111
ipv6 nhrp map FE80::2/64 9.9.2.2
ipv6 nhrp map FE80::3/64 9.9.3.3
ipv6 nhrp multicast dynamic

(instead of mcast dynamic use static)
ipv6 nhrp map multicast 9.9.2.2
ipv6 nhrp map multicast 9.9.3.3

SPOKE
int tunnel 1
ipv6 address FE80::2/64
tunnel source e0/0
tunnel mode gre multipoint
ipv6 nhrp network-id 222
ipv6 nhrp map FE80::1/64 9.9.1.1
ipv6 nhrp nhs FE80::1

If using Link-Local Addresses, configure them fixed. It makes your live way easier

Looking at
show ipv6 nhrp

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

interface Ethernet0/0
mac-address 0000.0000.1111
ipv6 address FE80::1 link-local
ipv6 address 2001::1/64

ipv6 route FEED:BEEF::2/128 ???????

What does the static route look like using link local addresses?

R1 — R2

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

interface Ethernet0/0
ipv6 address FE80::2 link-local
ipv6 address 2001::2/64

ipv6 route FEED:BEEF::1/128 ?????

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

interface Ethernet0/0
mac-address 0000.0000.1111
ipv6 address FE80::1 link-local
ipv6 address 2001::1/64

ipv6 route FEED:BEEF::2/128 e0/0 FE80::2

R1 — R2

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

interface Ethernet0/0
ipv6 address FE80::2 link-local
ipv6 address 2001::2/64

ipv6 route FEED:BEEF::1/128 e0/0 FE80::2

R1 — R6

interface loopback 0
ipv6 address 1::1/64

IPv6 EIGRP filtering:

Filter 1::1/64 on R6:

R1 — R6

interface loopback 0
ipv6 address 1::1/64

R6#
ipv6 router eigrp 100
distribute-list prefix-list PFX-1 in
eigrp router-id 0.0.0.6

ipv6 prefix-list PFX-1 seq 5 deny 1::/64
ipv6 prefix-list PFX-1 seq 10 permit ::/0 le 128

Output of:

debug ipv6 nd

and following config:

ipv6 unicast-routing
int e0/0
mac-address 0000.0000.1111
ipv6 enable

ICMPv6-ND: IPv6 Opr Enabled on Ethernet0/0
ICMPv6-ND: L2 came up on Ethernet0/0 (Layer 2 UP)
(performing DAD)
IPv6-Addrmgr-ND: DAD request for FE80::200:FF:FE00:1111 on Ethernet0/0

(checking if unique)
ICMPv6-ND: Sending NS for FE80::200:FF:FE00:1111 on Ethernet0/0

(no response back, address seems unique)
IPv6-Addrmgr-ND: DAD: FE80::200:FF:FE00:1111 is unique.

(sending last "warning" here I come)
ICMPv6-ND: Sending NA for FE80::200:FF:FE00:1111 on Ethernet0/0
ICMPv6-ND: L3 came up on Ethernet0/0 (Layer 3 UP)
ICMPv6-ND: Linklocal FE80::200:FF:FE00:1111 on Ethernet0/0, Up

(due to ipv6 unicast routing enabled on the router)
ICMPv6-ND: Created RA context for FE80::200:FF:FE00:1111/Ethernet0/0

(Router sending RA announcements to FF02::1)
ICMPv6-ND: Request to send RA for FE80::200:FF:FE00:1111
ICMPv6-ND: Setup RA from FE80::200:FF:FE00:1111 to FF02::1 on Ethernet0/0
ICMPv6-ND: MTU = 1500
ICMPv6-ND: ND output feature SEND executed on 3 - rc=0

How do you configure a static IPv6 default route?

ipv6 route ::/0 e0/0 fe80::1

ipv6 route ::/0 2001::1

What to expect of:

R1#show ipv6 ospf database

R1 — 12::x/64 — R2 — Area 1
1::1/64
2::2/64

interface Loopback0
ipv6 address 2::2/64

interface Ethernet0/0
ipv6 address 12::2/64
ipv6 ospf 1 area 1

ipv6 router ospf 1
router-id 0.0.0.2

interface Loopback0
ipv6 address 1::1/64

interface Ethernet0/0
ipv6 address 12::1/64
ipv6 ospf 1 area 1

ipv6 router ospf 1
router-id 0.0.0.1

R1#show ipv6 ospf database (LSA 1,2,8,9)
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Router Link States (Area 1)

ADV Router	Age	Seq#	Fragment ID	Link count	Bits
0.0.0.1	409	0x80000002	0	1	None
0.0.0.2	410	0x80000002	0	1	None

Net Link States (Area 1)

ADV Router	Age	Seq#	Link ID	Rtr count
0.0.0.2	410	0x80000001	3	2

Link (Type-8) Link States (Area 1)

ADV Router	Age	Seq#	Link ID	Interface
0.0.0.1	471	0x80000001	3	Et0/0
0.0.0.2	451	0x80000001	3	Et0/0

Intra Area Prefix Link States (Area 1)

ADV Router	Age	Seq#	Link ID	Ref-lstype	Ref-LSID
0.0.0.1	409	0x80000003	0	0x2001	0
0.0.0.2	410	0x80000002	0	0x2001	0
0.0.0.2	410	0x80000001	3072	0x2002	3

What will be the IPv6 link local address of the following config look like:

interface Ethernet0/2
mac-address 0012.3456.8910
ipv6 enable

interface Ethernet0/2
mac-address 0012.3456.8910
ipv6 enable

2nd bit flipped!

FE80::212:34FF:FE56:8910

or

FE80::0212:34FF:FE56:8910

Host entries for IPv6 Ips on routers:

Make your life easier pinging:

R1 — R2

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

R1#
interface Loopback0
ipv6 address FEED:BEEF::1/128

R2#
interface Loopback0
ipv6 address FEED:BEEF::2/128

ipv6 host R1 FEED:BEEF::1

R2# ping R1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to FEED:BEEF::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

Configure IPv6 EIGRP to gain reachability between the loopbacks:

R1 — R2

R1#
interface Loopback0
ipv6 address 1::1/64

int e0/0
ipv6 address 12::1/64
ipv6 address fe80::1 link-local

R2#
interface Loopback0
ipv6 address 2::2/64

int e0/0
ipv6 address 12::2/64
ipv6 address fe80::2 link-local

R1 — R2

R1#
ipv6 unicast-routing

interface Loopback0
ipv6 address 1::1/64

int e0/0
ipv6 address 12::1/64
ipv6 address fe80::1 link-local
ipv6 eigrp 100

ipv6 router eigrp 100
NO SHUTDOWN
eigrp router-id 0.0.0.1

R2#
ipv6 unicast-routing

interface Loopback0
ipv6 address 2::2/64

int e0/0
ipv6 address 12::2/64
ipv6 address fe80::2 link-local
ipv6 eigrp 100

ipv6 router eigrp 100
NO SHUTDOWN
eigrp router-id 0.0.0.2

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

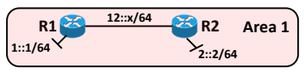
Colin

IPv6

Why are the following OSPFv6 routers not forming an adjacency?
Or seen with a flapping adjacency?

R1
interface Serial1/0
ipv6 address FE80::3 link-local
ipv6 address 23::1/64
clock rate 64000

R2
interface Serial1/0
ipv6 address FE80::3 link-local
ipv6 address 23::2/64
clock rate 64000



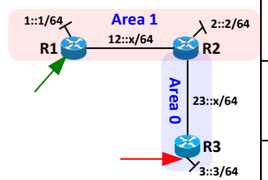
R1#show ipv6 interface e0/0
Ethernet0/0 is up, line protocol is up
IPv6 is stalled, link-local address is **FE80::3** **[DUP]**

R2#show ipv6 interface e0/0
Ethernet0/0 is up, line protocol is up
IPv6 is stalled, link-local address is **FE80::3**

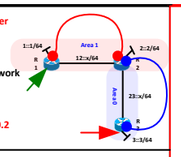
R1
interface Serial1/0
ipv6 address FE80::3 link-local
ipv6 address 23::1/64
clock rate 64000

R2
interface Serial1/0
ipv6 address FE80::3 link-local
ipv6 address 23::2/64
clock rate 64000

How to calculate the path from here To there in OSPFv6:



R1#show ipv6 ospf database router
Routing Bit Set on this LSA
Advertising Router: 0.0.0.2
Area Border Router
Link connected to: a Transit Network
Link Metric: 10
Local Interface ID: 3
Neighbor (DR) Interface ID: 3
Neighbor (DR) Router ID: 0.0.0.2



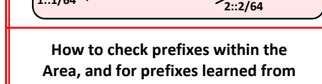
R1#show ipv6 ospf database inter-area prefix adv-router 0.0.0.2
...
Advertising Router: 0.0.0.2
Metric: 64
Prefix Address: 3::3

R1#show ipv6 route ospf
OI 3::3/128 [110/74]
via FE80::2, Ethernet0/0

What to expect of a

R1# show ipv6 ospf database router

Output:



R1#**show ipv6 ospf database router**
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Router Link States (Area 1)
LS age: 446
Options: **(V6-Bit, E-Bit, R-bit, DC-Bit)**
LS Type: Router Links
Link State ID: 0
Advertising Router: **0.0.0.1**
LS Seq Number: 8000000A
Checksum: 0xF5ED
Length: 40
Number of Links: 1
Link connected to: a Transit Network
Link Metric: 10
Local Interface ID: 3
Neighbor (DR) Interface ID: 3
Neighbor (DR) Router ID: 0.0.0.2
.....

IPv6 router LSA do NOT carry IPv6 information!

V6-Bit = IPv6 forwarding capability

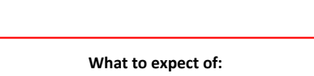
E-Bit = accepts external prefixes

R-Bit = router is active

DC-bit = capable of demand circuit links

What can happen to an existing OSPFv3 session if you do the following:

R1#conf t
interface e0/0
ipv6 address fe80::1 link-local

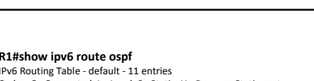


The OSPFv3 session gets dropped!!!
→ keep in mind in regards to the daily operation!!

R1#
%OSPFv3-5-ADJCHG: Process 1, Nbr 0.0.0.3 on Serial2/1 from FULL to DOWN, **Neighbor Down:** Interface down or detached

%OSPFv3-5-ADJCHG: Process 1, Nbr 0.0.0.3 on Serial2/1 from **LOADING to FULL**, Loading Done

R1#conf t
interface e0/0
ipv6 address fe80::1 link-local



What to expect of a

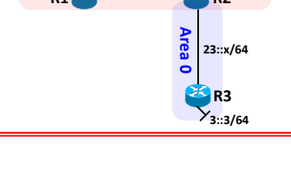
R1# show ipv6 ospf database link

Output:

R1#show ipv6 ospf database link
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Link (Type-8) Link States (Area 1)
LS age: 1147
Options: (V6-Bit, E-Bit, R-bit, DC-Bit)
LS Type: Link-LSA (Interface: e0/0)
Link State ID: 3 (Interface ID)
Advertising Router: 0.0.0.1
LS Seq Number: 80000006
Checksum: 0xB973
Length: 56
Router Priority: 1
Link Local Address: FE80::1
Number of Prefixes: 1
Prefix Address: 12::
Prefix Length: 64, Options: None

LS age: 1873
Options: (V6-Bit, E-Bit, R-bit, DC-Bit)
LS Type: Link-LSA (Interface: e0/0)
Link State ID: 3 (Interface ID)
Advertising Router: 0.0.0.2
LS Seq Number: 80000004
Checksum: 0xCD5F
Length: 56
Router Priority: 1
Link Local Address: FE80::2
Number of Prefixes: 1
Prefix Address: 12::
Prefix Length: 64, Options: None

How can you find the cost to the ASBR in OSPFv3 from R1?



R1#show ipv6 ospf database
Type-5 AS External Link States

ADV Router	Age	Seq#	Prefix
0.0.0.4	953	0x80000001	4::4/64

R1#show ipv6 ospf database inter-area router 0.0.0.4
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Inter Area Router Link States (Area 1)
...
Advertising Router: 0.0.0.2
LS Seq Number: 80000001
Checksum: 0xDD9E
Length: 32
Metric: 128
Destination Router ID: 0.0.0.4

R1#
show ipv6 ospf database router 0 | b 0.0.0.2
Advertising Router: 0.0.0.2
Link connected to: a Transit Network
Link Metric: 10
Local Interface ID: 3
Neighbor (DR) Interface ID: 3
Neighbor (DR) Router ID: 0.0.0.2

R1#show ipv6 route ospf
OE2 4::4/64 [110/**20**]
via FE80::2, e0/0

Forward metric 128+10 = 138

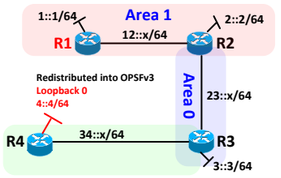
What to expect of a

R1# show ipv6 ospf database prefix

Output:

R1#show ipv6 ospf database prefix
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Intra Area Prefix Link States (Area 1)
Routing Bit Set on this LSA
LS age: 729
LS Type: Intra-Area-Prefix-LSA
Link State ID: 0
Advertising Router: 0.0.0.1
LS Seq Number: 80000004
Checksum: 0x9C3E
Length: 72
Referenced LSA Type: 2001
Referenced Link State ID: 0
Referenced Advertising Router: 0.0.0.1
Number of Prefixes: 2
Prefix Address: 1::1
Prefix Length: 128, Options: LA, Metric: 0
Prefix Address: 1:1::1
Prefix Length: 128, Options: LA, Metric: 0
.....

How will 4::4/64 be seen on R1 in case of it being redistributed into OSPFv3 as Type-1 or Type-2 ?



Type-1:
R1#**show ipv6 route ospf**
OE1 4::4/64 [110/**158**]
via FE80::2, Ethernet0/0

Total forward metric + 20 = 158

R4#
ipv6 router ospf 1
redistribute connected route-map RMP-CON **metric-type 1**

Type-2:
R1#**show ipv6 route ospf**
OE2 4::4/64 [110/**20**]
via FE80::2, Ethernet0/0

R4#
ipv6 router ospf 1
redistribute connected route-map RMP-CON **metric-type 2**

What to expect of a

R1#show ipv6 ospf database prefix 0

Output:

R2#**show ipv6 ospf database prefix 0**
OSPFv3 Router with ID (0.0.0.2) (Process ID 1)
Intra Area Prefix Link States (Area 1)
Routing Bit Set on this LSA
LS age: 1159
LS Type: Intra-Area-Prefix-LSA
Link State ID: 0
Advertising Router: 0.0.0.1
LS Seq Number: 80000004
Checksum: 0x9C3E
Length: 72
Referenced LSA Type: 2001
Referenced Link State ID: 0
Referenced Advertising Router: 0.0.0.1
Number of Prefixes: 2
Prefix Address: 1::1
Prefix Length: 128, Options: LA, Metric: 0
Prefix Address: 1:1::1
Prefix Length: 128, Options: LA, Metric: 0

prefix 0 within an area shows all attached prefixes, or look at the specific LSA-ID

How to check prefixes within the Area, and for prefixes learned from other Areas in OSPFv6 ?

For prefixes within the Area:

R1#show ipv6 ospf database prefix 0
Referenced Advertising Router: 0.0.0.1
Number of Prefixes: 2
Prefix Address: 1::1
.....
Referenced Advertising Router: 0.0.0.2
Number of Prefixes: 1
Prefix Address: 2::2

For Prefixes learned from other areas

R1#show ipv6 ospf database

Inter Area Prefix Link States (Area 1)

ADV Router	Age	Seq#	Prefix
0.0.0.2	739	0x80000001	23::/64
0.0.0.2	575	0x80000001	3::3/128

What to expect of:

R1# show ipv6 route ospf

R1#show ipv6 route ospf
IPv6 Routing Table - default - 11 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
O 2::2/128 [110/10]
via FE80::2, Ethernet0/0
OI 3::3/128 [110/74]
via FE80::2, Ethernet0/0
OI 23::/64 [110/74]
via FE80::2, Ethernet0/0

How can you look at those in detail?

R1#show ipv6 ospf database
.....
Inter Area Prefix Link States (Area 1)

ADV Router	Age	Seq#	Prefix
0.0.0.2	1925	0x80000001	2::2/128
0.0.0.2	1925	0x80000001	23::/64
0.0.0.2	1761	0x80000001	3::3/128

R1#show ipv6 ospf database inter-area prefix
OSPFv3 Router with ID (0.0.0.1) (Process ID 1)
Inter Area Prefix Link States (Area 1)

Routing Bit Set on this LSA
LS age: 139
LS Type: Inter Area Prefix Links
Link State ID: 0
Advertising Router: 0.0.0.2
LS Seq Number: 80000002
Checksum: 0x891E
Length: 44
Metric: 0
Prefix Address: 2::2
Prefix Length: 128, Options: None

Routing Bit Set on this LSA
LS age: 139
LS Type: Inter Area Prefix Links
Link State ID: 1
Advertising Router: 0.0.0.2
LS Seq Number: 80000002
Checksum: 0x8807
Length: 36
Metric: 64
Prefix Address: 23::
Prefix Length: 64, Options: None

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Security

Decribe all available types of ACLs:

Standard ACL
Extended ACL
IP named ACL
Lock and Key ACL (Dynamic ACLs)
Reflexive ACL
Established ACL
Time-based ACL (time-range)
Distributed time-based ACL
Turbo ACL
Receive ACL
Infrastructure protection ACL
Transit ACL
Classification ACL
Debugging traffic ACL

Turbo ACLs:

Compiles access-list for acceleration:

Router-config# **access-list compiled**

show access-list compiled

Radius Packet header:

Radius Packet header

8 bits	16 bits	32 bits
Code	Identifier	Length
Authenticator (16 bytes)		

Code
1 Access-Request
2 Access-Accept
3 Access-Reject
4 Accounting-Request
5 Accounting-Response
11 Access-Challenge

Identifier: Message Sequence Number, allows Radius client to match a Radius response

Authenticator: Used to authenticate the reply from the Radius server, MD5 hash

UDP 1812 (1645) for authentication / authorization
UDP 1813 (1646) for accounting requests

Standard Access-list parameters:

access-list 10 permit 10.1.1.0 0.0.0.255

access-list 10 permit 10.1.1.0 0.0.0.255 **log**

access-list 10 permit 10.1.1.0 0.0.0.255 **log-intput**
(Logs Layer 2 interface information)

Interface X
ip access-group 10 [in,out]

Classification ACL:

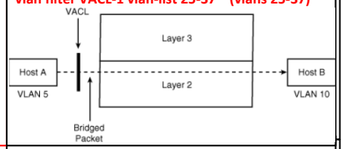
Usually holds only permit statements for various protocols, ports or flags. Used to identify traffic, or DoS attacks:

access-list 101 permit icmp any any eq echo
access-list 101 permit tcp any any eq syn
access-list 101 permit tcp any any eq fragment
access-list 101 permit udp any any eq fragment
access-list 101 permit ip any any eq fragment
access-list 101 permit tcp any any
access-list 101 permit udp any any
access-list 101 permit icmp any any
access-list 101 permit ip any any

VACL
Vlan access-list config:

vlan access-map VACL-1 10 *show vlan access-map*
match ip address ACL-IPv4
match ipv6 address ACL-IPv6
match mac address ACL-MAC-ADDR
action [forward,drop]

vlan filter VACL-1 vlan-list 25-37 (vlans 25-37)



Extended Access-list Parameters:

access-list 101 permit [tcp,udp,icmp,ip,PROTOCOL] ….
access-list 101 permit tcp any any eq 23

Interface X
ip access-group 101 [in,out]

TCP options:
Timeout in minutes, port, **established**, precedence, tos, log, log-input, time-range, fragments

UDP options:
TCP options:
Timeout in minutes, port, precedence, tos, log, log-input, time-range, fragments

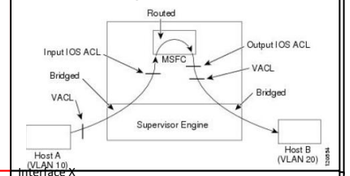
Tokens used for Banner messages:

$(hostname)	
$(domain)	
$(peer-ip)	**SLIP/PPP**
$(gate-ip)	**gateway**
$(encap)	**SLIP/PPP**
$(encap-alt)	**SL/IP**
$(mtu)	
$(line)	
$(line-desc)	

VACL on a routed port

Order of processing:

1. **VACL for input Vlan**
2. **Input IOS ACL**
3. **Output IOS ACL**
4. **VACL for output Vlan**



Lock and Key ACL

(Dynamic ACL)

Config:

username test password cisco123

line vty 0 4 ! Trigger Auth process
login local

*! **Time-out per uses** basis after 10 minutes*
username test autocommand access-enable host timeout 10

*! **Time-out** any user **globally** after 10 minutes:*
line vty 0 4
autocommand access-enable host timeout 10

access-list 102 permit tcp any host <router-ip> eq telnet
access-list 102 dynamic ACCESS timeout 15 permit tcp any any eq 80
deny ip any any log

interface X
ip access-group 102 in

Explanations:

No ip source-route

No ip proxy-arp

No ip gratuitous-arps

No ip directed-broadcast

No ip redirects

No ip unreachables

Disables strict / loose source routing

Router replies with own MAC for an IP attached to its other interface.

Turns of unsolicited ARP broadcasts IP of host but Routers MAC addr.

Can be used to map a network, also to use as amplifier in a DoS attack.

Disables ICMP redirects, is enabled with HSRP by default

Will not send unreachable messages for traffic pointing to Null0 interface.

Switchport Port-security

Config:

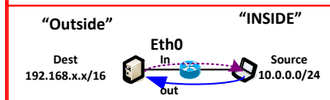
Interface X
switchport port-security
switchport port-security max 5 *Overall 5 allowed, detailed broken down to 3 and 2*
switchport port-security 3 vlan access
switchport port-security 2 vlan voice

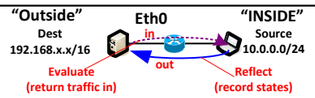
switchport port-security **agging** **-timeout**
- static
- type inactivity (idle)
- type absolute (ttl 5min clears cam tbl!)
switchport port-security agging time

switchport port-security violation shutdown *Discards traffic of exceeding MACs SNMP msg!*
switchport port-security violation restrict *Discards silently, no SNMP msg*
switchport port-security violation protect

Reflexive ACLs

Config:





Only return traffic that has been initiated from the inside is permitted!

interface Eth0
ip access-group ACL-IN in
ip access-group **ACL-OUT out**

ip access-list extended **ACL-IN**
evaluate tcp_reflect

ip access-group extended **ACL-OUT**
permit tcp 10.0.0.0/24 192.x.x/16 **reflect tcp_reflect**

ip reflexive-list timeout <TIMEOUT>
! timing out of old sessions

Auto-Secure:

conf t

auto-secure
! Disables common services

auto-secure no-interact
! User not prompted for interaction

show auto secure config

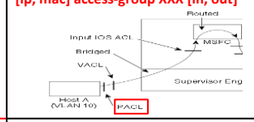
Shows all config that has been added part of the secure process.

Port Access-List

PACL config:

Does not support – log option
Does not support MPLS / ARP filtering
Filtering is based on the fields of the Ethernet datagr
see how much TCAM space is available:
show tcam counts

interface X
[ip, mac] access-group XXX [in, out]



Time-based ACLs:

time-range MY-RANGE

absolute [start time date] [end time date]

periodic days-of-week hh:m to days-of-week hh:mm

Apply via:

access-list <NR> permit tcp< SRC> <DST> **time-range MY-RANGE**

time-range WEEKDAYS_EVES
periodic weekdays 18:00 to 23:59
periodic weekdays 0:00 to 8:59

- interval from 00:01 to **02:00** will last from 00:01:00 to **02:00**:59
- **So if you want to end at exactly 04:00pm use to 15:59**

How to block unicast/multicast frames with a unknown destination on switches?

conf t
interface X
switchport block unicast
switchport block multicast

show interface fa0/1 **switchport**
Unknown unicast blocked: enabled
Unknown multicast blocked: enabled

Bad guy flooding the switch with random SRC MAC addrs -> forcing the switch to go into open fail mode

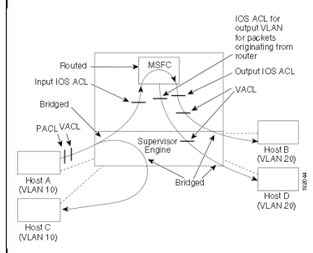
Switchport protected port. But once CAM table is full Host B can be attacked! -> block prevents this

Host B, nice guy

Flood traffic hits B, if switchport block not used

PACL, VACL, IOS ACL

Diagram:



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Security

IP Source Guard

Config:

DHCP Snooping (prerequisite) - IP Source Guard

ip dhcp snooping
ip dhcp snooping vlan X

L3 check only:
interface fa0/x
ip verify source

Any traffic incoming with a source other than assigned via DHCP or static will be filtered out.

L2+L3 combination check
interface fa0/x
switchport port-security
ip verify source port-security

ip source binding 1234.1234.abcd vlan 22 1.1.1.1 int fa0/x
Static entry for MAC 1234.x in vlan 22.

IP Source Guard

Config / troubleshooting:

ip dhcp snooping
ip dhcp snooping vlan X

OR

L3 SRC and SRC MAC check
interface x
ip verify source port-security
switchport port-security

L3 src check only:
interface x
ip verify source

Configure static binding:

ip source binding xxxx.xxxx.xxxx vlan X 10.1.1.1 int fa0/x

show ip verify source
show ip source binding

DAI
Dynamic ARP inspection

Config:

DAI relies on IP DHCP Snooping. Checks if ARP message is correct, claiming to be the right IP
-> mitigates ARP poisoning

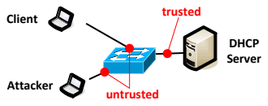
ip dhcp snooping
ip dhcp snooping vlan X

ip arp inspection vlan x
ip arp inspection filter ACL vlan X

arp access-list ACL
permit ip host 1.1.1.1 mac host xxxx.xxxx.xxxx

NOT relying on / using IP DHCP Snooping (static keyword):

ip arp inspection vlan x
ip arp inspection filter ACL vlan 100 static
arp access-list ACL
permit ip host 1.1.1.1 mac host xxxx.xxxx.xxxx



IP DHCP Snooping:

Ip dhcp snooping
Ip dhcp snooping vlan X — *Puts ports in vlan X in untrusted mode*

DHCP Server:
Interface X
ip dhcp snooping trust

show ip dhcp snooping
show ip dhcp snooping binding

Clients / untrusted ports:
interface X
ip dhcp snooping limit rate 100

Errdisable recovery cause arp-insepection interval <seconds>

IP DHCP snooping config:

ip dhcp snooping
ip dhcp snooping vlan X
no ip dhcp snooping information option

ip dhcp snooping vlan X
ip dhcp snooping database flash://snoop.db
ip dhcp snooping database write-delay X

Write-delay:
Default time from local entry to remote DB writing time.

Option 82:
Ip dhcp snooping information option RemoteID + CircuitID within DHCP Discover message, seen on the servers trusted port outbound.
(SW# within exec mode, not config!)
ip dhcp snooping binding xxxx.xxxx.xxxx vlan X 1.2.3.4 int X expiry

Control Plane Policing
CoPP

class map CMAP-COPP
match [ACL, protocol, ip prec, ip dhcp, vlan]

policy-map PMAP-COPP
class CMAP-COPP
police <rate> conform-action <action>
exceed-action <action>

control-plane
service-policy [input, output] PMAP-COPP

(IGP/BGP packets from an to Router)

Configuring CBAC

Steps:

1. select interface internal, external
2. configure ACL
3. define inspection rule
4. configure timeouts and thresholds
5. apply ACL and inspection rule to an interface
6. verify CBAC

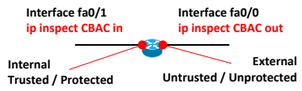
Fragmented packets can't be checked by CBAC!

Configuring CBAC:

Inspection Rule:
ip inspect name CBAC http
ip inspect name CBAC ftp

Inspection timeout / thresholds
ip inspect tcp synwait-time <30 sec>
ip inspect udp ....

Show ip inspect all
Show ip inspect [config, interface]



Virtual Fragmentation Reassembly (VRF)

Configuration:

Interface fa0/x
ip virtual-reassebly max-reasseblies 100 max-fragments 20 timeout 5

Max 100 IP datagrams to be reasembled

Max of 20 fragements per packet, at any given time.

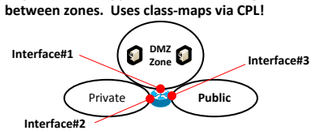
Waits 5 seconds, to reasemble, if not received in 5 secs, received packets and future fragements will be dropped.

Zone-Based Policy Firewall (ZFW)

Comparison ZFW and CBAC:

Built to overcome limitations of CBAC:
Traffic passing through the interface was subject to the same inspection policy.

ZFW:
Interfaces are assigned to zones, policy inspections are applied to traffic moving between zones. Uses class-maps via CPL!



Zone-Based Policy Firewall:

Steps:

1 Define zones

2 Define zone-pairs

3 Define class-map(s) which identify traffic
(traverses zone-pair)

4 Define policy-map / action to the traffic in class-map

5 Apply Policy-Map to zone-pair

6 Assign Interfaces to Zones

Zone-Based Policy Firewall

Config:

class-map type inspect match-any CLASS
match protocol tcp
match protocol udp

policy-map type inspect MYPOL
class type inspect CLASS
inspect

zone security public
zone security private

zone-pair security PAIR source private destination public
service-policy type inspect MYPOL

interface ethernet0
zone-member security private

interface ethernet1
zone-member security public

IP source tracker

Collect traffic flow statistics from host 1.1.1.1:

Router-config#
ip source-track 1.1.1.1

Ip source-track syslog-interval 2
Ip source-track export-interval 30

Syslog every 2 sec / exports flow info every 30 sec from route processor.

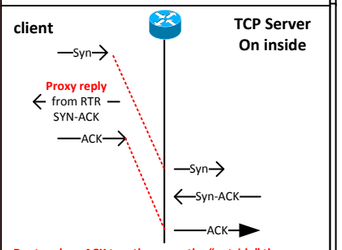
show ip source-track <IP-ADDR>

Address	SRC IF	Bytes	Pkts	Bytes/s	Pkts/s
1.1.1.1	Fa0/0	123G345M	562342	134535	

show ip source-track summary

TCP intercept

Diagram:



Router glues ACK together once the "outside" three way hand-shake has been confirmed.

TCP intercept

Config:

access-list 101 permit tcp any 1.1.1.1 0.0.0.0

ip tcp intercept list 101

ip tcp intercept max-incomplete low 400 high 500

ip tcp intercept one-minute low 30 high 60

Watch Mode: is passive, terminates connection after timeout.
Intercept Mode: actively intercepts SYNs, responds on behalf of the internal Server.

Drop incoming SYN lower then 30 session if 60 open sessions are reached.

show tcp intercept connections
show tcp intercept statistics

Unicast Reverse Path Forwarding

uRPF

Strict mode:

uRPF Strict Mode:

Soure Address must match the FIB Adjacency Info in the CEF table

Packets sourced from 10.0.0.0/8 arriving at ser0/0 failing the uRPF check will be logged and dropped:

access-list 101 deny ip 10.0.0.0/8 any log-input

Packets sourced from 172.x. arriving at ser0/0 failing the uRPF will be logged and forwarded:

access-list 101 permit ip 172.x.x any log-input

interface Serial0/0
ip verify unicast reverse-path 101

Unicast Reverse Path Forwarding

uRPF

Loose mode

Strict Mode: Resolves source IP address / source interface
Loose Mode: Resolves source network

In case Loose Mode is configured with a default route, Loose mode is useless!

ip cef

interface X
ip verify unicast source reachable-via any

Difference of

uRPF Strict Mode

uRPF Loose Mode:

uRPF Strict Mode:
Routing entry for Source IP?
Packet received on Interface where the IP should source?

Interface X
ip verify unicast source reachable-via rx

---

uRPF loose mode:
Is the source network in the routing table?

Interface X
ip verify unicast source reachable-via any

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Security

uRPF

Strict Mode

Loose Mode

Show outputs:

Strict Mode:

show ip interface fastEthernet 0/1 | include drops
5 verification drops
0 suppressed verification drops

Packet came from wrong interface, been dropped.

Loose Mode:

show ip interface fastEthernet 0/1 | include drops
0 verification drops
7 suppressed verification drops

suppressed = Packet came in wrong interface, but there is a source network in the FIB.

TACACS+

Response types:

Accept: Successfully authenticated
Reject: Incorrect credentials
Error: communication error between NAS and Server
Continue: Server is expecting additional info, user Prompt

TACACS encrypts entire body of the packet.

TACACS uses TCP port 49

Configuring Login authentication using TACACS+:

Using local user database as fallback

aaa new-model
aaa authentication login default group tacacs+ local

tacacs-server host 1.2.3.4
tacacs-server key secret123

Verify uRPF show commands:

show ip interface <interface>
...
IP verify source reachable-via RX, allow default, ACL 101
56 verification drops
192 suppressed verification drops

---

show cef interface <interface>
...
IP unicast RPF check is enabled

---

show ip traffic
...
0 no route, **0 unicast RPF**, 0 forced drop

Implementing AAA

Three types:

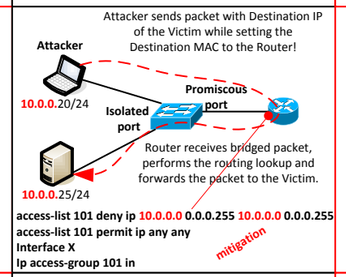
1. **self-contained AAA local security database**
2. **Cisco Secure ACS Server**
3. **Cisco Secure ACS Solutions Engine appliance**

Authorization Services:

Keyword	Description of Use
Network	authorizes connections PPP SLIP ARAP
Exec	attributes associated with EXEC term sessions
Command	Auths EXEC mode commands associated with priviledge levels
Auth-proxy Configuration	applying specific sec policies per user downloads configs from AAA server

Compromising Private Vlan implementation:

PVLAN



AAA overall configuration:

1. enable **aaa new-model**
2. configure IP of Radius or TACACS with a shared key
3. define authentication service **aaa authentication** cmd
4. apply authentication **login authentication** on line/int.
5. Define **authorization** method list service
6. Apply **authorization** method under line/interface
7. Define **accounting** method list
8. Apply **accounting** under line/interface

Named Method: applied to specific interfaces
Default Method: globally / automatically applied to all interfaces if no other list is specified.

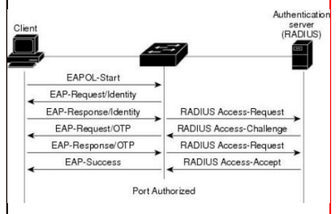
	Radius	TACACS+
Developer		
Transport Protocol		
AAA Support		
Challenge Response		
Protocol Support		
Security		

	Radius	TACACS+
Developer	industry standard	Cisco proprietary
Transport Protocol	UDP 1645,1646 UDP 1812,1813	TCP 49
AAA Support	combines authen and authorization separate accounting	uses AAA architecture separates the three services.
Challenge Response	Unidirectional single challenge	Bidirectional Multiple challengs
Protocol Support	No NetBEUI	Full support
Security	Encrypts only the password	Encrypts the entire packet

802.1x

Authentication process diagram:

802.1x Authentication process



AAA Authentication Methods

AAA authentication login

Applied by login authentication

keyword	Description
enable	enable pass authentication
group radius	list all RADIUS servers
group tacacs+	list all TACACS server
krb5	Use Kerberos 5 authentication
krb4-telnet	Use Kerberos 5 using Telnet
line	use the line password for authentication
local	use local username database
local-case	uses case-sensitive local database
none	no authentication used

Authentication Services

Keyword	Description
arap	authentication list for Appletalk Remote Access Protocol ARAP
login	enable authentication for ASCI based logins such as Telnet / SSH
enable	Authentication list for enabling access to the router
ppp	Auth list for any PPP-based protocol such as ISDN, remote dial-in...

TACACS+ packet header:

TACACS+ packet header

4	8	16	24	32 bits
Major	Minor	Packet Type	Seq-Num	Flags
Session ID (4 bytes)				
Length (4 bytes)				

Major Version: TACACS+ version number
Minor Version: maintaining backward compatibilty

Packet Type: TAC_PLUS_AUTHEN = 0x01 authentication
TAC_PLUS_AUTHOR: = 0x02 authorization
TAC_PLUS_ACCT: = 0x03 Accounting

Flags: Signify if packet is encrypted

AAA Authorization Methods:

AAA authorization login

Applied by authorization xxxx

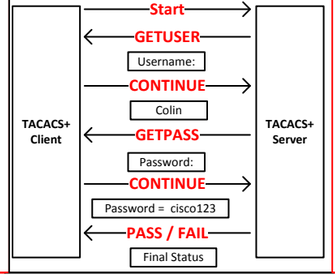
Keyword	Description
group radius	NAS requests from server, defines rights for users by associated attribute-value pairs
group tacacs+	NAS requests, user rights utilizing attribute-value pairs
if-authenticated	allowed access if successfully authenticated.
local	using local user database for authentication
none	Does not request authorization.

Accounting Services

Keyword	Description
Network	accounting info for all network related services such as PPP, SLIP, ARAP includes packet/byte count
Connection	all outbound connections from NAS telnet, local-area transport LAT PAD, rlogin
Exec	terminal sessions, username start, stop telephone number call origination
System	all system level events, reboots accounting is disabled or enabled.
Command	command accounting, exec commands which are executed on NAS

TACACS+ Communication

Authentication:



Configuring AAA RADIUS Server Groups

"globally and privately"

aaa group server radius **TEST-1**
server 1.2.3.4

radius-server **key super-secret123**

---

aaa group server radius **TEST-2**
server-private 2.2.2.2 **key secret123**

---

aaa authentication login default group **TEST-1**
aaa authentication ppp default group **TEST-2**

PPP authentication

if-needed:

if-authenticated:

aaa new-model
aaa authentication ppp default **if-needed** group radius
aaa authorization network default group radius **if-authenticated**

If-needed:
If the user has already authenticated by going trough the ASCI login procedure, PPP authentication is not necessary and skipped.

If-authenticated:
Indicates that users can be given access to requested services only if they have been authenticated first.

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Security

AAA login authentication

Password retry / lockout:

Aaa local authentication attempts max-fail 3

Show aaa local user locked

Clear aaa local user lockout

Users with priviledge level 15 can not be locked out with ASCII based logins.

IKE Phase 2:

Quick mode:

IKE phase 2 protects user data and establishes SA for Ipsec.

3 messages

IKE phase 2 negotiates:
- Protection suite (using ESP, AH)
- Algorithms in the protection suite (DES,3DES,AES,SHA)
- IP traffic that is being protected, proxy identities
- Optional keying material for negotiated protocols.

- At the end of phase 2 negotiations, two unidirectional IPSec SAs are established. One for sending, and one for receiving encrypted traffic

- Only one mode: Quick mode.

- Multiple phase 2 SA can be established over the same phase 1 SA.

Easy VPN

Head-End Router:

Part 1

```
aaa new-model                                          aaa for Xauth
aaa authentication login vpnauthen local
aaa authorization network vpnauthor local
username cisco password cisco1                         Xauth credentials

crypto isakmp policy 1
encryption 3des                                        Phase 1 params
authentication pre-share
group 2

crypto isakmp client configuration address-pool local POOL
crypto isakmp xauth timeout 60

crypto isakmp client configuration group EASYvpn
key cisco2
dns 1.2.3.4                                            Easy VPN group
domain cisco.com                                       Parameters &
pool POOL                                              split tunnel
access-list 101
```

Types of VPN technologies:

Secure VPN (cryptographic VPN)
- IPSec
- L2TP over IPSec
- SSL encryption

Trusted VPN (non-cryptographic VPN)
- MPLS VPN (Layer 3)
- BGP VPN (Layer 3)
- Multicast VPN (Layer 3)
- Transport of Layer 2 frames over MPLS (AtoM) (Layer 2)
- Virtual Private LAN Services VPLS (Layer 2)

Hybrid VPN
combination of trusted and secure tunnel, tunnel within tunnel setup

IKEv2 features:

-IKE dead peer detection / Initial contact

- NAT traversal support

- identities are always protected

- Certs can be referenced through URL + hash to avoid fragmentation

- EAP (MD-5, OTP, GTC) support

- Remote address acquisition, New Config Payload CP

- Two kinds of SA: IKE_SA used by IKE self and CHILD_SA used by IPSec

- Four message types:
  IKE_SA_INIT
  IKE_AUTH
  CREATE_CHILD_SA
  INFORMATIONAL

Easy VPN

Head-End Router:

Part 2

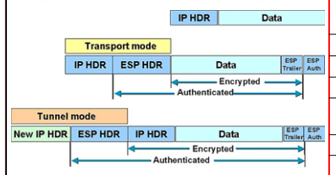
```
crypto ipsec transform-set TRANS esp-3des esp-sha-hmac

crypto dynamic-map DYNMAP 10
set transform-set TRANS                                Phase 2 params
reverse-route

crypto-map DYNMAP client authentication list vpnauthen
crypto-map DYNMAP isakmp authorization list vpnauthor
crypto-map DYNMAP client configuration address respond
crypto-map CISCO ipsec-isakmp dynamic DYNMAP

interface X (outside)
crypto map CISCO
ip local pool POOL 10.0.0.1 10.0.0.100
access-list 101 permit 1.1.1.0 0.0.0.255 any
```

IPSec Modes:

Diagram:

Transport Mode
Protectes the payload of the original datagram.

Tunnel Mode
Encrypts traffic, encapsulates the entire datagram.



	IKEv1	IKEv2
UDP Port		
Phases		
Keepalives		
Identity Hiding		
UDP/NAT		
SA Negotiation		
Number of MSGs		
EAP/CP		

	IKEv1	IKEv2
UDP Port	500	500,4500
Phases	Phase 1 6 / 3 messages Phase 2 3 messages	Phase 1 4 messages Phase 2 2 messages
Keepalives	No	Yes
Identity Hiding	in main-mode	Yes
UDP/NAT	no	Yes
SA Negotiation	Responder selects initiators proposal	Same as IKEv1, simpler
Number of MSGs	6-9	4-8
EAP/CP	No	Yes

Easy VPN

Client Router config:

(Network extension mode)

```
crypto ipsec client ezvpn MYVPN
connect auto
group easyvpn key cisco123
mode network-extension
peer 2.2.2.2
username cisco password cisco
xauth userid mode local

interface gi0/0
description outside
crypto ipsec client ezvpn MYVPN outside

interface gi0/1
description inside
crypto ipsec client ezvpn MYVPN inside
```

IPSec Protocol Headers:

ESP:

AH:

Encapsulating Security Payload (ESP):
- UDP port 50
- offers anti-replay protection
- does **not** provide protection to the outer IP header

Authentication Header (AH):
- UDP port 51
- offers anti-replay protection
- AH provides protection to the IP header.
- No confidentiality protection.

Mode / Protocol	Transport	Tunnel
AH	IP AH Data	IP AH IP Data
ESP	IP ESP Data ESP-T	IP ESP IP Data ESP-T
AH-ESP	IP AH ESP Data ESP-T	IP AH ESP IP Data ESP-T

IPSec VTI Configuration:

```
crypto isakmp policy 10
encryption 3des
authentication pre-share
group 2
crypto isakmp key cisco address 2.2.2.2 255.255.255.255
crypto transform-set MYTRANS esp-aes esp-sha
mode transport

crypto ipsec profile vti_profile
set transform-set MYTRANS

interface tunnel 0
ip address 172.16.1.1 255.255.255.252
tunnel source serial0
tunnel destination 3.3.3.3
tunnel mode ipsec ipv4
tunnel protection ipsec profile vti_profile
ip route X.X.X.X 255.255.255.0 Tunnel0
```

Cisco Easy VPN with Dynamic VTI

Server-Router

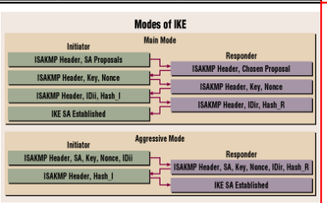
Part 1

```
aaa new-model                                          aaa for Xauth
aaa authentication login default local
aaa authorization network default local
ip cef
username cisco privilege 15 password 0 cisco1

policy-map TEST
 class class-default
 shape average 128000

crypto isakamp policy 10                               Phase 1
encryption 3des
authentication pre-share
group 2

crypto isakmp key cisco12 address 0.0.0.0 0.0.0.0
crypto isakmp keepalive 10
```

IPSEC IKE phase 1:

Main mode:

Aggressive mode:



Main mode: 6 messages
Default method
Aggressive mode: 3 messages
Faster but less secure, does not provide identity protection.

IPSec VPN Site-to-Site configuration:

```
crypto keyring SPOKES
pre-shared-key address 1.2.3.4 0.0.0.0 key Secret1

crypto isakmp policy 10
encryption 3des
authentication pre-share
group 2

crypto isakmp profile ISAKMP-PROF
keyring SPOKES
match identity address 1.2.3.4

crypto map CISCO 10 ipsec-isakmp
set peer 1.2.3.4
set transform-set MYTRANS
set isakmp-profile ISAKMP-PROF
match address 101

Interface Gi0/1
crypto map CISCO

access-list 101 permit 4.0.0.0 0.0.0.255 5.0.0.0 0.0.0.255

ip route 5.0.0.0 255.0.0.0 1.2.3.4
```

Cisco Easy VPN with Dynamic VTI

Server-Router

Part 2

```
crypto isakmp client configuration group cisco
key cisco
dns 1.2.3.4                                            Easy VPN
pool POOL                                              group
access-list 101

crypto isakmp profile ISAKMP                           ISAKMP and
 match identity group cisco                            bind
isakmp authorization list default                      parameters
client configuration address respond
virtual-templete 1

crypto ipsec transform-set TRANS esp-3des esp-sha-hmac
crypto ipsec profile MYIPSEC
set transform-set TRANS                                IPSec bind
set isakmp-profile ISAKMP                              parameters
```

Troubleshooting ISAKMP or Phase 1 VPN connections:

Verify ISAKMP parameters match exactly.

Verify pre-shared-keys match exactly.

Check that each side has a route to the peer address that you are trying to form a tunnel with.

Verify ISAKMP is enabled on the outside interfaces.

Is ESP traffic permitted in through the outside interface?

Is UDP port 500 open on the outside ACL?

Some situations require that UDP port 4500 is open for the outside.

Remote Access IPSec VPN

Overview:

- **RA IPSec VPN**
- **RA Secure Sockets Layer SSL VPN**

- **Cisco Easy VPN**
- **Dynamic VTI (DVTI)**

Easy VPN Solution:
Have centralized security policies at the head-end VPN server, pushed to the remote sites upon connection.

Easy VPN Software Client (laptop)
Easy VPN Hardware Client (ASA, PIX for LAN-to-LAN setups)

- **Client Mode / PAT mode:** single source ip
- **Network Extension Mode:** fully routable over tunel
- **Network Extension Plus Mode:** able to request IP address via mode configuration.

Cisco Easy VPN with Dynamic VTI

Server-Router

Part 3

```
int gi0/0
description outside
ip address x.x.x.x 255.255.255.0

int gi0/1
description inside
ip address y.y.y.y 255.255.255.0

interface virtual-template 1 type tunnel               For DVTI
ip unnumbered Gi0/0                                    cloning &
tunnel source gi0/0                                    apply IPSec
tunnel mode ipsec ipv4                                 profile
tunnel protection ipsec profile MYIPSEC

service-policy output TEST

ip local pool POOL 172.16.1.1 172.16.1.100             IP pool for
                                                       VPN users
ip route 0.0.0.0 0.0.0.0 gi0/0

access-list 101 permit 1.1.1.0 0.0.0.255 any
```

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

Colin

Security

Cisco Easy VPN with Dynamic VTI

Client-Router

Part 1

```
ip cef

Username cisco privilege 15 password 0 cisco1

Policy-map TEST
Class class-default
Shape average 128000

Crypto isakmp policy 10
Encr 3des
Authentication pre-share
Group 2

Crypto isakmp key cisco2 address 0.0.0.0 0.0.0.0
Crypto isakmp keepalive 10

Crypto ipsec client ezvpn MYVPN
Connect auto
Group cisco key cisco3
Peer 2.2.2.2
```

DMVPN
Single Hub DMVPN

HUB config:

```
crypto isakmp policy 10
encr 3des
authentication pre-share
group 2
crypto isakmp key SECRET address 0.0.0.0 0.0.0.0
crypto ipsec transform-set TRANS esp-3des esp-sha-hmac
crypto ipsec profile VPNPROF
set transform-set TRANS
interface Tunnel0
ip address 172.16.1.11
ip mtu 1400
ip nhrp authentication cisco
ip nhrp map multicast dynamic
ip nhrp network-id 123
ip nhrp holdtime 360
delay 1000
ip tcp adjust-mss 1360
tunnel source gi0/0
tunnel mode gre multipoint
tunnel protection ipsec profile VPNPROF
```

AAA Local Command Authorization

username ADMIN privilege 7 password 0 CISCO

privilege exec level 7 configure terminal
privilege exec level 7 undebug all
privilege exec level 7 show running-config
privilege exec level 7 debug ip rip

privilege configure level 7 interface

privilege interface level 7 shutdown
privilege interface level 7 no shutdown
privilege interface all level 7 ip

Cisco Easy VPN with Dynamic VTI

Client-Router

Part 2

```
crypto ipsec client ezvpn MYVPN
 Username cisco password ciscoX
 Xauth userid mode local
 Local-address Gi0/0
 Mode client

Interface X
Ip virtual-assembly
Crypto ipsec client ezvpn MYVPN

Interface Y
Ip virtual-assembly
Crypto ipsec client ezvpn MYPN inside

Interface Virtual-Template1 type tunnel
No ip address
Ip virtual-reassembly
Tunnel mode ipsec ipv4
Service-policy output TEST
```

DMVPN
Single Hub DMVPN

Spoke config:

```
crypto isakmp policy 10
encr 3des
authentication pre-share
group 2
crypto isakmp key SECRET address 0.0.0.0 0.0.0.0
crypto ipsec transform-set TRANS
interface Tunnel0
ip mtu 1400
ip nhrp authentication cisco
ip nhrp map 172.16.1.11  11.11.11.11
ip nhrp network-id 123
ip nhrp holdtime 360
ip nhrp nhs 12.16.1.11
delay 1000
ip tcp adjust-mss 1360
tunnel source fa0/0
tunnel destination 11.11.11.11
tunnel protection ipsec profile VPNPROF
```

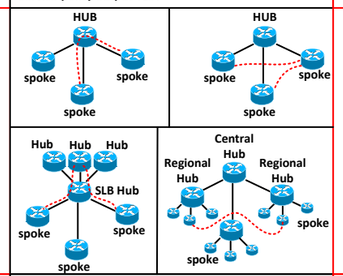
Extended ACLs which permits UDP traceroute:

traceroute UDP probes

permit udp any any range 33434 33474

DMVPN Diagrams

Phase 1	**Phase 2**
Phase 1 Server load balancing SLB	**Phase 3**



SSL VPN Access modes:

Clientless Mode (Layer 7):
- Browser-based
- Web-enabled applications (Outlook webaccess)

Thin-Client Mode (Layer 7):
- Delivered via Java Applet
- TCP-forwarding
- Extension of application support
- Telnet, pop3, SMTP, SSH, static port based applications

Thick-Client Mode (Layer 3):
- Traditional SSL VPN Client through Java, ActiveX
- AnyConnect VPN Client software
- Support of all IP-based applications

Filtering Fragmented Packets

Non-fragmented packets or **initial fragments** have a fragment **offset of zero** and **hold upper level protocol information**.

Non-initial fragments have a **non-zero fragment offset**, **hold no upper layer info**, but would still **slip through an ACL** like the following, **if the IP addresses match**:

permit tcp host 1.1.1.1 host 2.2.2.2 eq 80

ip access-list extended NO_FRAGMENTS
deny ip any any fragments
permit tcp any any eq 80

DMVPN deployment topologies

Hub and Spoke Designs
- Single Hub Single DMVPN (SHSD)
- Dual Hub Dual DMVPN (DHDD)
- Server Load Balancing (SLB)

Dynamic Mesh Designs
- Dual Hub Single DMVPN (DHSD)
- Multihub Single DMVPN (MHSD)
- Hierarchical (Tree-Based)

AAA Authentication Lists

```
aaa new-model
aaa authentication login CONSOLE local
aaa authentication login VTY group tacacs+ line
aaa authentication enable default group tacacs+
enable
aaa authentication password-prompt "Please Enter
Your Password:"
aaa authentication username-prompt "Please Enter Your ID:"
aaa authentication banner #
This system requires you to identify yourself.
#
aaa authentication fail-message #
Authentication Failed, Sorry.
#
tacacs-server host 155.1.146.100
tacacs-server directed-request
tacacs-server key CISCO
```

Lock N Key

Dynamic Access-lists:

```
- only one dynamic entry per access-list
- using dynamic ACLs with AAA enabled, make sure you are using
  local AAA.

username ENABLE password CISCO
username ENABLE autocommand access-enable host timeout 5

ip access-list extended DYNAMIC-1
dynamic PERMIT permit icmp any any
deny ip any any

interface FastEthernet0/0
ip access-group DYNAMIC-1 in

line vty 4
rotary 1
password CISCO
login
autocommand access-enable timeout 5

clear access-template DYNAMIC-1 PERMIT any 10.0.0.0 0.0.0.255
```

access-enable command unlocks the dynamic entries.

DMVPN
show commands:

show ip nhrp	**reveals NBMA address**
show crypto socket	**Local/Remote network**
show crypto ipsec sa	**remote crypto endpoints**
show crypto map	**peer, ACLs**

Debugging AAA for a telnet line:

```
debug aaa authentication

R5#telnet 150.1.1.1
Trying 150.1.1.1 ... Open

AAA/AUTHEN/START (649338587): using "default" list
AAA/AUTHEN/START (649338587): Method=tacacs+
(tacacs+)
AAA/AUTHEN(649338587): Status=ERROR
AAA/AUTHEN/START (649338587): Method=ENABLE
AAA/AUTHEN(649338587): Status=GETPASS
AAA/AUTHEN/CONT (649338587): continue_login
(user='(undef)')
AAA/AUTHEN(649338587): Status=GETPASS
AAA/AUTHEN/CONT (649338587): Method=ENABLE
AAA/AUTHEN(649338587): Status=PASS
```

Lock N Key

Additional features:

```
line vty 4
autocommand access-enable timeout 5
autocommand access-enable host timeout 5
```

access-enable host replaces the source IP specification (any) in the access-list entry with the IP of the authenticated user

access-list dynamic-extended
re-login to the router to extend the *absolute* timeout

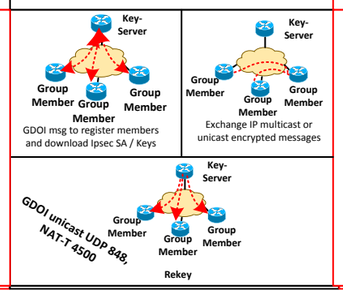
manual clear feature, with numbered extended ACL only

clear access-template <ACL-NUMBER> <DYNAMIC-ENTRY-NAME> <SRC-IP> <SRC-MASK> <DST-IP> <DST-MASK>

Get VPN

Diagram:

GDOI msg / traffic / re-keying



AAA Exec Authorization

example

```
aaa authorization console
aaa authorization exec default none
aaa authorization exec CONSOLE group tacacs+ local
aaa authorization exec VTY group tacacs+ if-authenticated

username ADMIN privilege 7 password 0 CISCO

line con 0
authorization exec CONSOLE

line vty 0 4
privilege level 15
password cisco
authorization exec VTY
login authentication VTY
```

Traffic Filtering with Policy Based Routing

Define Traffic:
ip access-list extended **ICMP**
permit icmp any any

route-map DROP
match ip **address ICMP**
match interface gi 0/0.67
match length 100 100 ***(min 100 bytes, max 100 bytes)***
set interface Null0 (send to Null0, drop)

interface gi 0/0.146
ip policy route-map DROP

interface Null0
no ip unreachables

Drop packet, but don't send ip unreachables

Once auth via telnet, permit any any eq telnet allowed.

If used with host, only for the authenticated host, permit tcp any any eq 23 opened.

```
username TELNET password 0 CISCO
username TELNET autocommand access-enable timeout 5
or
username TELNET autocommand access-enable host timeout 5
!
ip access-list extended DYNAMIC1
dynamic PERMIT_TELNET permit tcp any any eq telnet
deny tcp any host 191.1.27.7 eq telnet
deny tcp any host 191.1.7.7 eq telnet
deny tcp any host 191.1.77.7 eq telnet
deny tcp any host 191.1.177.7 eq telnet
deny tcp any host 150.1.7.7 eq telnet
permit ip any any
!
interface Serial0/0
ip access-group DYNAMIC1 in
!
interface Serial0/1
ip access-group DYNAMIC1 in
!
line vty 0 4
login local
```

clear access-template DYNAMIC1 PERMIT_TELNET any any

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

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Security

NBAR for Content-Based Filtering

```
class-map match-all EXTENSION
match protocol http url "*.bin|*.exe|*.com"

policy-map DROP
class EXTENSION
drop

interface Gi 0/0.146
service-policy output DROP
```

Tricky to find, while troubleshooting

CBAC Filtering

Show commands:

show ip inspect config

show ip inspect interfaces

show ip inspect sessions

show ip inspect all

show ip port-map | inc http

TFTP is the perfect protocol for testing, due to it using dynamic ports

Ethertype	Protocol	Ethertype	Protocol
	IPv4	0x800	IPv4
	ARP	0x0806	ARP
	Reverse-ARP	0x0835	Reverse-ARP
	802.1Q tagged frame	0x8100	802.1Q tagged frame
	IPX	0x8137	IPX
	IPX	0x8138	IPX
?	IPv6	0x86DD	IPv6
	MPLS unicast	0x8847	MPLS unicast
	MPLS multicast	0x8848	MPLS multicast
	PPPoe Discovery stage	0x8863	PPPoe Discovery stage
	PPPoe Session Stage	0x8864	PPPoe Session Stage
	LLDP	0x88CC	LLDP
	EAP over LAN	0x888E	EAP over LAN
	TRILL	0x22F3	TRILL

debug ip tcp intercept:

```
INTERCEPT: new connection
(155.1.67.7:11008 SYN -> 155.1.146.4:23)

INTERCEPT(*):
(155.1.67.7:11008 <- ACK+SYN 155.1.146.4:23)

INTERCEPT: 1st half of connection is established
(155.1.67.7:11008 ACK -> 155.1.146.4:23)

INTERCEPT(*): (155.1.67.7:11008 SYN -> 155.1.146.4:23)

INTERCEPT: 2nd half of connection established
(155.1.67.7:11008 <- ACK+SYN 155.1.146.4:23)
```

Advanced CBAC Features

Inspects router generated traffic, incl. RIP
ip inspect name INSPECT udp router-traffic

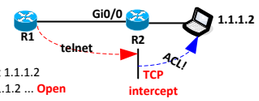
Use FTP inspect on port 80 for host 1.1.1.1
access-list 55 permit 1.1.1.1
ip port-map ftp port 80 list 55

Show port-security interface X:

```
SW3#show port-security interface fa0/6
Port Security              : Enabled
Port Status                : Secure-up
Violation Mode             : Protect
Aging Time                 : 10 mins
Aging Type                 : Inactivity
SecureStatic Address Aging : Disabled
Maximum MAC Addresses      : 2
Total MAC Addresses        : 2
Configured MAC Addresses   : 0
Sticky MAC Addresses       : 0
Last Source Address:Vlan   : 0011.200a.f000:146
Security Violation Count   : 0
```

Vlan ID

Tricky TCP intercept scenario:



R1#telnet 1.1.1.2
Trying 1.1.1.2 ... Open

R1 is receiving a three Way handshake even Tcp established is Denied by the inbound ACL! TCP intercept Answers in this case!

R2#
ip access-list extended NO_ACK
deny tcp any any established
permit ip any any

interface Gi0/0
ip access-group NO_ACK in

CBAC TCP/UDP Intercept Feature:

- Maximum of 100 half-open connections, keep dropping the sessions until their number reaches 80.
- Limit the new connections rate to 30 per minute, damp it to 15 if exceeded.
- Limit half-open tcp per server to 10, block for 60 sec if exceeded.

```
ip inspect max-incomplete low 80
ip inspect max-incomplete high 100
ip inspect one-minute low 15
ip inspect one-minute high 30
ip inspect tcp max-incomplete host 10 block-time 1
ip inspect tcp synwait-time 10

ip inspect name DEFEND tcp
ip inspect name DEFEND udp

interface FastEthernet 0/0
ip inspect DEFEND out
```

HSRP and Port-Security

HSRP configured, using the BIA MAC address instead of an additional HSRP virtual MAC addr

Port-security configured, only 1 MAC allowed

```
interface FastEthernet 0/0
ip address 155.1.146.4 255.255.255.0
standby 2 ip
standby use-bia
```

Arp cache of clients need to be flushed!

TCP intercept watch mode:

```
ip tcp intercept mode watch
ip tcp intercept watch-timeout <TIMEOUT>

router forcefully sends RST if the client/server connection
did not establish after <timeout> seconds.
also after 20 seconds without any interaction.
```

VLAN Filters for Non-IP Traffic

Allows STP, ARP on the Vlan, every thing else is denied by implicit deny any any:

```
mac access-list extended ALLOWED_L2_TRAFFIC
permit any any lsap 0x4242 0x0
permit any any 0x010B 0x0
permit any any 0x806 0x0
```

The list is then applied using the vlan filter

```
vlan access-map VLAN22_FILTER 20
match mac address ALLOWED_L2_TRAFFIC
action forward
```

Apply filter to VLAN:

```
vlan filter VLAN22_FILTER vlan-list 22
vlan filter TEST vlan-list all     (1-4096)
```

What does the following command do:

ip dhcp relay information trust-all:

Instruct the IOS DHCP Server to accept DHCP messages with a zero "giaddr" using the global command:

```
ip dhcp relay information trust-all
```

A DHCP Relay is supposed to set the "giaddr" field to its own IP address

Aggregating logging entries:

Aggregate logging messages so that a log entry is generated after five access-list entry hits, also generates the five minutely logging message

```
ip access-list log-update threshold 5
```

---

reduce CPU by **process switching** only **one** packet **per second**

```
ip access-list logging interval 1000
```

Rate-limiting logging -> CPU process switching if log / log-input is used on ACLs

MAC address-lists

Filtering Layer 2 protocols:

PVST+, ARP,CDP,VTP,DTP,UDLD,STP

```
mac access-list extended ALLOWED_L2_TRAFFIC
permit any any lsap 0x4242 0x0
permit any any 0x010B 0x0
permit any any 0x806 0x0
```

PVST+	0x010B
ARP	0x806
CDP	0x2000
VTP	0x2003
DTP	0x2004
UDLD	0x0111
IEEE STP BPDUs	0x4242

SNAP-encapsulated packets can be matched using an LSAP value of 0xAAAA

To check filtering, make opposite switch the root for one Vlan and filter it on the port, check if the local switch can not see the root on that port.

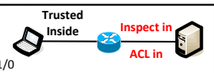
Show ip dhcp snooping

Output:

```
SW1#show ip dhcp snooping
Switch DHCP snooping is enabled
DHCP snooping is configured on following VLANs: 5
Insertion of option 82 is enabled
circuit-id format: vlan-mod-port
remote-id format: MAC
Option 82 on untrusted port is not allowed
Verification of hwaddr field is enabled
Interface Trusted    Rate  limit (pps)
------------------------  -------  ----------------
FastEthernet0/1      no      10
FastEthernet0/13     yes     unlimited
```

Option 82:
Remote-id = BIA of switch
Port-ID = Port where the Client is attached

Stateful Filtering with CBAC




```
interface Serial 0/1/0
ip inspect INSPECT out
ip access-group INBOUND in

ip access-list extended INBOUND
deny ip any any


ip inspect name INSPECT ftp alert on        / alerts only

ip inspect name INSPECT http audit-trail on

ip inspect name INSPECT udp timeout 30  /inactivity 30sec
ip inspect name INSPECT tftp
```

Use IPX for troubleshooting Layer2 MAC address lists filtering Non-IP protocols:

```
Router1#
ipx routing

interface FastEthernet 0/1
ipx network 146 encapsulation snap
                                    (Vlan146)
R1#show ipx interface fastEthernet 0/0
FastEthernet0/0 is up, line protocol is up
IPX address is 146.000d.edc8.4f60, SNAP [up]

On router 2 test reachability via:
ping 146.000d.edc8.4f60
```

Useful DHCP Snooping show commands:

show ip dhcp snooping database detail

more flash:/dhcp-bindings.txt

```
SW1#show ip dhcp snooping binding
MacAddress IpAddress Lease(sec) Type VLAN
Interface
------------------ --------------- ---------- ------------- ----
00:0C:31:EF:4E:60  155.1.146.5  85188  dhcp-snooping 5
FastEthernet0/1
Total number of bindings: 1
```

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Security

DHCP Snooping and the Information Option

Setting the remote-id and circuit-id strings:

SW2:

ip dhcp snooping
ip dhcp snooping vlan 5

ip dhcp snooping **information option format remote-id string SWITCH2**
ip dhcp snooping information option allow-untrusted

interface FastEthernet0/6
ip dhcp snooping vlan 5 **information option format-type circuit-id string CLIENT22**

Interface fa0/1
Ip dhcp snooping trust

Remote-ID = dhcp relay (sw2)
Circuit-id =point of client's attachment

show ip arp inspection vlan X

Output:

```
SW2#show ip arp inspection vlan 146
Source Mac Validation :      Enabled
Destination Mac Validation :  Enabled
IP Address Validation :      Enabled
Vlan  Configuration Operation  ACL Match        Static ACL
----  ------------- ---------  ---------        ----------
146   Enabled       Active     ARP_VLAN146      No

Vlan  ACL Logging   DHCP Logging   Probe Logging
----  -----------   ------------   -------------
146   Acl-Match     Deny           Off
```

Control Plane Protection (CPPr)

Explaining:

`control-plane host subinterface`

`control-plane transit subinterface`

CPPr treats the Route Processor (RP) as a virtual interface attached to the router classified into three categories or sub-interfaces:

control-plane host subinterface
receives all control plane TCP/UDP traffic that is directly destined for router interfaces.non TCP/UDP control traffic will end up on the CEF exception sub-interface.
Has most policing, port-filtering, per protocol queue thresholds

control-plane transit subinterface.
Handles *transit* IP packets not handled via CEF Ethernet interface and no ARP lookup has been made yet for the next-hop, making the CEF adjacency incomplete

What happens when a partially trusted port receives a DHCP packet with an zero GiAddr content?

ip dhcp snooping
information option allow-untrusted
&
Interface X
ip dhcp snooping trust

Need to be set that the switch will NOT reject packets with a Giaddr of zero value.

Troubleshoot via:
access-list 100 permit udp any any eq bootps

debug ip packet 100 dump


```
debug ip dhcp snooping event
%DHCP_SNOOPING-5-DHCP_SNOOPING_NONZERO_GIADDR:
DHCP_SNOOPING drop
```

show ip verify source

Output:

```
show ip verify source

Interface Filter-type Filter-mode IP-address Mac-address Vla
--------- ----------- ----------- ---------- ----------------- ----
Fa0/6 ip-mac     active  155.1.67.6   00:0C:CE:65:50:A0 67
Fa0/6 ip-mac     active 155.1.146.3 00:0C:CE:65:50:A0  25
```

Control Plane Protection (CPPr)

Explaining:

`control-plane CEF exception subinterface`

This is where packets causing an exception in the CEF switching path land. include non- IP router-destined traffic, such as CDP, L2 keepalive messages, ARP packets and IP packets with options or TTL <=1. Non-UDP local multicast traffic destined to the router, OSPF updates fall under this category.

NBAR can NOT be used for control-plane traffic classification !!

Dynamic ARP Inspection

maximum, 16 entries in the ARP logging buffer.

Enable all additional sanity checks for ARP packets

arp access-list ARP_VLAN146
permit ip host 155.1.146.1 mac host 000d.edc8.4f60 log
permit ip host 155.1.146.4 mac host 0015.c634.6c61 log

ip arp inspection vlan 146
ip arp inspection vlan 146 logging acl-match matchlog
ip arp inspection log-buffer entries 16
ip arp inspection log-buffer logs 4 interval 10

! Checks content of the ARP packets

ip arp inspection validate src-mac dst-mac ip

! Apply the ARP ACL

ip arp inspection filter ARP_VLAN146 vlan 146

Controlling Terminal Line Access

! Global ACL 99 in place for VTY access:

line vty 0 4
access-class 99 in
login local

User TELNET has a second ACL, permitting this user only from ACL 100 allowed networks.

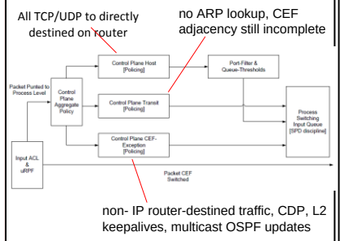
username TELNET password CISCO
username TELNET **access-class 100**

Access-class 100 could be useful in combination of restricting rotary access to ports like 80, 161 etc..

Control Plane Protection (CPPr)

Diagram:

no egress policing for any of the host subinterfaces



What speciality is to keep in mind using Reflexive Access-lists?

account for **local traffic** by either statically **permitting** the **traffic** in the **inbound ACL** or use **local policy routing** to **divert** the local traffic **across** the **loopback** interface and make it re-enter the router

IOS Login Enhancements

username TEST password TEST
access-list 99 permit 150.1.5.5

! 3 unsuccessful attempts in 30sec block for 40 sec
login block-for 40 attempts 3 within 30

! Exempt traffic sourced in 99 from block restriction
login quiet-mode access-class 99

Log every 3rd unsuccessful attempt:
login on-failure log every 3

Log every successful attempt:
login on-success log

login delay 2

line vty 0 4
login local

Control Plane Protection (CPPr)

Control-plane host:

```
policy-map CPP_HOST_POLICY
class BGP
police rate 256000

control-plane host
service-policy input CPP_HOST_POLICY
```

Dynamic arp inspection command by command:

Used to trust/disable inspection on trunks:
ip arp inspection trust

Check correctness of contents of ARP packets for src and DST
ip arp inspection validate src-mac dst-mac

IP address consistency checks for ARP packets
Ensures no host binds 0.0.0.0 or 255.255.255.255
ip arp inspection validate ip

For host NOT using DHCP create static entries:
ip arp inspection filter <ARP_ACL> vlan <vlan_ID> static

Starts logging allowed or denied packets
ip arp inspection vlan <VLAN_ID> logging acl-match

Role Based CLi

```
aaa new-model
enable view

parser view DEBUG
secret CISCO
commands exec include show running-config
commands exec include all debug
commands exec include all undebug

parser view INTERFACE1
secret CISCO
commands interface include all ip
commands configure include interface
commands exec include configure terminal
commands configure include interface FastEthernet0/0

parser view SUPER superview
secret CISCO
view DEBUG
view INTERFACE1
```

How can one check for OPEN ports in the control-plane:

show control-plane host open ports

Dynamic arp inspection Commands:

Logging packets with a source IP of 0.0.0.0
ip arp inspection vlan <VLAN_ID> logging dhcp-bindings {all | permit | none}

ip arp inspection vlan <VLAN_ID> logging arp-probe

regulate the size of this buffer
ip arp inspection log-buffer entries <N>

switch empties this buffer using a rate-limited procedure
ip arp inspection log-buffer logs <number> <interval>

estrict the rate of received ARP packets to <*pps*> per <*seconds*> interval
ip arp inspection limit rate {<pps> burst interval <seconds> | none }

Controlling the ICMP Messages Rate

Interface X
no ip unreachables

limits the total rate of all router-generated unreachable messages (100 per second = <10>)
ip icmp rate-limit unreachable <once per this ms>

Control the rate of "packet-too-big" messages (<1> = 1000 times per second)
ip icmp rate-limit unreachable DF <once per ms>

Control Plane Protection (CPPr)

Control-plane host / port-filter:

Control-plane host, port-filtering feature:
will effectively **drop** all packets destined to closed ports **before affecting router's CPU**

class-map **type port-filter** match-all **CLOSED_PORTS**
match closed-ports
match **not port 3020**
match **not port 520**

Close all except of 3020 (rotary-group) or RIP routing protocol

policy-map **type port-filter** FILTR_CLOSED_PORTS
class **CLOSED_PORTS**
drop

control-plane host
service-policy type port-filter input FILTR_CLOSED_PORTS

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Security

Control-Plane Protection (CPPr)

Control-plane host / queue-threshold

separate limit enforced for this particular protocol in the common input queue, only one threshold policy map possible. Map different threshold class maps to route map.

class-map **type queue-threshold** CMAP_BGP
match protocol bgp

policy-map **type queue-threshold BGP-Tresh**
class CMAP_BGP
queue-limit 50 —— **In packets**

control-plane host
service-policy **type queue-threshold input BGP-Tresh**

Flexible Packet Matching

-**Load a PHDF (optional).** PHDF Packet Header Definition File written in XML

load protocol system:fpm/phdf/ip.phdf
load protocol system:fpm/phdf/icmp.phdf

system:fpm/phdfs

Define a protocol stack (optional).
class-map type-stack
match-all <NAME>

ZFW Application Inspection

AIC

Config too big to display here!

Look up on page 211 INE, section-11-security.pdf
Lab Volume 1, task 11.41

Rotary / Base TCP ports

explained

Services	Base TCP port	Base for Lines
Telnet protol	3000	2000
Raw TCP no telnet	5000	4000
Telnet binary mode	7000	6000
XRemote protol	10000	9000

line vty 0
password cisco
login
rotary 20

using rotary 20, one could telnet to 3020 to the router

Flexible Packet Matching

Packet matching

(order of match statements is important):

class-map type stack match-all TCP_IPIP_ETHER

stack-start l2-start

Stack Growth

match field **layer 1** ETHER type eq 0x800 next IP

match field **layer 2** IP protocol eq 4 next IP

match field **layer 3** IP protocol eq 6 next TCP

Bridge IRB

Input-type-list

show interface irb

Define Bridging either (IRB or CRB)

access-list 201 deny 0x86dd
access-list 201 permit 0x0 0xFFFF

deny IPv6

interface X
bridge-group 1
bridge-group 1 input-type-list 201

How to check CPPr

Queue-thresholds:

CEF-exceptions subinterface statistics:

show policy-map type queue-threshold control-plane host

show policy-map control-plane cef-exception

show policy-map control-plane transit

Flexible Packet Matching

Filter ICMPs with string AAA in payload, look no deeper than 256 bytes in packet:

class-map **type stack** ICMP_IN_IP_IN_ETHER
stack-start l2-start
match field ether type eq 0x800 next ip
match field layer 2 ip protocol eq 1 next icmp

class-map **type access-control** match-all
ICMP_ECHO_STRING
match field icmp type eq 8
match start icmp payload offset 0 size 256 regex ".*AAAA.*"

policy-map **type access**
ACCESS_CONTROL_POLICY
class **ICMP_ECHO_STRING**
log

interface Fa 0/1
service-policy type access-control input
STACK_POLICY

policy-map **type access-control STACK_POLICY**
class ICMP_IN_IP_IN_ETHER
service-policy **ACCESS_CONTROL_POLICY**

Control Plane Protection

Show commands:

show control-plane features

show control-plane counters
Feature Path Packets processed/dropped/errors
Aggregate 164103/0/0
Host 13840/0/0
Transit 9736/0/0
Cef-exception 140558/0/0

class-map type port-filter match-all CLOSED_PORTS
match closed-ports
match not port TCP 2020
match not port TCP 2040

IOS ACL Selective IP Option Drop

IP source route [strict / loose]:

silently discard all packets with IP options using the command:

ip options drop

Or use an access-list:

IP source route **loose**:

deny ip any any option lsr

IP source route **strict**:

deny ip any any option ssr

ASCII table:

Decimal	Hex	Character
65 .. 90	41 .. 5B	A .. Z
97 .. 122	61 .. 7A	a .. z
48 49 .. 57	30 31 .. 39	0 1 .. 9

Control Plane Protection

RMPs:

control-plane host
service-policy input HOST_RATE_LIMIT
service-policy type port-filter input HOST_PORT_FILTR

control-plane transit
service-policy input TRANSIT_RATE_LIMIT

control-plane cef-exception
service-policy input CEF_EXCEPTION_RATE_LIMIT

Troubleshooting IP source route [loose / strict]

using ping

deny ip any any option lsr is set in an ACL on the other side:

```
Rack1SW1#ping
Protocol [ip]:
Target IP address: 155.1.37.3
....
Loose, Strict, Record, Timestamp, Verbose[none]:
Loose
Source route: 155.1.37.3
….
Sending 5, 100-byte ICMP Echos to 155.1.37.3,
timeout is 2 seconds:
Packet has IP options: Total option bytes= 7,
padded length=8
Loose source route: <*>
(155.1.37.3)
Unreachable from 155.1.37.3. Received packet has
options
Total option bytes= 7, padded length=8
Loose source route: <*>
(155.1.37.3)
```

Show ip port-map

Output:

```
R4#show ip port-map
Default mapping:  snmp          udp port 161
system defined
Default mapping:  echo          tcp port 7
system defined
Default mapping:  echo          udp port 7
system defined
Default mapping:  telnet        tcp port 23
system defined
Default mapping:  wins          tcp port 1512
system defined
Default mapping:  n2h2server    tcp port 9285
system defined
Default mapping:  n2h2server    udp port 9285
system defined
```

Zone Based Firewall

show parameter-map type inspect

Output:

R5#show parameter-map type inspect
parameter-map type inspect PMAP_PARAMS
audit-trail on
alert off
max-incomplete low 1000
max-incomplete high 2000
one-minute low 10
one-minute high 100
udp idle-time 10
icmp idle-time 5
dns-timeout 15
tcp idle-time 3600
tcp finwait-time 5
tcp synwait-time 30
tcp max-incomplete host 200 block-time 1
sessions maximum 5000

Flexible Packet Matching

FPM overview:

- Using FPM you can match any string, byte or even bit at any position in an IP (or theoretically non-IP) packet
- FPM is completely stateless and can not discover dynamic protocol ports
- Only the initial fragment can be inspected. IP packets with IP options are not matched by FPM -> sent to CPU
- Inspects only unicast packets, no MPLS packets

Configuring FPM filter:

(1) Loading protocol headers.
(2) Defining a protocol stack.
(3) Defining a traffic filter.
(4) Applying the policy & Verification

Zone Based Firewall

ZFW Rate Limiting flows

Supports two types of rate-limiting:

1) Limiting aggregate packet rate for the flows between security zones.
2) Limiting the maximum number and/or rate of the half-open connections for TCP/UDP sessions.

policy-map type inspect OUTSIDE_TO_INSIDE
class ICMP
inspect
police 256000 burst 8000

Zone Based Firewall

Limiting max number of half open connections / paramaters:

parameter-map type inspect **PMAP_PARAMS**
max-incomplete low 1000
max-incomplete high 2000
one-minute low 10
one-minute high 100
tcp max-incomplete host 200 block-time 1
sessions maximum 5000
dns-timeout 15

policy-map type inspect PMAP_OUTSIDE_DMZ
class CMAP_OUTSIDE_TO_DMZ_ACCESS
police rate 512000 burst 32000
inspect PMAP_PARAMS

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Security

The difference between

bridge crb and bridge irb

bridge crb (router has no SVI in L2 domain, not reachable)

bridge x bridge ip
(bridge IP packets, no ip route mode)

bridge x route ip
(ignore IP packets, follow IP routing rules)

---

bridge irb
If BVI is in bridge group, enable either IP bridging or IP routing, but not both!

```
bridge irb              (bvi represents L3 in L2 domain)
  bridge X route ip     (similar as a SVI)
  bridge X protocol IEEE  (probably necessary)
  int Z, bridge group X
  int BVIx
```

802.1x Authentication

Config using Radius:

```
aaa new-model

aaa authentication login default none
aaa authentication dot1x default group radius

dot1x system-auth-control

interface FastEthernet0/9
switchport mode access
dot1x port-control auto

interface FastEthernet0/10
switchport mode access
dot1x port-control auto

ip radius source-interface Loopback0

radius-server host 204.12.1.100
radius-server key CISCO
```

Securing sub-interfaces

For traffic transiting by using a policy-map:


```
class-map match-all FROM_ETHERNET
match input-interface FastEthernet0/1

policy-map SAME_INTERFACE
class FROM_ETHERNET
drop

interface FastEthernet0/1.52
service-policy output SAME_INTERFACE

interface FastEthernet0/1.53
service-policy output SAME_INTERFACE
```

Classic IOS Transparent Firewall

Using bridge IRB

```
interface BVI1                                  bridge irb
ip address 10.0.0.6 255.255.255.0               bridge 1 protocol ieee
                                                bridge 1 route ip
ip inspect name INSIDE_PROTOCOLS http
ip inspect name OUTSIDE_PROTOCOLS http

ip access-list extended OUTSIDE_IN
permit tcp any any eq 80
deny ip any any log

access-list 201 deny 0x86dd                     ! block IPv6
access-list 201 permit 0x0 0xFFFF

interface FastEthernet 0/0
ip inspect INSIDE_PROTOCOLS IN
bridge-group 1
bridge-group 1 input-type-list 201

interface FastEthernet 0/1
ip inspect OUTSIDE_PROTOCOLS OUT
bridge-group 1
bridge-group 1 input-type-list 201
```

802.1x

show dot1x all

Output:

```
Dot1x Info for FastEthernet0/9
----------------------------------
PAE                     = AUTHENTICATOR
PortControl             = AUTO
ControlDirection        = Both
HostMode                = SINGLE_HOST
ReAuthentication        = Disabled
QuietPeriod             = 60
ServerTimeout           = 30
SuppTimeout             = 30
ReAuthPerio             = 3600 (Locally configured)
ReAuthMax               = 2
MaxReq                  = 2
TxPeriod                = 30
RateLimitPeriod         = 0

SW1#show dot1x all
Sysauthcontrol              Enabled
Dot1x Protocol Version      2
Critical Recovery Delay     100
Critical EAPOL              Disabled
```

ERSPAN Source Session:

```
ERSPAN Source Session:

monitor session <session-nr> type erspan-source
description SNIFF of bla
source interface fa0/x
(optional filter vlan_range ..)
 destination
  ip address <IP.IP.IP.IP>
  erspan-id <flow-ID>
  origin ip address <IP.IP.IP.IP> [force]     ! SRC  of flow
  ip ttl <ttl>
  ip prec <IPP-Value>
  no shutdown
```

Troubleshooting:

Classic IOS Transparent Firewall

Using bridge IRB

(L2 firewall mode)

```
show bridge

Total of 300 station blocks, 297 free
Codes: P - permanent, S - self
Bridge Group 1:
Address           Action Interface Age RX count TX count
0013.c451.f240  forward  Fa0/0.146 0  123          23
0013.c440.3980 forward  Fa0/0.67   0   297          23


show ip inspect config

show ip inspect sessions

debug ip inspect l2-transparent packets
```

Troubleshooting AAA Servers:

show aaa servers:

```
SW1#show aaa servers

RADIUS: id 1, priority 1, host 204.12.1.100, auth-port 1645, acct-port
1646
    State: current UP, duration 1636s, previous duration 0s
    Dead: total time 0s, count 0
    Quarantined: No
    Authen: request 0, timeouts 0
        Response: unexpected 0, server error 0, incorrect 0, time 0ms
        Transaction: success 0, failure 0
    Author: request 0, timeouts 0
        Response: unexpected 0, server error 0, incorrect 0, time 0ms
        Transaction: success 0, failure 0
    Account: request 0, timeouts 0
        Response: unexpected 0, server error 0, incorrect 0, time 0ms
        Transaction: success 0, failure 0
    Elapsed time since counters last cleared: 14m
```

ERSPAN Destination Session:

```
ERSPAN Destination

monitor session <session-nr> type erspan-destination
description bla
destination interface fa0/x
source
  ip address <ip.ip.ip.ip> [force]       ! must match source
  erspan-id <flow-ID>
  no shutdown
```

ZFW-Based IOS Transparent Firewall

CPL (L2 firewall mode)

Part-1

```
class-map type inspect match-any
CMAP_PROTOCOLS_FROM_INSIDE
match protocol http

class-map type inspect match-any
CMAP_PROTOCOLS_TO_INSIDE
match protocol ftp

class-map type inspect CMAP_RIP_TRAFFIC
match access-group name ACL_RIP_TRAFFIC

policy-map type inspect PMAP_INSIDE_TO_OUTSIDE
class CMAP_PROTOCOLS_FROM_INSIDE
inspect

policy-map type inspect PMAP_OUTSIDE_TO_INSIDE
class CMAP_PROTOCOLS_TO_INSIDE
inspect
```

ZFW-Based IOS Transparent Firewall

CPL (L2 firewall mode)

Part-2

```
zone security INSIDE
zone security OUTSIDE

zone-pair security ZP_INSIDE_TO_OUTSIDE source INSIDE
destination OUTSIDE

service-policy type inspect PMAP_INSIDE_TO_OUTSIDE

zone-pair security ZP_OUTSIDE_TO_INSIDE source
OUTSIDE destination INSIDE

service-policy type inspect PMAP_OUTSIDE_TO_INSIDE

interface FastEthernet 0/0
bridge-group 1
zone-member security INSIDE

interface FastEthernet 0/2
bridge-group 1
zone-member security OUTSIDE
```

IOS IPS

Integration steps

Step 1. Downloading IOS IPS files
Step 2. Creating IOS IPS configuration directory on flash
Step 3. Configuring IOS IPS crypto key
Step 4. Enabling IOS IPS
Step 5. Loading IOS IPS signature package to router
Step 6: Tuning Signatures

IOS IPS

(config reference only)

Copy paste only, as no longer in version 5 lab

```
ip ips name MYIPS
ip ips config location flash:ips
ip ips notify sdee
ip ips notify log
!
interface FastEthernet 0/1
ip ips MYIPS in
!
interface FastEthernet 0/0
ip ips MYIPS in
!
ip ips signature-category
category all
retired true
exit
exit
!
ip ips signature-definition
signature 2004 0
status
enabled true
retired false
exit
exit
signature 1004 0
status
enabled true
retired false
exit
engine
event-action deny-attacker-inline
exit
exit
```

show ip ips all

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VPN / MP-BGP / MPLS

VRF Lite

Router#
ip vrf VPN_A
rd 100:1
ip vrf VPN_B
rd 100:2
Int Gi0/0.67
ip vrf forwarding VPN_A
ip addr ...
Int Gi0/0.76
ip vrf forwarding VPN_B
ip addr ...

Don't forget

Switch#
ip routing
ip vrf VPN_A
rd 100:1
ip vrf VPN_B
rd 100:2
Interface / routes…

Trunk

ip route vrf VPN_A 192.168.7.0 255.255.255.0 Gi0/0.76 1.1.1.1
ip route vrf VPN_B 172.16.7.0 255.255.255.0 Gi0/0.67 2.2.2.2

Show mpls ldp neigbour

Output:

R6#show mpls ldp neighbor
Peer LDP Ident: 150.1.4.4:0; Local LDP Ident 150.1.6.6:0
TCP connection: 155.1.146.4.646 - 155.1.146.6.33662
State: Oper; Msgs sent/rcvd: 17/17; Downstream
Up time: 00:03:58
LDP discovery sources:
GigabitEthernet0/0.146, Src IP addr: 155.1.146.4
Addresses bound to peer LDP Ident:
204.12.1.4 155.1.146.4 155.1.0.4 155.1.45.4
150.1.4.4

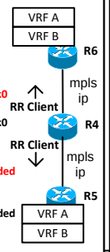
MP-BGP VPNv4

R4's config

Route-reflector

router ospf 1
mpls ldp autoconfig
router-id 150.1.4.4

router bgp 100
no bgp default ipv4-unicast
bgp log-neighbor-changes
neighbor 150.1.5.5 remote-as 100
neighbor 150.1.5.5 update-source Loopback0
neighbor 150.1.6.6 remote-as 100
neighbor 150.1.6.6 update-source Loopback0
address-family vpnv4
neighbor 150.1.5.5 activate
neighbor 150.1.5.5 send-community extended
neighbor 150.1.5.5 route-reflector-client
neighbor 150.1.6.6 activate
neighbor 150.1.6.6 send-community extended
neighbor 150.1.6.6 route-reflector-client
exit-address-family



Show ip vrf output:

SW1#show ip vrf

Name	Default RD	Interfaces
VPN_A	100:1	VI67
		Lo101
VPN_B	100:2	VI76
		Lo102

MPLS LDP

Configuring MPLS LDP password on only one side:

conf t
no mpls ldp neighbor 2.2.2.2 password CISCO

TCP-6-BADAUTH: No MD5 digest from 1.1.1.1(47531) to 2.2.2.2(646)

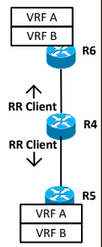
Configuring a wrong MPLS LDP password:

conf t
mpls ldp neighbor 2.2.2.2 password WRONG-pass

TCP-6-BADAUTH: Invalid MD5 digest from 1.1.1.1(43524) to 2.2.2.2(646)

MP-BGP VPNv4

R5/R6's config

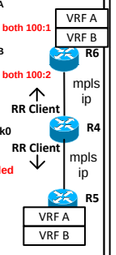


interface FastEthernet 0/0
ip vrf forwarding VPN_A
ip address x.x.x.x 255.255.255.0
ip vrf VPN_A
rd 100:1
route-target both 100:1

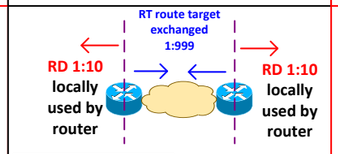
interface FastEthernet 0/1
ip vrf forwarding VPN_B
ip address x.x.x.x 255.255.255.0
ip vrf VPN_B
rd 100:2
route-target both 100:2

router bgp 100
no bgp default ipv4-unicast
neighbor 150.1.4.4 remote-as 100
neighbor 150.1.4.4 update-source Loopback0
address-family vpnv4 unicast
neighbor 150.1.4.4 activate
neighbor 150.1.4.4 send-community extended

address-family ipv4 vrf VPN_A
redistribute connected
redistribute static
address-family ipv4 vrf VPN_B
redistribute connected
redistribute static



Significants of RD route-distinguisher and RT route target



ip vrf A
rd 1:10
route target export 1:999
route target import 1:999

ip vrf A
rd 1:10
route target export 1:999
route target import 1:999

Show mpls neighbor password

Output:

Necessary config:

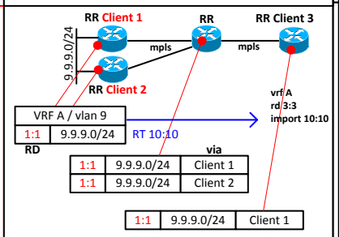
mpls ldp password required
mpls ldp neighbor 150.1.5.5 password CISCO

R1#show mpls ldp neighbor password
Peer LDP Ident: 150.1.5.5:0; Local LDP Ident 150.1.4.4:0
TCP connection: 150.1.5.5.42010 - 150.1.4.4.646
Password: required, neighbor, in use
State: Oper; Msgs sent/rcvd: 28/28

MP-BGP VPNv4

And Route-Reflector

Using the same RD on PE's:



RR only passes on the best path to RR Client 3, to over come this use different route targets

Enable mpls in two ways:

Interface X
mpls ip

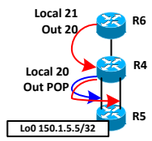
or

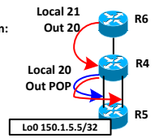
if OSPF is configured use following command to enable all OSPF enabled interfaces for MPLS:

mpls ldp autoconfig [area 2]

Tracing from R6 to R5's loopback address:

Following the unidirectional label path:





R6#traceroute 150.1.5.5
1 155.1.146.4 [MPLS: Label 20 Exp 0] 92 msec 92 msec 88 msec
2 155.1.0.5 12 msec * 8 msec

R4#
1 155.1.45.5 0 msec
155.1.0.5 12 msec *

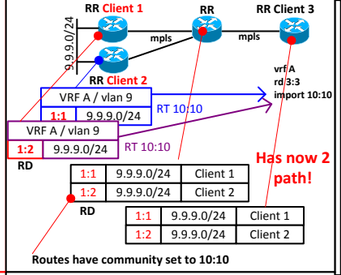
R5#
1 150.1.5.5 0 msec * 0 msec

MP-BGP VPNv4

and Route-Reflector

Using the different RD on PE's:

RR only passes best path to Client 3:



Routes have community set to 10:10

MPLS LDP discovery:

1. initially LDP sends multicast discovery messages using 224.0.0.2 UDP 646

2. Hears other LDP router,
(highest IP or mpls ldp router-id <interface>)
Will start to establish a TCP session to other LDP router-ID (normaly from loopback)
to use the physical address instead:
mpls ldp discovery transport-address <interface>

3. Using LDP-Router-IDs, rtrs establish TCP session to port 646. Can be authenticated using: interface X, mpls ldp neighbor <IP> password <password>
Or globally:
mpls ldp password required

4. LFIB should be getting populated

MPLS Label Filtering

Normally labels are generated for all entries in the routing table outbound. In order to generate labels only for specific prefixes use an access-list and specify the prefixes you want to have labels assigned for. Generate labels only for Loopbacks for example:

access-list 99 permit 150.1.6.6

no mpls ldp advertise-labels
mpls ldp advertise-labels for 99

R6#show mpls forwarding-table

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
16	Untagged	204.12.1.0/24	0	Gi0/0.146	1.2.3.4
17	Untagged	155.1.0.0/24	0	Gi0/0.146	1.2.3.4

Prevent BGP to automatically activate a configured session:

Prevents bgp from automatically activating the session:

router bgp 100
no bgp default ipv4-unicast

MPLS IP

Configuration using

Local address for LDP

Enable all OSPF interfaces for MPLS

Make passwords mandatory:

mpls ip — Enable MPLS

mpls ldp router-id Loopback0 force — set mpls router-id

interface FastEthernet 0/1
mpls ldp discovery transport-address interface — Using local address to establish LDP session

router ospf 1
mpls ldp autoconfig — Enable MPLS on all OSPF enabled interfaces

Make password mandatory
mpls ldp password required
mpls ldp neighbor 150.1.5.5 password CISCO

MPLS IP

Configuration using

The loopback for the LDP session

Enable MPLS per interface

Make passwords mandatory

mpls ip
Using Loopback0 for LDP session
mpls ldp router-id Loopback0 force

interface Serial 0/1/0
mpls ip — Enable MPLS per interface

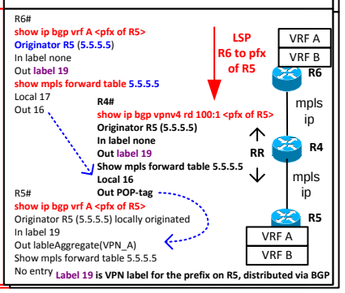
Make password mandatory
mpls ldp password required
mpls ldp neighbor 150.1.4.4 password CISCO

MPLS label switch path

Explained:

LSP from R6 to a prefix announced from R5

PE-P-PE



Label 19 is VPN label for the prefix on R5, distributed via BGP

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Colin

http://www.flashcardguy.ch

VPN / MP-BGP / MPLS

MP-BGP Prefix Filtering

Import/export maps

import map <ROUTE_MAP_NAME>
export map <ROUTE_MAP_NAME>
can match based on:
- ACLS
- prefix-lists
- extended-communities

Can be used to set extended-communities via:
set extcommunity rt

Import-map has implicit deny as default!

If not permitted by export maps the prefix will not be exported into the BGP process

Troubleshooting MP-BGP / MPLS

Commands:

On PE

show ip bgp vpnv4 vrf X <prefix>

Look for the originator of the prefix, and check his advertised Label for the VPN prefix.

show ip mpls forwarding table <IP of originator>

Look for the outgoing label and interface. Follow path Until the Label gets POP'ed. Then follow the routing table.

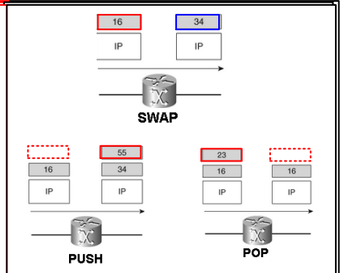
On P router:

show ip bgp vpnv4 all <prefix>

Then check for the right RD / VPN / customer, then follow the LSP to the Egress PE.

MPLS

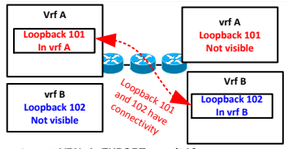
SWAP, PUSH, POP



MP-BGP Prefix Filtering

Example diagram:

Allowing single prefixes from VPN A to VPN B of another PE



route-map VPN_A_EXPORT permit 10
match ip address prefix-list LO101
set extcommunity rt 100:55

route-map VPN_A_EXPORT permit 20
set extcommunity rt 100:1

ip vrf VPN_A
export map VPN_A_EXPORT
route-target both 100:1
route-target import 100:66

VPN B
Exports Lo102 to 100:66
Everything else to 100:2
imports 100:2
imports 100:55

RIPv1 not supported as PE-CE protocol

PE-CE Routing with RIPv2

router rip
version 2
address-family ipv4 vrf VPN-X

redistribute bgp <AS-Nr> metric <value>

Sets the RIP metrics via BGP MED attribute

redistribute bgp <AS-Nr> metric transparent

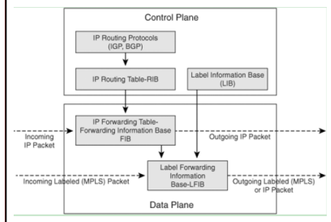
Is utilizing BGP MED attribute, RIP metrics learned from the remote site (transparent)

router bgp 100
address-family ipv4 vrf VPN-X
redistribute rip mertic <1-16> or <16+>

RIB / LIB

FIB / LFIB

Picture:



RIB

MP-BGP Prefix Filtering

Importing a prefix into VPN A

VPN A RT 100:1
PFX was set to RT 100:66

R5#**sh ip bgp vpnv4 all** 192.168.6.6
BGP routing table entry for 100:1:192.168.6.0/24, version 29
Paths: (1 available, best #1, table VPN_A)
...
Extended Community: RT:100:66
...

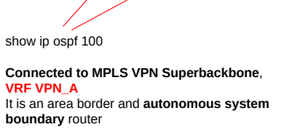
BGP routing table entry for 100:2:192.168.6.0/24, version 28
Paths: (1 available, best #1, no table) **vpnv4 entry**
...
Extended Community: RT:100:66
...

VPN a has imported this prefix from RT 100:66

PE-CE Routing with RIP

Filtering the rip route out using a **bgp** redistributed metric within 0-16

router rip
version 2
address-family ipv4 vrf VPN-X
redistribute bgp 100



router bgp 100
address-family ipv4 vrf VPN-X
redistribute rip mertic 5

RIB commands:

LIB commands:

FIB commands:

LFIB commands:

RIB:
show ip route vrf x

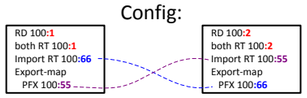
FIB:
show adjacency detail
show ip cef vrf x

LIB:
show mpls bindings
show mpls ip bindings

LFIB:
Show mpls forwarding

MP-BGP Prefix Filtering:

Config:



ip vrf VPN_A
rd 100:1
route-target both 100:1
route-target **import 100:66**
export map VPN_A_EXPORT

interface Loopback101
ip vrf forwarding VPN_A
ip address 172.16.5.5 255.255.255.0

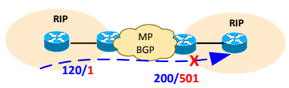
ip prefix-list LO101 permit 172.16.5.0/24

route-map VPN_A_EXPORT permit 10
match ip address **prefix-list LO101**
set extcommunity rt 100:55

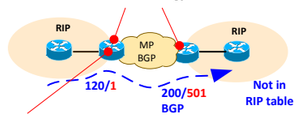
route-map VPN_A_EXPORT **permit 20**
set extcommunity **rt 100:1**

PE-CE Routing with RIP

Filtering the rip route out using a **bgp** redistributed metric of over 16



router rip
version 2
address-family ipv4 vrf VPN-X
Redistribute bgp 100



router bgp 100
address-family ipv4 vrf VPN-X
redistribute rip mertic 500 **(anything over 16)**

Show mpls forwarding-detail x.x.x.x detail

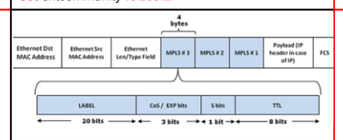
Output of label swap, push:

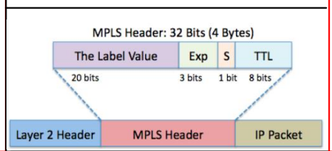
Incomming label 23 is swapped with label 20, and label 16 is pushed onto label 20

R1#**show mpls forwarding-table 10.200.254.4 detail**
Local Tag | Outgoing tag or VC | Prefix or Tunnel Id | Bytes tag switched | Outgoing interface | Next Hop
23 | **16** | 10.200.254.4/32 | 0 | Tu1 | point2point
MAC/Encaps=14/22, MRU=1496, **Tag Stack{20 16}**, via Et0/0/0
006047008810D00024A4008008847 00014000000000
No output feature configured

MPLS Header:

Picture:

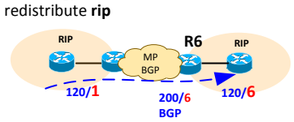




PE-CE Routing with RIP

Router rip
redistribute bgp <AS-Nr> metric 5

router bgp
redistribute **rip**



R6#show ip route vrf VPN_B 31.3.0.0
Routing entry for 31.3.0.0/16
Known via "bgp 100", distance 200, metric 12345, type internal
Redistributing via rip
Advertised by rip metric transparent
Last update from 150.1.4.4 00:21:04 ago
Routing Descriptor Blocks:
* 150.1.4.4 (Default-IP-Routing-Table), from 150.1.4.4, 00:21:04 ago
Route metric is 12345, traffic share count is 1
AS Hops 0

Area 1

MPLS label operations:

Pop
Swap
Push
Untagged/No Label
Aggregate

Pop: **top label is removed**

Swap: **top label is removed and replaced with new label**

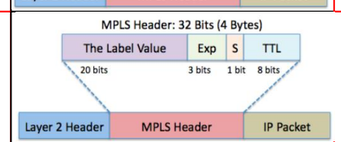
Push: **top label is replaced with a new label (swapped), and one or more labels are added (pushed) on top of the swapped label.**

Untagged/No Label: **stack is removed, forwarded unlabeled (L2 destination FR, PPP..)**

Aggregate: **label stack removed. IP lookup done the IP packet (L3 VPN)**

MPLS Header:

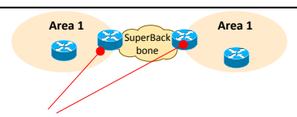
And Label distribution modes:



20 bits equivalent to 1'048'575 label IDs

Label Distribution mode:
Unsolicited downstream UC mode
Label retention mode:
Liberal Label Retention LLR mode
LSP control mode:
Independent LSP control mode

PE-CE Routing with OSPF



show ip ospf 100

Connected to MPLS VPN Superbackbone,
VRF VPN_A
It is an area border and **autonomous system boundary** router

MPLS labels

Default range

Labels within 0 - 15

Default label range: **16 – 100 000**

Reserved Labels 0 - 15

Label 0 **explicit 0 for IPv4**

Label 1 **router alert label**

Label 2 **explicit 0 for IPv6**

Label 3 **implicit 0**

Label 14 **OAM alert label**

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VPN / MP-BGP / MPLS

MPLS labels

0, 2, 3, 1, 14 explained:

Label 0 explicit 0 for IPv4
Label 2 explicit 0 for IPv6

Copy EXP bits of outer label to inner label, preserving QoS bits

Label 3 implicit 0
PE **requests POP** operation from P router. Only for directly connected or summary routes

Label 1 router alert label
Label check in Software!

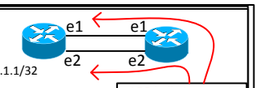
Label 14 OAM alert label
Not used by Cisco

Basic MPLS LDP config:

```
ip cef

mpls ldp router-id Loobpack0 force
mpls label protocol LDP

int loopback0
ip address 10.10.10.10 255.255.255.255

interface X
ip address x.x.x.x/yy
mpls ip
```

mpls ldp discovery transport address

Explained:



Int lo1
Ip address 1.1.1.1/32

LDP hello transport IP 1.1.1.1

```
interface e1
ip addr x.x.x.x / 24
mpls ldp discovery transport address 1.1.1.1
mpls ip

interface e2
ip addr x.x.x.x / 24
mpls ldp discovery transport address 1.1.1.1
mpls ip
```

When a router has multiple links to the same LDP router, the same transport addr must e advertised on all parallel links.

Configuring the MPLS label range:

And

show mpls label range:

RTR(config)#**mpls label range 16 1048575**

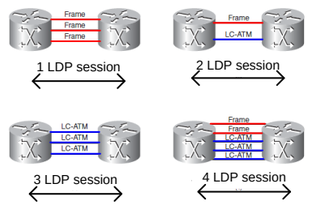
event#**show mpls label range**
Downstream Generic label region: Min/Max label: **16/1048575**

show mpls ldp discovery detail:

```
RTR#show mpls ldp discovery detail
Local LDP Identifier:
10.200.254.2:0
Discovery Sources:
Interfaces:
  Ethernet0/1/2 (ldp): xmit/recv
  Enabled: Interface config
  Hello interval: 5000 ms; Transport IP addr:
  10.200.254.2
    LDP Id: 10.200.254.5:0
    Src IP addr: 10.200.215.2; Transport IP addr:
    10.200.254.5
    Hold time: 15 sec; Proposed local/peer: 15/15 sec
    Reachable via 10.200.254.5/32

mpls ldp discovery [  hello / hold-time <15> /
                      interval <5> ]
```

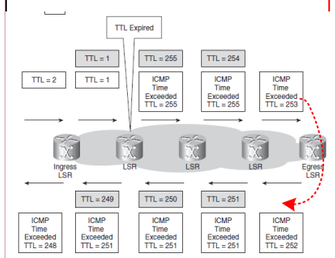
Number of MPLS LDP session:

Frame based transport / Mixed / LC-ATM:



TTL expired in MPLS network

Picture:



MPLS ldp discovery

When there is no route to the LDP neighbor:

Discovered via multicast, but unable to connect via TCP:

show mpls ldp discovery [detail]:

```
RTR#show mpls ldp discovery
  Local LDP Identifier:
  10.200.254.2:0
   Discovery Sources:
   Interfaces:
     Ethernet0/1/4 (ldp): xmit/recv
         LDP Id: 10.200.254.1:0
     POS5/0/0 (ldp): xmit/recv
         LDP Id: 10.200.254.3:0; no route
```

Check show ip route for LSRI

```
london#show mpls ldp discovery detail
..
    POS5/0/0 (ldp): xmit/recv
        Enabled: Interface config
        Hello interval: 5000 ms; Transport IP addr:
        10.200.254.2
        LDP Id: 10.200.254.3:0; no route to
        transport addr
```

MPLS
LDP bound IP addresses:

```
rtr#show mpls ldp neighbor detail
...
Addresses bound to peer LDP Ident:
10.200.254.2 10.200.210.2 10.200.218.2
10.200.211.1 10.200.215.1
Peer holdtime: 180000 ms; KA interval: 60000 ms;
Peer state: estab
```

Remote LSR binds each local IGP prefix in the routing table and advertise them through LDP

```
R1#show mpls ldp bindings
lib entry: 10.200.211.0/24, rev 12
local binding: label: imp-null
remote binding: lsr: 10.200.254.5:0, label: 18
remote binding: lsr: 10.200.254.3:0, label: imp-null
```

show mpls interfaces fastEthernet 2/6 detail:

```
RTR#show mpls interfaces fastEthernet 2/6 detail
Interface FastEthernet2/6:
IP labeling enabled
LSP Tunnel labeling not enabled
BGP labeling not enabled
MPLS not operational
MTU = 1500

RTR(config)#interface FastEthernet2/6
RTR(config-if)#mpls mtu 1508

RTR#show mpls interfaces fastEthernet 2/6 detail
...
MTU = 1508
```

(system jumbomtu)

Identifying the remote LSR and label space being used:

```
RTR#show mpls ldp discovery
  Local LDP Identifier:
  10.200.254.2:0
   Discovery Sources:
   Interfaces:
     Ethernet0/1/4 (ldp): xmit/recv
         LDP Id: 10.200.254.1:0
```

4 bytes **identifies LSR** uniquely

2 Bytes **identifies the label space**,
- if **set to 0 platform-wide label** space,
- if **set to 1**, **per interface label space** is used.

show mpls ldp bindings:

Check the local actions for a PFX:

```
RTR#show mpls ldp bindings
lib entry: 10.200.210.0/24, rev 4

lib entry: 10.200.211.0/24, rev 12
local binding: label: imp-null                    POP action
remote binding: lsr: 10.200.254.5:0, label: 18
remote binding: lsr: 10.200.254.1:0, label: 32
remote binding: lsr: 10.200.254.3:0, label: imp-null

lib entry: 10.200.254.1/32, rev 31
local binding: label: 24                          SWAP action
remote binding: lsr: 10.200.254.5:0, label: 22
remote binding: lsr: 10.200.254.1:0, label: imp-null
remote binding: lsr: 10.200.254.3:0, label: 26
```

MPLS
Maximum Receive Unit

MRU:

- informs the LSR how big a received labeled packet of a certain FEC can be that can still be forwarded out of this LSR without fragmenting it.
- value per FEC (or prefix) and not per interface!

show mpls forwarding-table x.x.x.x detail
MAC/Encaps=14/14, **MRU=1512**, Tag Stack{}

MPLS
LDP session establishment:

1. Discover via LDP Hello's Multicast 224.0.0.2 UDP 646

2. Attempt TCP connection port 646
LDP initialization messages containing:
- **Timer values**
- **Label distribution method**
- **VPI / VCI ranges (LC-ATM)**
- **DLCI ranges for Frame-Relay**

If peers disagree they will retry. To throttle:

mpls ldp backoff <initial-backoff> <max>

Attempts will increase exponentiall from
5 sec **120 sec**

Show mpls ip binding

Check for binding inuse:

```
                                        Local binding
london#show mpls ip binding
10.200.254.1/32
in label:       24
out label:      22          lsr: 10.200.254.5:0
out label:      imp-null    lsr: 10.200.254.1:0  inuse
out label:      26          lsr: 10.200.254.3:0
```

Traffic being **forwarded** to the ones marked as **inuse**

MPLS LDP functions:

MPLS LDP functions are:

- Discovery of LSRs running LDP

- Session establishment and maintenance

- Advertising of label mappings

- Notifications
(Malformed PDU, Unknown TLV, keepalive timer expired, unilateral session shutdown, initialization messages, internal errors, loop detection, other events)

Show mpls ldp neighbor x.x.x.x detail:

Check which end is the TCP server of the LDP session:

```
show mpls ldp neighbor 10.200.254.5 detail
Peer LDP Ident: 10.200.254.5:0; Local LDP Ident
10.200.254.2:0
TCP connection: 10.200.254.5.11537 -
10.200.254.2.646
State: Oper; Msgs sent/rcvd: 16/19; Dow
Last TIB rev sent 50
Up time: 00:00:36; UID: 9; Peer Id 1;
LDP discovery sources:
Ethernet0/1/2; Src IP addr: 10.200.215.2
holdtime: 15000 ms, hello interval: 5000 ms
Addresses bound to peer LDP Ident:
10.200.254.5 10.200.215.2 10.200.216.1
Peer holdtime: 180000 ms; KA interval: 60000
Peer state: estab
```

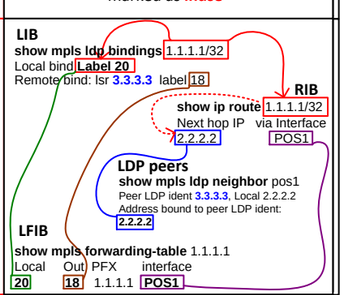
Remote side is the TCP server

MPLS

LIB **RIB**

LFIB **LDP peers**

Output:



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VPN / MP-BGP / MPLS

MPLS LDP label withdraw behaviour:

OLD DEFAULT:
MPLS LDP does not withraw labels from a neigbor it has learned the prefix/label. (no split-horizon)
To configure this behaviour:

mpls ldp neighbor x.x.x.x implicit-withdraw

debug mpls messages received

debug mpls ldp bindings

MPLS LDP autoconfig:

router ospf 1
mpls ldp autoconfig area 0

R1#**show mpls interfaces detail**
Interface Ethernet3/1:
IP labeling enabled (ldp):
Interface config
IGP config
LSP Tunnel labeling enabled
BGP labeling not enabled
MPLS operational

R1#**show mpls ldp discovery detail**
....
Ethernet3/1 (ldp): xmit/recv
Enabled: Interface config, IGP config;
...

Verifying CEF switching:

Enable cef: ip cef

Clear ip cache (fast switched cache)

show ip cache (cef switched packets will not be displayed)

Show interface stats includes fast-switched and cef switched

no ip route-cache cef

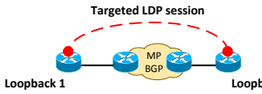
show interface stats

show ip cache (will show entries, switch falled back to fast-switching)

no ip route-cache (packets will no be process-switched)

MPLS

Targeted LDP Sessions:



mpls ldp neighbor [vrf x] 1.2.3.4 targeted ldp

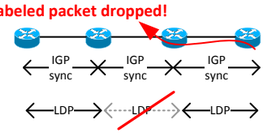
For LDP neighbors that are NOT directly connected

Targeted LDP can improve the label convergence time, in situations with flapping links.

MPLS LDP-IGP Synchronization

Concept:

Labeled packet dropped!



LDP session is down, while IGP is up!

OSPF will not form an adjacency until a link if the LDP session is not established first across that link. (No hello's on link)

OSPF will announce the link with a max metric of 65536 or 0xFFFF until synchronization is achieved.

mpls ldp sync

Switching methods:

- CEF
- fast-switching
-process switching:

ip cef ↓ Packets are CEF switched

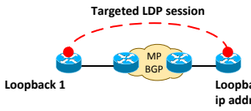
no ip route-cache cef — Packets are now fast-switched

↓

no ip route-cache — Packets are now process switched CPU

MPLS LDP

Targeted Hello Accept:



access-list standard ACCEPT-LDP
permit 2.2.2.2

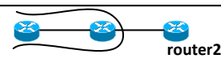
mpls label protocol ldp
mpls ldp router-id Loopback0 force

mpls ldp discovery targeted-hello accept from ACCEPT-LDP

(Allow hello's only from 2.2.2.2)

MPLS LDP-IGP Synchronization

Spoke problem:



In combination with **mpls ldp sync** in this situation, router 2 would never achieve a OSPF adjacency. OSPF waits for LDP!

Solution:
Configure hold-down timer for the synchronization.

Router2
mpls ldp igp sync holddown <msec>
Disable sync per interface
no mpls ldp igp sync

If the hold-down timer expires before the LDP session is established, the OSPF adjacency is built anyway.

IOS switching path that a packet takes

Incoming Interface	Outgoing Interface	Switching Method
CEF	Process	CEF
Process	CEF	Fast
Process	Fast Switching (IP route cache)	Fast Switching
CEF	Fast Switching	CEF

MPLS LDP Inbound Label Binding Filtering

Accept ACLS

Filter out all labels except for the Loopback addresses of the PE's:

mpls ldp neigbor x.x.x.x **accept ACCEPT-LBLS**

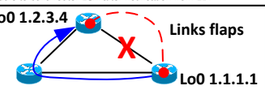
mpls ldp neigbor x.x.x.x [vrf x] accept ACCEPT-LBLS

Access-list standard ACCEPT-LBLS
permit 1.2.3.4

R1#**show mpls ldp bindings**
lib entry: 10.200.254.2/32, rev 69
local binding: label: 27
lib entry: 10.200.254.3/32, rev 71
local binding: label: 19
remote binding: lsr: **1.2.3.4**:0, **label: 21**

No label visible for PFX which are not permitted by the ACL:

MPLS LDP Session protection



mpls ldp neighbor [vrf x] 1.2.3.4 targeted ldp

mpls ldp session protection [vrf x] for ACL

LDP session is kept as long as there is an alternative path between the LSRs

show mpls ldp neighbor serial 4/0 detail
...
LDP Session Procetcion enabled, state: Ready — *standy*
Duration infinite
...
LDP Session Procetcion enabled, state: Protecting — *Link down, triggered*
Duration infinite

BGP / IGP / CEF recursion:

BGP Prefix	10.99.1.1/32
BGP nexthop	10.200.254.4
IGP next-hop	10.200.200.2

RTR#**show ip bgp 10.99.1.1**
BGP routing table entry for 10.99.1.1/32, version 13
Paths: (1 available, best #1, table Default-IP-Routing-Table)
Not advertised to any peer
Local
10.200.254.4 (metric 85) from 10.200.254.4 (10.200.254.4)
Origin IGP, metric 0, localpref 100, valid, internal, best

RTR#**show ip cef 10.200.254.4**
10.200.254.4/32
nexthop 10.200.200.2 Ethernet0/0/0 label 23

RTR#**show ip cef 10.99.1.1**
10.99.1.1/32
nexthop 10.200.200.2 Ethernet0/0/0 label 23

Controlling MPLS LDP label advertisement

Configuration:

Advertise-labels

no mpls ldp advertise-labels
mpls ldp advertise-labels for PFX to PEER-List1
mpls ldp advertise-labels for PFX-2 to PEER-List2

access-list PFX permit 10.200.254.4
access-list PFX permit 10.200.254.3
access-list PFX deny any
access-list PEER permit 10.200.254.5
access-list PEER deny any

Only prefixes 10.200.254.3/32 and 10.200.254.4/32 are advertised to LDP peer 10.200.254.5

R1#**show mpls ldp bindings advertisement-acls**
Advertisement spec:
Prefix acl = PFX; Peer acl = PEER
lib entry: 10.200.211.0/24, rev 15
lib entry: 10.200.254.3/32, rev 21
Advert acl(s): Prefix acl 1; Peer acl 2
lib entry: 10.200.254.4/32, rev 2
Advert acl(s): Prefix acl 1; Peer acl 2

MPLS

LDP-IGP synchronization

Show and debugs:

mpls ldp igp sync holddown 3000

debug mpls ldp sync [int x] peer-acl ACL]

IGP forms an adjacency anyway to give LDP the opportunity to build an LDP session across that link

%LINK-3-UPDOWN: Interface Serial4/0, changed state to up
LDP-SYNC: Se4/0: queue swif_updown, set INTFADDR_PENDING.
LDP-SYNC: Se4/0: process swif_updown, clear INTFADDR_PENDING.
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial4/0, changed state to up
%OSPF-5-ADJCHG: Process 1, Nbr 10.200.254.4 on Serial4/0 from LOADING to FULL,Loading Done
LDP-SYNC: Se4/0: No session or session has not send initial update, ignore adjoining event.
%LDP-5-NBRCHG: LDP Neighbor 10.200.254.4:0 is UP
LDP-SYNC: Se4/0: session 10.200.254.4:0 came up, sync_achieved up
LDP-SYNC: Se4/0, OSPF 1: notify status (required, achieved, no delay, **holddown 30000**)
OSPF: schedule to build router LSA after notification from LDP

CEF load-sharing

RTR#show cef interface ethernet 1/2
Per packet load-sharing is disabled

RTR(config)#int et 1/2
RTR(config-if)#ip load-sharing per-packet

RTR#show cef interface ethernet 1/2
Per packet load-sharing is enabled

restore CEF default:

ip load-sharing per-destination

show ip cef 10.200.254.4 internal

Output:

paris#**show ip cef 10.200.254.4 internal**
10.200.254.4/32, version 26, epoch 0, RIB, refcount 5, per-destination sharing
16 hash buckets
....
<0 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<1 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<2 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<3 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<4 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<5 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<6 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<7 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<8 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<9 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<10 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<11 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<12 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<13 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640
<14 > IP adj out of Ethernet1/2, addr 10.200.201.2 6346B8C0
<15 > IP adj out of Ethernet1/3, addr 10.200.203.2 6346C640

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VPN / MP-BGP / MPLS

show ip cef exact-route <SRC-IP> <DST-IP>

Output:

show ip cef exact-route SOURCE-IP DESTINATION-IP

RTR#**show ip cef exact-route 10.200.254.1 10.200.254.4**
10.200.254.1 -> 10.200.254.4 => IP adj out of Ethernet1/2, addr 10.200.201.2

RTR#show ip cef exact-route 10.200.1.2 10.200.254.4
10.200.1.2 -> 10.200.254.4 => IP adj out of Ethernet1/3, addr 10.200.203.2

VPNv4

RR Group config:

-subdivide the vpnv4 routes into groups
- increases scalability

On Route Reflector 1:
router bgp X
address-family vpnv4
bgp rr-group <1-500> {ext-com-list}

ip extcommunity-list 1 **permit rt 1:1**
ip extcommunity-list 1 **deny** rt **1:2**
ip extcommunity-list 1 **permit** rt **1:3**
ip extcommunity-list 1 **deny** rt **1:2**

On Route Reflector 2:
ip extcommunity-list 1 **deny rt 1:1**
ip extcommunity-list 1 **permit** rt **1:2**

BGP vpnv4

OSPF metric propagation

RTR#**show ip ospf 42**
Routing Process "ospf 42" with ID 10.99.1.1
Domain ID type 0x0005, value 0.0.0.42
Connected to MPLS VPN Superbackbone, VRF cust-one

RTRx#**show ip bgp vpnv4 rd** 1:1 10.200.200.1
BGP routing table entry for 1:1:10.200.200.1/32, version 5649
Paths: (1 available, best #1, table cust-one)
Not advertised to any peer
Local
10.200.254.2 (metric 3) from 10.200.254.2 (10.200.254.2)
Origin incomplete, metric 10, localpref 100, valid, internal, best
Extended Community: RT:1:1 OSPF
DOMAIN-ID:0x0005:0x0000002A0200
OSPF RT:0.0.0.0:5:1 OSPF ROUTER ID:10.99.1.1:1281,
mpls labels in/out nolabel/18

Area:route-type:option

show ip cef vrf x <prefix> [detail]

Top and bottom MPLS labels:

Output:

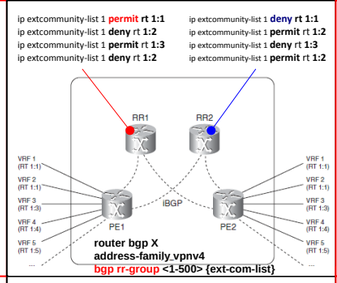
RTR#**show ip cef vrf cust-one 10.100.103.2**
10.100.103.2/32
nexthop 10.200.200.2 Ethernet0/0/0 **label 23 21**

RTR#**show ip cef vrf cust-one 10.100.103.2 detail**
10.100.103.2/32, epoch 5
recursive via 10.200.254.4 **label 21**
nexthop 10.200.200.2 Ethernet0/0/0 **label 23**

Top Label: 23 **Bottom Label: 23**

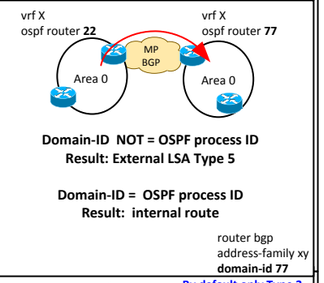
VPNv4

RR Group config:



BGP vpnv4

Extended communities for OSPF



Domain-ID NOT = OSPF process ID
Result: External LSA Type 5

Domain-ID = OSPF process ID
Result: internal route

router bgp
address-family xy
domain-id 77

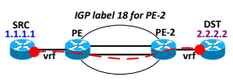
show mpls forwarding-table labels
label **exact-path ipv4** *source-address destination-address*

Output:

horizon#**show mpls forwarding-table**

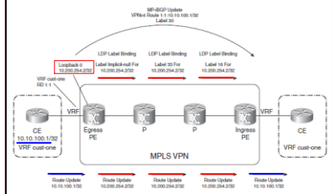
Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
17	Pop tag	10.200.254.3/32	252	Et1/3	10.200.203.2
	Pop tag	10.200.254.3/32	0	Et1/2	10.200.201.2
18	16	10.200.254.4/32	10431273	Et1/2	10.200.201.2
	16	10.200.254.4/32	238	Et1/3	10.200.203.2

show mpls forwarding-table labels 18 exact-path ipv4 <SRC> <DST>



show mpls forwarding-table labels 18 exact-path ipv4 1.1.1.1 2.2.2.2
1.1.1.1 -> 2.2.2.2 : Eth1/3 (next-hop x.x.x.x) Label Stack: 16

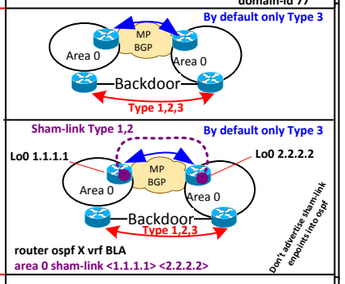
Life of a IPv4 Packet across a MPLS VPN Backbone:



VPNv4

OSPF sham Links

explained:



show cef table

Output:

london#**show cef table**
Global information:
MTRIE information:
TAL: node pools:
pool[C/8 bits]: 45 allocated (0 failed), 46800 bytes {3 refcount}

3 active IPv4 tables out of a maximum of 2048

VRF	Prefixes	Memory	Flags
Default	38	23620	
cust-one	11	14680	LCS
cust-one-ipv4	11	14680	LCS

1 active IPv6 table out of a maximum of 1

VRF	Prefixes	Memory	Flags
Default	0	60	

show ip cef vrf x <PFX>

show ip bgp vpnv4 rd 1:1 <PFX>

Explained:

inPE#**show ip cef vrf** cust-one 10.10.100.1 /32 detail
10.10.100.1/32, epoch 0
recursive via 10.200.254.2 **label 30**
nexthop **10.200.214.1** POS0/1/0 **label 16**

VPN label 30 IGP label to loopbk0 16

inPE#**show ip bgp vpnv4 rd 1:1** 10.10.100.1
BGP routing table entry for 1:1:10.10.100.1/32, version 81
Paths: (1 available, best #1, table cust-one)
Not advertised to any peer
Local
10.200.254.2 (metric 3) from 10.200.254.2 (10.200.254.2)
Origin incomplete, metric 1, localpref 100, valid, internal, best
Extended Community: RT:1:1,
mpls labels in/out nolabel/**30**

BGP loopback
IGP next hop

Verifying OSPF sham links

RTR#**show ip ospf 42 neighbor**

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.200.200.1	1	FULL/DR	00:00:35	10.10.2.1	Ethernet0/1/2
10.99.1.2	0	FULL/ -	-	10.99.1.2	OSPF_SL2

RTR#**show ip ospf 42 sham-links**
Sham Link OSPF_SL2 to address 10.99.1.2 is up
Area 0 source address 10.99.1.1
Run as demand circuit
DoNotAge LSA allowed. Cost of using 10 State
POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40,
Hello due in 00:00:03
Adjacency State FULL (Hello suppressed)

Show ip cef table IPv4 [customer-x]

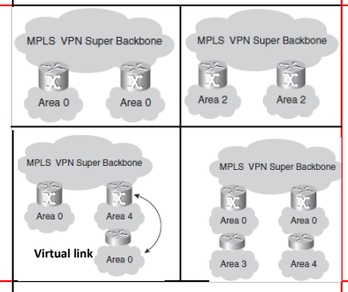
Output:

RTR#**show cef table IPv4 cust-one**
Table: IPv4:cust-one (id 1)
ref count: 3
reset count: 1
flags (0x01): LCS
smp allowed: yes
default network: none
route count: 11
route count (fwd): 11
route count (non-fwd): 0
Database epoch: 8 (11 entries at this epoch)
Subblocks:
None

RTR#**show cef table IPv4 Default**
Table: **IPv4:Default** (id 0)
ref count: 17
reset count: 1

Possible OSPF MPLS VPN Scenarious

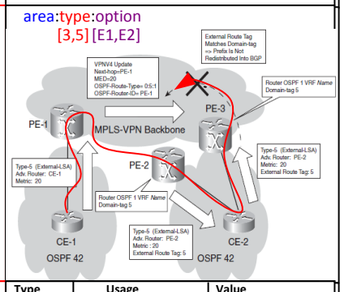
Superbackbone diagrams:



Down-Bit and Domain Tag:

MP-BGP --> OSPF = down bit is set

OSPF --> MP-BGP = domain-id is set



Show ip bgp vpnv4 rd 1:1 labels

Output explained:

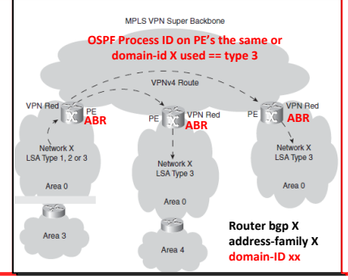
RTR#**show ip bgp vpnv4 rd 1:1 labels**

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1 (cust-one)		
10.10.2.0/24	10.200.254.2	29/36
10.10.4.0/24	0.0.0.0	26/nolabel
10.10.4.2/32	0.0.0.0	37/nolabel
10.99.1.2/32	0.0.0.0	27/nolabel
10.10.100.1/32	10.200.254.2	32/35
10.10.100.3/32	10.10.4.2	38/exp-null
10.88.1.1/32	10.200.254.2	34/34
10.99.1.1/32	10.200.254.2	28/33
10.200.200.1/32	10.200.254.2	30/32

Prefixes with next hop 0.0.0.0, have no outgoing label, learned from VRF interface, should be forwarded unlabeled towards CE

Labeled traffic

Internal OSPF Routes Across MPLS VPN Backbone



BGP extended communities for EIGRP

Type	Usage	Value
0x8800	General route info	Flags + Tag
0x8801	Route metric info and Autonomous System	Autonomous Systm + Delay
0x8802	Route metric info	Reliability, Hop Count, Bandwith
0x8803	route metric info	Reserved field, Load, MTU
0x8804	External route info	Remote Autonomous System, Remote ID
0x8805	External route info	Remote Protocol, Remote metric

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VPN / MP-BGP / MPLS

BGP Extended communities for EIGRP

RTR#**show ip bgp vpnv4 all** 10.10.100.1
BGP routing table entry for 1:1:10.10.100.1/32, version 28
...
Extended Community:
RT:1:1 Cost:pre-bestpath:128:409600 **0x8800**:32768:0 **0x8801**:42:153600 **0x8802**:65281:256000 **0x8803**:65281:1500, mpls labels in/out 22/nolabel

Internal

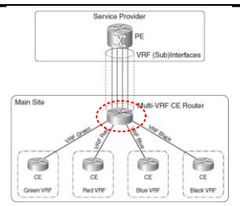
BGP extcommunities for EIGRP

RTR#**show ip bgp vpnv4 all** 10.200.200.1
BGP routing table entry for 1:1:10.200.200.1/32, version 91
Extended Community:
RT:1:1 Cost:pre-bestpath:129:409600 **0x8800**:0:0 **0x8801**:42:153600 **0x8802**:65281:256000 **0x8803**:65281:1500 **0x8804**:0:168453121 **0x8805**:11:0, mpls labels in/out nolabel/31

External

Capability vrf-lite on OSPF enabled CE

Explained:



router ospf 1
capability vrf-lite

CE performs down-bit / domain-tag check, disabled by capability vrf-lite

Upgrading

ip vrf x

To ip vrf definition x:

Previous:

ip vrf ABC
rd 1:1
route-target export 1:1
route-target import 1:1

vrf upgrade-cli multi-af-mode common-policies

Are you sure ? [yes]: yes
Number of VRFs upgraded: 1

vrf definition ABC
rd 1:1
route-target export 1:1
route-target import 1:1

address-family ipv4
exit-address-family

EIGRP VRF configuration:

Cust A
EIGRP AS Nr: **19**

Cust B
EIGRP AS Nr: **45**

router eigrp X
address-family ipv4 vrf cust-A
autonomous-system 19

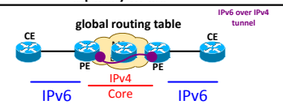
address-family ipv4 vrf cust-B
autonomous-system 45

Differences between

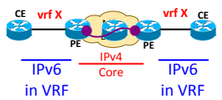
6PE and 6VPE

Picture:

6PE



6VPE



show bgp vpnv6 unicast vrf x <PFX>

Output

RD explained:

R1#**show bgp vpnv6 unicast vrf A** 2001:DB8:1:2::1/128
BGP routing table entry for **[1:1]2001:DB8:1:2::1/128**, version 5
....

RD for IPv6 in [1:1]

Pre-Bestpath POI

Cost community ID: 0 – 255
Cost value: 0 – 4294967295

The lower cost ID is more preferred.

bgp bestpath cost-community ignore

EIGRP internal community ID: 128
EIGRP external community ID: 129

The lower cost ID is more preferred.

Format: **Cost-POI-com-ID:value**

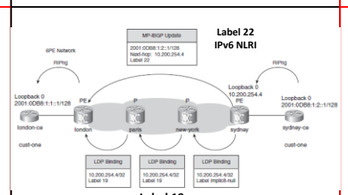
route-map X permit 10
set extcommunity cost 1 100

BGP considers POI over all other regular BGP comparison steps.

RTR#**show ip bgp vpnv4 all** 10.10.100.1
BGP routing table entry for 1:1:10.10.100.1/32, version 28
...
Extended Community:
RT:1:1 **Cost:pre-bestpath:128:409600** 0x8800:32768:0

MPLS 6PE

Routing and Label Distribution:



Label 19
Is used to reach the PE Sydney 10.200.254.4

6PE: Using IPv4 mapped IPv6 address ::FFFF:192.168.1.22

Hide the MPLS topology so the customer does not have visibility:

Makes only sense on PE routers

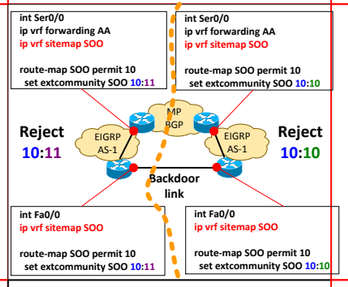
no mpls ip propagate-ttl

no mpls ip propagate-ttl forwarded

Disabling TTL propagation for customers only, ISP internal still has visibility

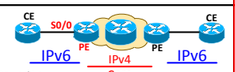
EIGRP PE-CE Backdoor links

Extcommunity SOO



6PE / MPLS

PE configuration:



int s0/0
ipv6 address 2001::1/64
ipv6 rip customer-1 enable
ipv6 enable

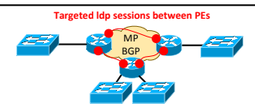
int fa0/0
ip address 10.0.0.1 255.255.255.0
mpls ip

router bgp 1
address-family ipv6
neighbor 1.1.1.1 **activate**
neighbor 1.1.1.1 **send-community both**
neighbor 1.1.1.1 **send-label**
redistribute rip customer-1

Basic VPLS

PE config:

Targeted ldp sessions between PEs



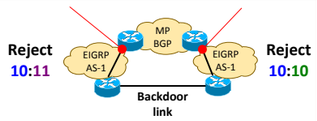
l2 vfi <name> manual

vpn id <number>

neighbor 1.2.3.4 encapsulation mpls

interface X
xconnect vfi <name>
L2tunnel-protocol [cdp,stp,vtp,..]

SOO set for an EIGRP route:



PE-1#**show ip eigrp vrf cust-one topology** 10.10.100.3 255.255.255.255
IP-EIGRP (AS 42): Topology entry for 10.10.100.3/32
....
Extended Community: SoO:10:10

R6#**show bgp vpnv4 unicast vrf** VPN_A 150.1.8.0
Extended Community: SoO:10:10 RT:100:1
Cost:prebestpath:128:156160...

Verifying 6PE operation:

RTR#**show bgp ipv6 unicast neighbors**
...
Neighbor capabilities:
...
Address family IPv6 Unicast: advertised and received
ipv6 MPLS Label capability: **advertised and received**

RTR#**show bgp ipv6 unicast** 2001:DB8:**1:2::1/128**
...
Local
::FFFF:10.200.254.4 (metric 4) from 10.200.254.4 (10.200.254.4)
Origin incomplete, metric 2, localpref 100, valid, internal, best, mpls labels in/out nolabel**/22**

RTR#**show bgp ipv6 unicast labels**

Network	Next Hop	In label/Out label	
2001:DB8:1:1::1/128	::	29/nolabel	**pop**
2001:DB8:**1:2::1/128**	**::FFFF:10.200.254.4**	nolabel/22	**push**

VPLS

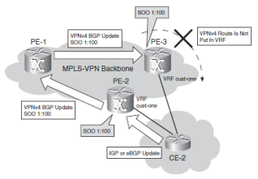
Troubleshooting commands:

VPLS-PE-1#**show vfi cust-one**
VFI name: cust-one, state: up
Local attachment circuits:
Vlan111
Neighbors connected via pseudowires:
10.100.100.2 10.100.100.3

show mpls l2transport summary

VPLS-PE-1#**show mpls l2transport vc 1 detail**
Local interface: VFI cust-one up
Destination address: 10.100.100.2, VC ID: 1, VC **status**: up
Tunnel label: 17, next hop point2point
Output interface: PO5/1, **imposed label stack {17 18}**
Create time: 2d17h, last status change time: 01:04:54
Signaling protocol: **LDP, peer 10.100.100.2:0** up
MPLS VC labels: local 16, remote 18
Group ID: local 0, remote 0
...

SOO config explained:



SOO route-map
route-map CUST-A permit 10
set extcommunity soo 1:100

Applying SOO route-map for BGP
router bgp 1
address-family ipv4 vrf CUST-A
neighbor 1.2.3.4 route-map CUST-A in

Applying SOO on the VRF interface
interface fa0/0
ip vrf sitemap CUST-A

Applying SOO route-map for static routes
router bgp 1
address-family ipv4 vrf CUST-A
Redistribute static route-map CUST-A

6VPE PE configuration:

ipv6 unicast-routing
ipv6 cef

vrf definition CUST-1
rd 1:1
address-family ipv6
route-target export 1:1
route-target import 1:1
exit-address-family

mpls ldp route-id loopback0 force

int fa0/0
ip address 10.0.0.1/24 Facing P router
mpls ip

int ser0/0
vrf forwarding CUST-1
ipv6 address 2001::1/64
ipv6 enable Facing vrf customer

router bgp 1
neighbor 1.1.1.1 update-source Loopback 0

address-family vpnv6
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both

address family ipv6 vrf CUST-1
neighbor 2001::2 remote-as XXX

EoMPLS Carrying Simple Ethernet

pseudowire-class one
encapsulation mpls

interface FastEthernet9/0/0
no ip address
xconnect 10.200.254.4 2000 pw-class one

PE1#**show mpls l2transport vc 2000**

Local intf	Local circuit	Dest address	VC ID	Status
Fa9/0/0	Ethernet	10.200.254.4	2000	UP

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VPN / MP-BGP / MPLS

MPLS Diffserver Tunneling Models:

Uniform Model

Short Pipe Model

Pipe Model

Uniform Model

Customer sets **DSCP**, **copied** into **EXP** field of label

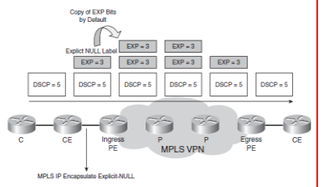
Short Pipe Model

EXP bits set according to Service Provider's policy
Scheduling / Discarding based on DSCP

Pipe Model

EXP bits set according to Service Provider's policy
Scheduling / Discarding based on EXP

Explicit Null label on CE Router



Explicit null which means penultimate hop router does not pop the label. Sends with label value of 0 but with other fileds including EXP bits intact, QoS is preserved.

mpls ip encapsulate explicit-null

Categories of QoS Information for Table-Map

Packet Marking Category	Value Range
Cos	0 – 7
IP Precedence	0 – 7
DSCP	0 – 63
QoS-Group	0 – 99
MPLS EXP imposition	0 – 7
MPLS EXP topmost	0 – 7

To Packet-Marking Type	From Packet-Marking Type
Precedence	
DSCP	
CoS	
MPLS EXP topmost	
MPLS EXP imposition	

To Packet-Marking Type	From Packet-Marking Type
Precedence	CoS QoS group
DSCP	CoS QoS group
CoS	Precedence DSCP
MPLS EXP topmost	QoS group
MPLS EXP imposition	Precedence DSCP

What does mpls ip ttl-expiration pop 1 Do?

Unlike the default, where if a TTL expires along the path, the packet is sent to the Egress PE.

With mpls ip ttl-expiration pop 1

If a ttl expires on a P router, the P router sends back a ICMP unreachable to the source router of the packet.

Debugging MPLS packets Using ACLS:

debug mpls packets 2700

access-list 2700 permit [mpls label table or any] [mpls label number] [mpls exp value] [mpls End of Stack BoS]

access-list 2700 permit any 16 any any

Label, EXP, TTL

MPLS turbo: Et3/1: rx: Len 122 Stack {16 0 253} {24 0 254} - ipv4 data
MPLS turbo: Se4/0: tx: Len 108 Stack {24 0 252} - ipv4 data

MPLS LSP Ping:

- tests one particular FEC
- uses UDP port 3503
- LSR never forewards such a packet if LSP is broken

Reply Modes:	Meaning:
1	Do not reply
2	Reply via IPv4/IPv6 UDP packet
3	Reply via IPv4/IPv6 UDP packet Router Altert
4	Reply via an application-level control channel

ping mpls ipv4 1.2.3.4/32 [verbose]
ping mpls pseudowire
ping mpls traffic-eng

ping mpls ipv4 1.2.3.4/32 destination 1.1.1.1 1.1.1.20 repeat 1
destination range

MPLS echo packet format:

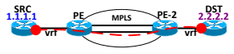
Version Number		Global Flags	
Message Type	Reply Mode	Return Code	Return Subcode
Sender's Handle			
Sequence Number			
Timestamp Sent (seconds)			
Timestamp Sent (microseconds)			
Timestamp received (seconds)			
Timestamp received (microseconds)			
TLVs ...			

Troubleshooting Load balancing in MPLS LSPs with traceroute mpls:

RTR#**traceroute mpls ipv4 2.2.2.2/32 destination 127.0.0.1 127.0.0.10**

Type escape sequence to abort.
Destination address **127.0.0.1**
0 10.200.210.1 MRU 1500 [Labels: 44 Exp: 0]
I 1 10.200.210.2 MRU 1500 [Labels: 37 Exp: 0] 68 ms
I 2 10.200.211.2 MRU 1504 [Labels: implicit-null Exp: 0] 100 ms
! 3 10.200.214.2 80 ms

Destination address **127.0.0.4**
0 10.200.210.1 MRU 1500 [Labels: 44 Exp: 0]
I 1 10.200.210.2 MRU 1500 [Labels: 41 Exp: 0] 80 ms
I 2 10.200.215.2 MRU 1504 [**Labels: implicit-null** Exp: 0] 60 ms
! 3 10.200.216.2 68 ms

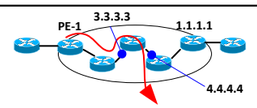


MPLS LSP Ping return codes

Value	Meaning
0	no return code
1	malformed echo request received
2	one ore more TLVs misunderstood
3	Replying router is egress for the FEC
4	Replying router has no mapping for the FEC
5	Downstream mapping mismatch
6	Upstream interface index unknown
7	Reserved
8	Label-Switched at stack depth RSC
9	Label-switched but no MPLS forwarding at stack
10	Mapping for this FEC is not given label at stack
11	No label entry at stack depth
12	Protocol not associated with interface at FEC
13	Premature termination of ping due to label stack shrinking to a single label

MPLS LSP Ping

return codes



PE-1#ping mpls ipv4 1.1.1.1/32 verbose
'B' - unlabled output interface
Type escape sequence to abort.
B size 100, reply addr 3.3.3.3, **return code 9**
B size 100, reply addr 3.3.3.3, return code 9

PE-1#**traceroute mpls ipv4 1.1.1.1.1/32 verbose**
Type escape sequence to abort.
0 3.3.3.1 3.3.3.3 MRU 1500 **[Labels: 44** Exp: 0]
B 1 3.3.3.3 4.4.4.4 MRU 1504 **[No Label]** 80 ms, ret code 9
B 2 3.3.3.3 4.4.4.4 MRU 1504 [No Label] 72 ms, ret code 9
...
B 3 3.3.3.3 4.4.4.4 MRU 1504 [No Label] 88 ms, ret code 9

MPLS ATOM Config:

1. VC identifiers have to match
2. VC Type either port mode or vlan-mode

port mode:
int fa0/x
xconnect
int fa0/x.1

Vlan mode:
int fa0/x.1
encap dot1q 10
xconnect

pseudowire class X
encapsulation mpls

3. MTU

4. Authentication

- Topmost label is the transport label PE Loopback
- Second label identifies the remote AC.

interface FastEthernet 0/1
xconnect 1.1.1.1 **100** encapsulation mpls

mpls ldp neighbor 1.1.1.1 password CISCO

L2TPv2

- Uses IP protocol 115 or UDP packets

L2TPv3

Background Info:

- mandatory to specify a pseudowire class
- specify the source IP address used for L2TPv3 session via the pw-command **ip local interface <IFNAME>**.
- **ip dfbit set**, which avoids in-core fragmentation and performance degradation
- copy the TOS byte from encapsulated packets to the tunnel, **ip tos reflect** or statically via **ip tos <VALUE>**
- **ip local pmtu,** allowes PE to send CE icmp unreachables
- **ip dfbit set,** drop if packets can not be fragmented

L2TPv3

Config:

pseudowire-class L2TPV3
encapsulation l2tpv3

ip local interface Loopback0
ip pmtu
ip dfbit set
ip tos reflect

default interface FastEthernet 0/1
interface FastEthernet 0/1
xconnect 1.2.3.4 100 **encapsulation l2tpv3** pw-class L2TPV3

Verifying L2TPv3

Config:

R5#**show l2tp session all**
L2TP Session Information Total tunnels 1 sessions 1
Session id 19547 is up, **tunnel id 38503**
Remote session id is 55660, remote tunnel id 34507
Locally initiated session
Call serial number is 1694600001
Remote tunnel name is R6
Internet **address** is **150.1.6.6**
Local tunnel name is R5
Internet **address** is **150.1.5.5**
IP protocol 115
Session is L2TP signaled
Session state is established, time since change 00:00:35
Session PMTU enabled, **path MTU is** 1496 bytes

MPLS

Basic AToM config of two PE's

PE1
mpls ldp router-id Loopback0 force
mpls label protocol ldp
pseudowire-class one
encapsulation mpls

int serial 0/0
encapsulation [hdlc, ppp]
xconnect 2.2.2.2 100 pw-class one

PE2
mpls ldp router-id Loopback0 force
mpls label protocol ldp
pseudowire-class one
encapsulation mpls

int serial 0/0
encapsulation [hdlc, ppp]
xconnect 3.3.3.3 100 pw-class one

MPLS

Troubleshooting Atom:

R1#**show mpls l2transport vc 100 detail**
Local interface: Se0/0/0 up, line protocol up, HDLC up
Destination address: 10.200254.4, **VC ID: 100**, **VC status: up**
Output int: E0/0, imposed **label** stack **{19 23}**

VC Label
IGP Label

show mpls l2transport hw-capability int X

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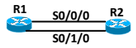
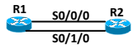


MPLS

Using TDP on parralel links using the local interfaces as transport address




```
mpls ip
mpls ldp router-id loopback 0 force

interface Serial 0/1/0
mpls ip
mpls ldp discovery transport-address interface
mpls label protocol tdp

interface Serial 0/0/0
mpls ip
mpls ldp discovery transport-address interface
mpls label protocol tdp
```

L2TPv3 configuration example:


```
R1#
interface Loopback0
ip address 1.1.1.1 255.255.255.255

pseudowire-class THE-WIRE
encapsulation l2tpv3
ip local interface Loopback0

interface e0/1
xconnect 2.2.2.2 100 encapsulation l2tpv3 pw-class THE-WIRE
```

```
R2#
interface Loopback0
ip address 2.2.2.2 255.255.255.255

pseudowire-class THE-WIRE
encapsulation l2tpv3
ip local interface Loopback0

interface e0/1
xconnect 1.1.1.1 100 encapsulation l2tpv3 pw-class THE-WIRE
```

show xconnect all

show l2tun session [all]

Output:


```
R1#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down          AD=Admin Down     IA=Inactive
  SB=Standby  RV=Recovering    NH=No Hardware

XC ST  Segment 1                  S1 Segment 2                      S2
------+---------------------------------+-+---------------------------------+--
UP   ac   Et0/1(Ethernet)         UP l2tp 2.2.2.2:100               UP
```

```
R1#show l2tun session all
.
Session vcid is 100
  Circuit state is UP
.
Remote tunnel name is R2
  Internet address is 2.2.2.2
Local tunnel name is R1
  Internet address is 1.1.1.1
IP protocol 115
```

System

Exec Aliases

alias interface si **service-policy input**

alias configure iae **ip access-list extended**

alias exec ri **show ip route**

alias exec rb **show ip bgp**

Configuring Change Notification and Logging

archive

track local config changes

archive
log config
logging enable
logging size 1000
logging queue size 1000 entries max.

notify syslog
log via syslog that changes occured
hidekeys
don't send passwords via syslog

Generating Exception Core Dumps

Show exception write core

exception core-file r3-core
Create core-dump named r3-core
exception protocol ftp
exception dump 155.1.146.100
exception memory fragment 64000 reboot
Reload case that memory fragmentation prohibits a process from allocating more than 64Kbytes of memory
exception memory minimum 1000000 reboot
reload as soon as free memory falls below 1Mbyte
no ip ftp passive
ip ftp username cisco
ip ftp password cisco
no exception crashinfo
Disable local crash information collection

System Message Logging

show logging

logging on

logging buffered 8192 debugging
save debugging up to 8192 bytes to buffers

logging console debugging
send debugging to console

logging rate-limit console all 1
limit console messages to one per second

logging monitor informational
users via telnet should see only informational and above messages

line console 0
logging synchronous
log messages should not interrupt other command output

Config / change notification And logging

Show archive log config all

output:

R4#**show archive log config all**
idx sess user@line Logged command
1 1 console@console | logging enable
2 1 console@console | logging size 1000
3 1 console@console | notify syslog
4 1 console@console | hidekeys
5 2 console@console |interface Gi0/0
6 2 console@console | description i am testing

R4#show archive log config all provisioning
hidekeys
interface GigabitEthernet0/0
description i am testing

Conditional Debugging

debug condition interface Gi0/0.67
debug ip rip

Extremely helpful on busy routers

Conditions could be:
- Interfaces
- usernames
- calling lines

Undebug all does not remove the conditions!

undebug condition interface Gi0/0.67
Proceed with removal? [yes/no]: yes
Condition 1 has been removed

Syslog Logging

logging queue-limit trap 256
set message queue depth to 256

logging trap notifications
log all messages starting at notifications to syslog

logging origin-id string ROUTER4

logging facility local1

logging source-interface Loopback0

logging host 155.1.146.100 (default, UDP 514)

logging host 155.1.146.100 transport tcp port 5000

Configuration Archive & Rollback

- use "sw1-config" as the prefix
- save local copy if switches saves to NVRAM (wr)
- save a copy to IP and locally every 24 hours

archive
path tftp://155.1.58.100/sw1-config
write-memory
time-period 1440

show archive

show archive config differences flash:/saved-config system:/running-config

Telnet Service Options

service telnet-zeroidle
idle outgoing telnet sessions, send remote host to pause output.
ip telnet source-interface Loopback0
ip telnet tos 60
set IP precedence 3 for outgoing telnet packets
ip telnet quiet Trying R4 address #1 ... Open
ip telnet hidden addresses Trying R4 (155.1.146.4)... Open
hide R4's IP when telnetting to it
no ip domain-lookup
ip host R4 155.1.146.4
local host entry for R4
busy-message R4 # Sorry, your connection failed #
display this message if telnet to R4 fails.

Logging Counting and Timestamps

service timestamps **debug uptime**
service timestamps **debug datetime msec**

service timestamps **log uptime**
service timestamps **log datetime year**

service sequence-numbers
revent against tampering with stored syslog information.

logging count
count syslog messages

Logging with Access-Lists

ip access-list extended LOGGING
permit udp any any eq rip **log-input** Log L2 info MAC addr
permit ip any any

interface FastEthernet 0/1
ip access-group LOGGING in

ip access-list logging interval 10
Send a logging message no more than once per 10 seconds

ip access-list log-update threshold 2
Generate a cumulative log entry for every 2 matched packets

Tuning Packet Buffers

Automatic buffer tuning:
buffers tune automatic
or use static assignments:
buffers small permanent 100
buffers middle permanent 50
buffers big permanent 100
buffers verybig permanent 20
buffers large permanent 10
buffers huge permanent 10

Interfaces have own private buffer pool, ints have access to public buffer pools, vary in size.

- Dynamicaly sized buffers inefficient.
- Manual sized buffers more efficient.

Syslog:

Logging count

Show logging count:

logging count
count syslog messages

R6#show logging count

Facility	Message Name	Sev	Occur	Last Time
SYS	CONFIG_I	5	4	Jul XX 2008 23:39:00
SYS TOTAL			4	
LINEPROTO	UPDOWN	5	2	Jul XX 2008 23:38:37
LINEPROTO TOTAL			2	
LINK	UPDOWN	3	1	Jul XX 2008 23:38:36
LINK	CHANGED	5	1	Jul XX 2008 23:38:28
LINK TOTAL				

TCP Keepalives

-is useful for probing idle connection to see if they are still active

service tcp-keepalives-out
service tcp-keepalive-in

To test telnet from R1 to R2, perform on R2:
show tcp brief all
TCB Local Address Foreign Address(state)
849905B4 155.1.146.1.23 155.1.146.6.17316 **ESTAB**

R1#show tcp tcb 849905B4
Timer Starts Wakeups Next
KeepAlive 7 0 0x1BECF6D
...
Flags: passive open, active open, retransmission timeout,
keepalive running

Tuning Packet Buffers

Buffer hit / misses:

A buffer "hit" mean a buffer was available for use when a packet arrived,
a buffer "miss" means the IOS had to allocate a new buffer on demand for the packet.

R4#show buffer
Buffer elements:
1119 in free list (1119 max allowed)
20848 hits, 0 misses, 619 created
Public buffer pools:
Small buffers, 104 bytes (total 68, permanent 50, peak 68 @ 02:15:59):
67 in free list (20 min, 150 max allowed)
22081 hits, **6 misses**, 0 trims, 18 created
0 failures (0 no memory)
Middle buffers, 600 bytes (total 49, permanent 25, peak 49 @
...

Logging to Flash Memory

mkdir flash:/var
mkdir flash:/var/log

logging file flash:/var/log/syslog 32768 notifications
logging on

show logging:
...
File logging: file flash:/var/log/syslog,
max size 32768, min size 0,
level notifications, 2 messages logged
....

Debugging

TCP keepalives:

debug ip tcp transactions

After 4 timeouts, TCP connection is forcefully closed.

```
TCP66: keepalive timeout (0/4)
Rack1R1#
TCP66: keepalive timeout (1/4)
Rack1R1#
TCP66: keepalive timeout (2/4)
Rack1R1#
TCP66: keepalive timeout (3/4)
Rack1R1#
TCP66: keepalive timeout (4/4)
TCP66: state was ESTAB -> CLOSED [23 ->
155.1.146.6(17316)]
TCB 0x849905B4 destroyed
```

service tcp-keepalives-out
service tcp-keepalive-in

Terminal Line Settings

show line vty 0

vacant-message #
refuse-message # Sorry, the line is already in use#

line vty 0 4
session-timeout 1
exec-timeout 2 0 Timeout after 2 mins of inactivity
lockable
absolute-timeout 5 Will disconnect in any case in 5 min!
ip netmask-format hexadecimal Display netmasks in HEX
length 20 Terminal length no more then 20 lines
transport input telnet
line vty 0
rotary 1 Makes vty0 listen to port 3001
line console 0
session-limit 1 Allowes only one user

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System

SNMPv2 Server

snmp-server community CISCO RW
snmp-server location Default Location
snmp-server contact Default Contact
snmp-server ifindex persist
Ensure that interface index numbers persist between reloads.
snmp-server system-shutdown

access-list 98 permit 155.1.146.100
snmp-server tftp-server-list 98
Only allow configuration transfers via TFTP to/from the host 155.X.146.100

CPU and Memory Thresholds

memory free low-watermark processor 1000
set up the free memory low threshold to 1000Kbytes

memory reserve critical 512
Reserve 512Kbytes of memory for the notification process using the memory command.

process cpu threshold type total rising 50 interval 5
*monitor CPU usage every 5 seconds using the **process cpu** command, and to generate a rising threshold event every time the CPU usage hits 50%*

snmp-server enable traps cpu threshold
send snmp CPU traps

SNMPv3

View 2:

traps

Enable SNMP traps for LinkUp and LinkDown events only, and send them to the destination host 155.X.146.100 using the security model "priv" and the username TRAP.

snmp-server group TRAP v3 priv

snmp-server user TRAP TRAP v3 auth sha CISCO priv des56 CISCO

snmp-server host 155.1.146.100 traps version 3 priv TRAP

snmp-server enable traps snmp linkup linkdown

show snmp commands:

show snmp
Chassis: 26388555
Contact: Default Contact
Location: Default Location
…..

show snmp community
Community name: ILMI
Community Index: cisco0
Community SecurityName: ILMI
storage-type: read-only active

show snmp mib ifmib ifindex
Ethernet0/0: Ifindex = 1
Loopback0: Ifindex = 7
Null0: Ifindex = 6
Serial0/0: Ifindex = 3
Ethernet0/1: Ifindex = 2

Testing Memory thresholds:

show memory summmary

```
Head Total(b) Used(b)    Free(b) Lowest(b)
Largest(b)
Processor
6420A860 59725728 14638656  45087072 44403156 43632028
```

memory free low-watermark processor 50000

```
%SYS-4-FREEMEMLOW: Free Memory has
dropped below low watermark
Pool: Processor Free: 45087396
Threshold: 51200000
```

memory free low-watermark processor 5000

```
%SYS-5-FREEMEMRECOVER: Free Memory has
recovered above low watermark
Pool: Processor Free: 45087660
Threshold: 5120000
```

SNMPv3

show snmp user:

show snmp user

User name: TRAP
Engine ID: 800000090300001192 21DA80
storage-type: nonvolatile active
Authentication Protocol: SHA
Privacy Protocol: DES
Group-name: TRAP

User name: NORMAL
Engine ID: 800000090300001192 21DA80
storage-type: nonvolatile active
Authentication Protocol: SHA
Privacy Protocol: DES
Group-name: NORMAL

SNMPv2c Access Control

Restrict RW access from one subnet, log all other attempts for community cisco:
Expose other hosts that attempt to access the router via SNMP.

access-list 99 permit 155.1.146.0 0.0.0.255
access-list 99 deny any log

snmp-server community CISCO RW 99

limit community PUBLIC to read-only mode, Restrict access MIB access only to the "cisco" subtree:

snmp-server community PUBLIC view ROVIEW ro
snmp-server view ROVIEW cisco included

Testing CPU thresholds:

process cpu threshold type total rising 5 interval 5
5 sec
5%

%SYS-1-CPURISINGTHRESHOLD: Threshold: Total CPU Utilization(Total/Intr): 32%/0%, Top 3 processes(Pid/Util): 3/31%, 91/0%, 2/0%

SNMPv3

show snmp group

show snmp group

groupname: NORMAL security model:v3 priv
readview : NORMAL writeview: NORMAL
notifyview: <no notifyview specified>
row status: active

groupname: RESTRICTED security model:v3 auth
readview : RESTRICTED writeview: <no writeview specified>
notifyview: <no notifyview specified>
row status: active access-list: 99

show snmp community

R4#show snmp community
Community name: ILMI
Community Index: cisco0
Community SecurityName: ILMI
storage-type: read-only active

Community name: CISCO
Community Index: cisco4
Community SecurityName: CISCO
storage-type: nonvolatile active access-list: 99

Community name: PUBLIC
Community Index: cisco5
Community SecurityName: PUBLIC
storage-type: nonvolatile active

SNMPv3

Generall info:

- group defines what access rights a set of users have and controls which SNMP objects (MIBs) can be accessed for reading and writing
- group defines which SNMP objects can generate notifications to the members of a group
- security *model* (SNMP version)
- security *level* (authentication and/or encryption)
- *read* view has implicit permit, if no write or notify is defined.

security *levels* are defined as
noauth noAuthNoPriv, (no auth, no encrypt)
auth AuthNoPriv (auth, no encrypt)
priv AuthPriv (auth and encrypt)

Group security model, but password and encryption key) are set per-user

SNMPv3

show snmp view

show snmp view
*ilmi system - included permanent active
*ilmi atmForumUni - included permanent active
NORMAL iso - included nonvolatile active
v1default iso - included permanent active
v1default internet.6.3.15 - excluded permanent active
v1default internet.6.3.16 - excluded permanent active
v1default internet.6.3.18 - excluded permanent active
v1default ciscoMgmt.394 - excluded permanent active
v1default ciscoMgmt.395 - excluded permanent active
v1default ciscoMgmt.399 - excluded permanent active
v1default ciscoMgmt.400 - excluded permanent active
RESTRICTED ifEntry.0.3 FF:EF included nonvolatile active
*tv.FFFFFFFF.FFFFFFFF.FFFFFFFF0F
iso.2.840.10036 - included volatile active
*tv.FFFFFFFF.FFFFFFFF.FFFFFFFF0F internet - included volatile active

show snmp view

R4#show snmp view
*ilmi system - included permanent active
*ilmi atmForumUni - included permanent active
ROVIEW cisco - included nonvolatile active
v1default iso - included permanent active
v1default internet.6.3.15 - excluded permanent active
v1default internet.6.3.16 - excluded permanent active
v1default internet.6.3.18 - excluded permanent active
v1default ciscoMgmt.394 - excluded permanent active
v1default ciscoMgmt.395 - excluded permanent active
v1default ciscoMgmt.399 - excluded permanent active
v1default ciscoMgmt.400 - excluded permanent active

SNMPv3

Views 1:

Normal

snmp-server ifindex persist

! create view NORMAL to include iso branch.

snmp-server view NORMAL iso included

! create group with read, write view NORMAL

snmp-server group NORMAL v3 priv read NORMAL write NORMAL

! assign user NORMAL to group, set security model to priv
! set auth password CISCO and encryption key to CISCO

snmp-server user NORMAL NORMAL v3 auth sha CISCO priv des56 CISCO

SNMPv1
SNMPv2
SNMPv3

Ports:

UDP 161 for polling,
UDP 162 for notifications

```
debug snmp packet
```

SNMP Traps and Informs

snmp-server enable traps snmp linkdown linkup
snmp-server host 155.1.146.101 **inform** version 2c CISCO
snmp-server host 155.1.146.100 CISCO

interface Serial0/0
no snmp trap link-status

show snmp host
Notification host: 155.1.146.101 udp-port: 162 type: inform user: CISCO security model: v2c

Notification host: 155.1.146.100 udp-port: 162 type: trap user: CISCO security model: v1

SNMPv3

View 2:

restricted

snmp-server ifindex persist

! create view RESTRICTED to include ifEntry 3 branch.

snmp-server view RESTRICTED ifEntry.*.3 included

! create group with read view restricted, use security model auth.

snmp-server group RESTRICTED v3 auth read RESTRICTED access 99

! Assign user RESTRICTED to group Restricted, only use auth with a key of CISCO

snmp-server user RESTRICTED RESTRICTED v3 auth sha CISCO

SNMP MAC Address Notifications

interface FastEthernet0/5
snmp trap mac-notification added
snmp trap mac-notification removed

snmp-server enable traps mac-notification

! rate-limit notifications 1 per second
mac-address-table notification interval 1

! 100 notification events in history buffer
mac-address-table notification history-size 100

mac-address-table notification

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System

SNMP MAC Address Notifications:

show mac-address-table notification

clear mac-address-table dynamic

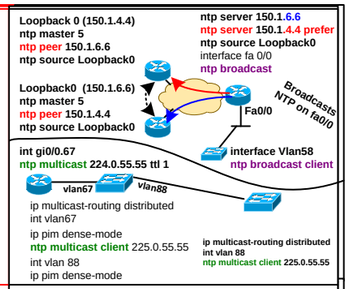
show mac-address-table notification
MAC Notification Feature is Enabled on the switch
Interval between Notification Traps : 2 secs
Number of MAC Addresses Added : 7
Number of MAC Addresses Removed : 7
Number of Notifications sent to NMS : 9
Maximum Number of entries configured in History
MAC Notification Traps are Enabled
History Index 0, Entry Timestamp 3441456, Despatch Timestamp 3441456
MAC Changed Message :
Operation: Deleted Vlan: 58 MAC Addr: 0004.9a0b.62c1 Dot1dBasePort: 7

show ip http server status

show ip http server status
HTTP server status: Enabled
HTTP server **port: 8080**
HTTP server **authentication** method: **local**
HTTP server access class: 0
HTTP server base path: flash:
Maximum number of concurrent server **connections allowed: 2**
Server idle time-out: 180 seconds
Server life time-out: 180 seconds
Maximum number of requests allowed on a connection: 1
HTTP server active session modules: ALL
HTTP secure server capability: Present
HTTP secure server status: Enabled
HTTP secure server port: 4043
HTTP secure server **ciphersuite**: des-cbc-sha
HTTP secure server client authentication: Disabled
HTTP secure server trustpoint:
HTTP secure server active session modules: ALL

NTP

ntp peer
ntp broadcast
ntp multicast



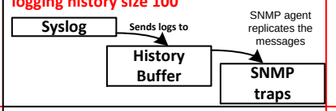
SNMP Notifications of Syslog Messages

send debugging and higher prio messages via SNMP to x.x.x.x

snmp-server enable traps syslog
snmp-server host 155.1.146.100 CISCO

Set syslog SNMP buffer size to 100 msgs

logging history debugging
logging history size 100



show ip http client all

show ip http client all
HTTP client status: Enabled
HTTP client application session modules:
Id : 1
Application Name : HTTP CFS
Version : HTTP/1.0
Persistent : persistent
Response-timeout : 0
Retries : 0
Proxy :
HTTP client current connections:
Persistent connection = enabled (default)
Connection establishment timeout = 10s (default)
Connection idle timeout = 30s (default)
Maximum number of connection establishment retries = 1 (default)
Maximum http client connections per host : 2
HTTP secure client capability: Present
HTTP secure client ciphersuite: des-cbc-sha
HTTP secure client trustpoint:

Show ntp associations details

Output:

SW2#show ntp associations detail
155.1.58.5 dynamic, our_master, sane, valid, stratum 6
ref ID 150.1.4.4, time D6DFC145.83F9908B (09:37:09.515 UTC Fri Mar 28 2014)
our mode bdcast client, peer mode bdcast, our poll intvl 64, peer poll intvl 64
root delay 45.29 msec, root disp 17.17, reach 177, sync dist 420.959
delay 2.18 msec, offset -2.8375 msec, dispersion 380.07
precision 2**18, version 3

CDP

no cdp log mismatch duplex

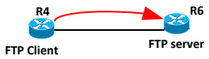
cdp source-interface Loopback0

! send CDP announcement every 10 seconds
cdp timer 10

!instruct other devices to hold the updates for 40 seconds
cdp holdtime 40

interface FastEthernet 0/0
no cdp enable

FTP Server and Client



R4 forces active mode, R6 sets up active control channel to R4! -> FW

R6#
ftp-server enable
ftp-server topdir flash:

R4#
no ip ftp passive
ip ftp source-interface Loopback0
ip ftp username CISCO
ip ftp password CISCO

NTP in Lab

```
Adjust NTP clocks in order to
synchronize quicker. If clocks are to
far apart from each other, this could
take ages to converge.

R4#clock set 00:00:01 Jan 1 2012
R5#clock set 00:00:01 Jan 1 2012
R6#clock set 00:00:01 Jan 1 2012
SW1#clock set 00:00:01 Jan 1 2012
SW2#clock set 00:00:01 Jan 1 2012
SW3#clock set 00:00:01 Jan 1 2012
```

NTP Key ID's have to match on both ends!

CDP

show commands:

R4#**show cdp**
Global CDP information:
Sending CDP **packets every 10** seconds
Sending a **holdtime value of 40** seconds
Sending **CDPv2** advertisements is enabled
Source interface is **Loopback0**

R4#**show cdp interface**
FastEthernet0/1 is up, line protocol is up
Encapsulation ARPA
Sending CDP packets every 10 seconds
Holdtime is 40 seconds

R4#**show cdp traffic**
CDP counters :
Total packets output: 160, Input: 148
Hdr syntax: 0, Chksum error: 0, Encaps failed: 0
No memory: 0, Invalid packet: 0, Fragmented: 0
CDP version 1 advertisements output: 0, Input: 0
CDP version 2 advertisements output: 160, Input: 148

TFTP Server and Client

R6:
tftp-server flash:XXX.bin alias R6-IOS **10**

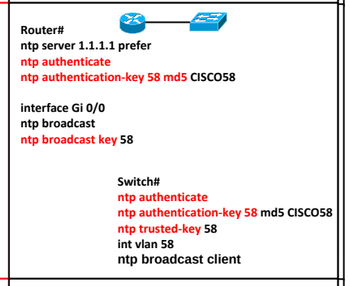
access-list **10** permit 150.1.1.1

R1:
ip tftp source-interface Loopback0

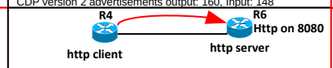
```
debug tftp events
```

NTP Authentication

ntp broadcast:



IOS HTTP Server and Client

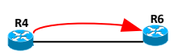



```
ip http client source-interface Loopback0
ip http client username CISCO
ip http client password CISCO
ip http client secure-ciphersuite des-cbc-sha
```

local user needs privilege level 15

```
username CISCO password 0 CISCO
ip http server
ip http max-connections 2
ip http path flash:
ip http port 8080
access-list 80 permit 150.1.0.0 0.0.255.255
ip http access-class 80
ip http authentication local
ip http secure-server
ip http secure-port 4043
ip http secure-ciphersuite des-cbc-sha
```

Remote Shell




```
#R4
rsh 150.1.6.6 /user R6 show run interface Serial 0/0
```

Config:
R1:
ip rcmd remote-username RCP
ip rcmd source-interface Loopback0

R6:
ip rcmd rcp-enable
ip rcmd rsh-enable

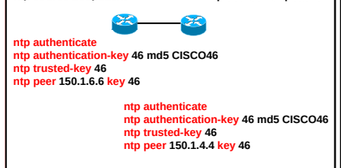
No password is required to access the local system only entry in local ".rhosts" table

ip rcmd remote-host R6 150.1.1.1 Rack1R1 enable
ip rcmd remote-host RCP 150.1.1.1 Rack1R1 enable

Run commands on **from R1 on R6**:
rsh 150.1.6.6 /user R6 show run int gi0/0

NTP authentication

ntp peer x.x.x.x

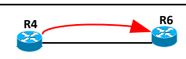


A good way to test http / tcp oriented sessions:

copy http://1.2.3.4:80/IOS-X.bin null:

Remote Shell

Performing remote commands:




```
#R4
rsh 150.1.6.6 /user R6 show run int Ser0/0
```

R4#
copy rcp://150.1.6.6/saved-config null:
Source username [RCP]?
Accessing rcp://RCP@150.1.6.6/saved-config...!
1941 bytes copied in 0.056 secs (34661 bytes/sec)

debug ip tcp rcmd

The difference between

NTP peer
NTP server

NTP Peer:

Both routers can update their clocks vice-versa,
Like a cluster of NTPs

NTP Server:
The local "ntp client" can only get the time, but will not update his local time to the other NTP server.

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Donate

Thanks for appreciating my efforts

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System

NTP Authentication

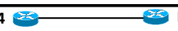
NTP Master <–> NTP Server

```
Loopback 0 (150.1.4.4)
ntp master 5
ntp source Loopback0
ntp authenticate
ntp authentication-key 4 md5 CISCO4
```

```
ntp server 150.1.6.6
ntp server 150.1.4.4 prefer
ntp source Loopback0
ntp authenticate
ntp trusted-key 4
ntp server 150.1.4.4 key 4
ntp authentication-key 4 md5 CISCO4
ntp trusted-key 6
ntp server 150.1.6.6 key 6
ntp authentication-key 6 md5 CISCO6
```

```
Loopback0 (150.1.6.6)
ntp master 5
ntp source Loopback0
ntp authenticate
ntp authentication-key 6 md5 CISCO6
```

How to find the client identifier on a Cisco Router / Switch:




```
R4(config)#interface FastEthernet0/1
R4(config-if)#ip address dhcp
```

```
R4#show dhcp lease
Temp IP addr: 0.0.0.0 for peer on Interface: FastEthernet0/1
Temp sub net mask: 0.0.0.0
DHCP Lease server: 0.0.0.0, state: 1 Selecting
DHCP transaction id: 14F4
Lease: 0 secs, Renewal: 0 secs, Rebind: 0 secs
Next timer fires after: 00:00:01
Retry count: 0 Client-ID: cisco-0007.ebde.5622-Et0/1
Client-ID hex dump: 636973636F2D303030372E656264652E
353632322D4574302F31

R5#
ip dhcp pool HOST_R4
client-identifier 00636973636F2D303030372E656264652E
353632322D4574302F31
```

Reverse Telnet On AUX lines:

```
line aux 0
no modem inOut
transport input telnet
```

Clear line <nr-of-aux-line>

Telnet to the AUX-line via:

port number by adding 2000 + TTY = 20xx

Telnet <IP> 20xx

```
alias exec auxup telnet 127.0.0.11 2097
alias exec auxdown clear line 97
```

NTP

Check if ntp is authenticated:

```
R4#show ntp associations detail | inc auth
150.1.6.6 configured, authenticated, selected, sane, valid, stratum 5
```

Auto-Install over LAN Interfaces using DHCP

Boot files / sequence

If the DHCP/BOOTP server did not provide a boot-file name, the router looks for:

network-confg or
cisconet.cfg

This to allow the router to determine its hostname. If the host name is found, the router then checks for

<hostname>-confg

If that lookup fails, the router uses router-confg or outer.cfg

KRON Command Schedule

Configure policy first:

kron **policy-list SAVE_CONFIG**
cli *show int X | redirect tftp://1.2.3.4/int-x.txt*

Apply policy to occurrence:

kron occurrence **SAVE_DAILY** at 8:00 recurring
policy-list **SAVE_CONFIG**

occurrence either one-shot or recurring

show kron schedule

NTP

Access Control

Server only hosts listed in ACL5

```
ntp access-group serve-only 5
access-list 5 permit 5.5.5.5
```

Only allow IPs out of ACL 6 to update the local clock:

```
ntp access-group peer 6
access-list 6 permit 150.1.6.6
access-list 6 permit 127.127.7.1
```

NTP locally uses 127.127.7.1 To update its clock

Auto-Install over LAN Interfaces using RARP

router sends out RARP requests for an IP address after it fails to obtain an address via DHCP/BOOTP

ip dns server
ip host R4 155.1.146.4

```
arp 155.1.146.4 0007.ebde.5622 arpa
inteface FastEthernet 0/0
no shutdown
ip rarp-server 155.1.146.1
```

tftp-server flash:r4-confg
tftp-server flash:network-confg

EEM Scripting: Interface Events

Background info:

Event detectors:
- CLI event detector
- Syslog event detector
- Interface Counter thresholds
- Counter (generic)
- SNMP
- None (event manager run)
- Watchdog periodic timer events

Event subscribers
- start with an `action` keyword
-TCL scripts

access global variables via
`event manager environment`

NTP
message types:

- control messages
  peer status
  set a management parameter

- update/request messages
  time synchronization

Troubleshooting

Auto-Install over LAN Interfaces using RARP

```
debug tftp events
debug tftp packets
debug arp
```

RARP: **Rcvd RARP req for** 0007.ebde.5622
TFTP: **Opened** flash:**network-confg**, fd 0, size 1440
TFTP: **Opened** flash:**R4-confg**, fd 0, size 1494

EEM Scripting: Interface Events

Run script every 30 seconds, write to flash:

event manager applet *TEST*
event timer watchdog name timer time 30
action 0.5 cli command "enable"
action 1.0 cli command "show clock | append flash:file.txt"
action 2.0 cli command "show ip cache flow | append flash:file.txt"
action 3.0 cli command "show voip rtp conn" | append flash:file.txt"

If you type IDI on the cli, file.bla will be deleted:

event manager applet TEST
event cli pattern "IDI" **sync no skip yes**
action 1.0 cli command "enable"
action 2.0 cli command "delete /force flash:file.bla"

show event manager policy registered

NTP
access control levels:

NTP access control defines four levels:

- Peer **(permits NTP updates/requests to the host as well as control queries)**
- Serve **(permits NTP requests, but rejects NTP updates)**
- serve-only **(permits NTP requests only, does not accept control Queries)**
- query-only **(accepts NTP control queries, no local system time synchronization with a remote system is allowed.)**

IOS Menus

Once you login to a router:

Operator Menu
1 Display IP Routing Table
2 Display Running Config
3 Escape to Shell
4 Disconnect

```
menu OPERATOR title #
Operator Menu
#
menu OPERATOR text 1 Display IP Routing Table
menu OPERATOR command 1 show ip route
menu OPERATOR text 2 Display Running Config
menu OPERATOR command 2 show run
menu OPERATOR text 3 Escape to Shell
menu OPERATOR command 3 menu-exit
menu OPERATOR text 4 Disconnect
menu OPERATOR command 4 exit
menu OPERATOR clear-screen
username OPERATOR autocommand menu OPERATOR
username OPERATOR password CISCO
username OPERATOR privilege 15
line vty 0 4
login local
```

EEM Scripting: Syslog Events

No shutting serial interface if shut, Sending email of connected users:

```
event manager applet INTERFACE_SHUTDOWN
event tag 1.0 syslog pattern "Interface Serial0/0/0.*changed.*down"
action 1.0 cli command "enable"
action 2.0 cli command "conf t"
action 3.0 cli command "interface Serial 0/0/0"
action 4.0 cli command "no shutdown"
action 5.0 cli command "end"
action 6.0 cli command "show users"
action 7.0 mail server "155.1.146.100" to "admin@INE.com" from "r5@INE.com" subject "Interface Shutdown Alert" body "Interface Serial 0/0/0 unshut, current users $_cli_result"
```

show event manager policy registered

Auto-Install over LAN Interfaces using DHCP


```
R5#
ip dns server
ip host R4 155.1.146.4
ip host R5 150.1.5.5

ip dhcp pool HOST_R4
host 155.1.146.4 255.255.255.0
client-identifier 0063.6973.636f.2d30.30.....
default-router 155.1.146.1
dns-server 155.1.146.6
option 66 ascii "R5"

tftp-server flash:r4-confg
flash:/r4-config
```

order of preference is:
sname
option 66
option 150
siaddr

IOS Banners

```
banner motd #
Welcome to IOS Router
#
banner login #
Please authenticate yourself
#
banner exec #
Hi, you are on the line $(line), have a nice time at $(hostname)
#
banner incoming #
This is a reverse telnet connection
#
line console 0
no motd-banner
no exec-banner
```

Troubleshooting

EEM

Event Manager:

show event manager policy registered

debug event manager detector syslog

debug event manager action cli

Run Event applet manually:

event manager run TEST-THIS

```
no event manager applet LOOPBACK_SHUTDOWN
event manager applet LOOPBACK_SHUTDOWN
event cli pattern ".*interface Loopback.*" sync yes
action 1.0 cli command "enable"
action 1.1 cli command "configure terminal"
action 1.2 cli command "$_cli_msg"
action 1.3 cli command "shutdown"
```

```
ip sla 1
icmp-echo 115.0.0.1
request-data-size 1250
timeout 25
threshold 20
frequency 30
!
ip sla schedule 1 start-time now life forever
```

Account for timed out packets after 25 msec

Max latency 20 msec

Ping every 30 sec

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System

DHCP address pool with secondary subnets:

```
ip dhcp pool POOL
 network 172.16.0.0 /16
 default-router 172.16.0.1
 domain-name cisco.com
 dns-server 172.16.1.102 172.16.2.102
 lease 30

 network 172.16.1.0 /24 secondary
  override default-router 172.16.1.1
  end

 network 172.16.2.0 /24 secondary
  override default-router 172.16.2.1
```

Disabling BFD Echo Mode Without Asymmetry

BFD Version 0 and therefore does not use the echo mode

disable BFD echo mode without asymmetry—no echo packets will be sent by the router, and the router will not forward BFD echo packets that are received from any neighbor routers.

```
conf t
no bfd echo
```

When ever you see this while doing a **write memory**
Or
copy running-config startup-config:

```
SW4#write memory
startup-config file open failed (Not enough space)
```

Don't waiste time!

1. **Copy the entire config into Notepad and reload the box.**
2. **once reloaded, paste the config back on.**

Your proctor has been doing this to you:

```
write memory
conf t
boot config-file flash:/
end
```

first to saved config

Then pointed the config file into nowhere

ODAP Subnet allocation Server

And

ODAP manager Config

Subnet allocation Server:

```
ip dhcp pool VRF-POOL
  vrf RED
 network 172.16.0.0 /16
 subnet prefix-length 26
```

show ip dhcp pool

ODAP manager:

```
ip dhcp pool usergroup1
 origin dhcp subnet size initial /26 autogrow /26
 lease 0 1
```

Configuring BFD Templates

```
conf t
bfd-template single-hop <template-name>
 interval min-tx 50 min-rx 50 multiplier 5
```

The task says something like, configure "clock timezone GMT +8"

And this happens:

```
R2(config)#clock ?
  <cr>

R2(config)#exit
R2#
```

The task says, configure clock timezone GMT +8

The correct command is:

```
conf t
clock timezone GMT +8

R2(config)#clock ?
<cr>
R2(config)#exit
```

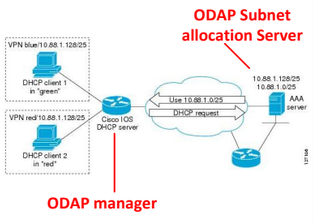
Because something is strange you type clock ? Then out of nothing.. the "exit" on the next line appears.

The proctor or Narbik is picking on you!!

```
R2#sh run | i alias
alias configure clock exit
```

ODAP address pool management

Terminology:



Troubleshooting BFD

```
show bfd neighbors [details]

debug bfd packet

debug bfd event
```

How does HSRP elect the active Node?

1. Higher priority:

```
int fa0/x
standby <nr> priority <1-255>
```

2. If Priorities are even, highest IP address.

Default priority 100

Bidirectional forwarding detection

BFD per interface:

BFD for static routes:

BFD per interface:

```
bfd interval <msec> min_rx <msec> multiplier <interval-multiplier>

interface fa0/x
bfd interval 50 min_rx 50 multiplier 5
```

```
int fa0/x
ip address 10.0.0.2 255.255.255.0
bfd interval 50 min_rx 50 multiplier 5

ip route static bfd fa0/0 10.0.0.1 group GRP-1 {passive}
ip route 0.0.0.0  0.0.0.0  10.0.0.1

 show ip static route
 show ip static route bfd
```

BFD in an HSRP Network

standby bfd / standby bfd all-interfaces
needed only if BFD has been manually disabled on a router or interface

```
ip cef
interface Fa0/x
bfd interval 200 min_rx 200 multiplier 3
 standby 1 ip 10.0.0.11
 standby 1 preempt
 standby 1 priority 110
```

What options are there in regards to HSRP authentication?

```
 standby 1 authentication cisco
(default password, not visible)

 standby 1 authentication text Cisco

 standby 2 authentication md5 key-string HSRP

standby 3 authentication md5 key-chain CHAIN
```

BFD limitations with IP redirects

When using BFD echo mode BFD version 0, you must disable the sending of Internet Control Message Protocol (ICMP) redirect messages

```
no ip redirects

bfd slow-timer <msec>
```

Write a EEM script which creates Interface Loopback 0 with ip 1.1.1.1/32

none = manual trigger

Sync yes = run commands one by one, prevents command over-run situations.

```
event manager applet BLA
 event none sync yes
 action 1.0  cli command "enable"
 action 1.1  cli command "conf t"
 action 1.2  cli command "int lo0"
 action 1.3  cli command  "ip address 1.1.1.1 255.255.255.255"
 action 1.4  cli command "end"

Manually run it:
event manager run BLA
```

```
%SYS-5-CONFIG_I: Configured from console by  on vty0 (EEM:BLA)
%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
```

How does HSRP elect the active Node?

As you write ....lot.of. Hit control-V on the key board, then write the ? And continue

```
R1#conf t
username test password 0 I.have.a.lot.of.?.for.you
```

Copy and pasting the config, will end in chaos and pain due to the ? Wrongly interpreted due to the missing Control-V interaction!!!

```
key chain EVIL
 key 1
  key-string ???.is.this.how.you.looked.like
```

BFD and uRPF

Does not work!

BFD echo mode does NOT work in conjunction with Unicast Reverse Path Forwarding (uRPF)

Write an **EEM script** with prints "THIS WILL NOT WORK DUDE"

If one enters this on the Cli:

ping 1.2.3.4

Skip yes = will skip the entered ping command!

```
event manager applet PING
 event cli pattern "ping 1.2.3.4" skip yes sync yes
 action 1.0 syslog msg "THIS WILL NOT WORK DUDE"

R1#ping 1.2.3.4
R1#
%HA_EM-6-LOG: PING: THIS WILL NOT WORK DUDE
```

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Services

Proxy ARP

interface Fa0/0
ip proxy-arp
ip local-proxy-arp

The switch can ping 1.1.1.1 even he has no default GW.

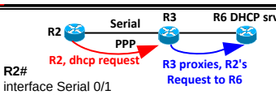
Using Proxy-Arp on the router!

DHCP Client

Setting client-identifier

interface FastEthernet 0/0
ip address dhcp client-id FastEthernet 0/0

DHCP Proxy



R2#
interface Serial 0/1
encapsulation ppp
ip address negotiated
no peer neighbor-route

R3#
interface Serial 1/3
encapsulation ppp
ip address 155.1.23.3 255.255.255.0
peer default ip address dhcp
no peer neighbor-route

ip address-pool dhcp-proxy-client
ip dhcp-server 155.1.146.6

Bootp

Packet header:

Operation code	HW type	HW addr length	Hops
Transaction Identifier			
Seconds		Flags	
Client IP address (CIAddr)			
Your IP address (YIAddr)			
Server IP address (SIAddr)			
Gateway IP address (GIAddr)			
Client Hardware Address (CHAddr)			
Server Name (Sname)			
Boot File Name (128 bytes)			
Vendor-Specific Area (64 bytes) fixed option length!			

Troubleshooting DHCP

Sequence:

D O R A

debug dhcp detail

debug dhcp detail

Int x
no ip address dhcp
ip address dhcp

debug ip dhcp server event
debug ip dhcp server packets

show ip dhcp pool
show ip dhcp database
show ip dhcp binding

release dhcp

DHCP Information Option

Relay:
ip dhcp relay information option

interface FastEthernet0/0
ip dhcp relay information option subscriber-id VLAN58

Server:
ip dhcp class TEST
relay agent information
relay-information hex
020c020a00009b013a05000000006065 64c414e3538

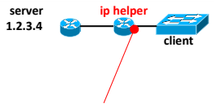
ip dhcp pool VLAN58
class TEST
address range 155.1.58.8 155.1.58.8

DHCP

Packet header:

Operation code	HW type	HW addr length	Hops
Transaction Identifier			
Seconds		Flags	
Client IP address (CIAddr)			
Your IP address (YIAddr)			
Server IP address (SIAddr)			
Gateway IP address (GIAddr)			
Client Hardware Address (CHAddr)			
Server Name (Sname)			
Boot File Name (128 bytes)			
Vendor-Specific Area (variable size) / allows more options			

DHCP Relay



interface FastEthernet 0/0
ip helper-address 1.2.3.4

DHCP option 82

DHCP option 82

|5216|020C|020A|00009B013A0500000000|0606|564C414E35|

option 82 (0x52) of total length 22 (0x16)

First suboption remote-id (0x02) total length 12 (0xC)

Remote-Id TLV (type 0x02 length 0x0A)

Remote-id value 10 bytes,

Next suboption is 0x06 length 0x06

ASCI Value

DHCP Server

service dhcp

ip dhcp excluded-address 155.1.146.100 155.1.146.254

ip dhcp pool VLAN146
network 155.1.146.0 /24
default-router 155.1.146.6 155.1.146.4
dns-server 155.1.146.6 155.1.146.4
lease 0 12

no ip bootp server **Ignore BOOTP**

ip dhcp database flash:/bindings

DHCP Host Pools

R6#**sh ip dhcp binding**
Bindings from all pools not associated with VRF:
IP address Client-ID/ Lease expiration Type
Hardware address/
User name
155.1.146.1 0063.6973.636f.2d30.3031.332e.3766.3766.2e36.3261.302d.4661.302f.30 Infinite Manual

ip dhcp pool R1_HOST
host 155.1.146.1 255.255.255.0
client-identifier 0063.6973.636f.2d30.3031.3……

ip address / no ip address dhcp

DHCP Authorized ARP

- Allows the DHCP process to populate the ARP cache with the DHCP-based entries
- Authorized ARP enabled at interface level will disable any dynamic ARP learning on that interface.

ip dhcp pool VLAN146
update arp

ip dhcp pool R1_HOST
update arp

interface fa0/0.146
arp authorize
arp timeout <seconds>
arp probe interval <sec> count 15

Show ip dhcp pool

Output:

R6#**show ip dhcp pool**

Pool VLAN146 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses : 254
Leased addresses : 0
Pending event : none
1 subnet is currently in the pool :
Current index IP address range Leased addresses
155.1.146.1 155.1.146.1 - 155.1.146.254 0

DHCP on-Demand Pool

R3:
interface Serial 1/2
encapsulation ppp
ip address 155.1.13.3 255.255.255.0
peer default ip address 155.1.13.1
ppp ipcp mask 255.255.255.0
ppp ipcp dns 155.1.146.4 155.1.146.6
no peer neighbor-route

R1:
interface Serial 0/1
encapsulation ppp
ip address negotiated
ppp ipcp mask request
ppp ipcp dns request
no peer neighbor-route

ip dhcp pool ODAP_POOL
import all
origin ipcp

router rip
no validate-update-source

R1 imports DHCP infos via IPCP from R3 (RIP functional via DHCP received IP)

IP SLA

ip sla 2
tcp-connect 54.1.1.254 23 control disable
timeout 5000

ip sla schedule 2 life forever start-time now

ip sla monitor 2
type tcpConnect dest-ipaddr 54.1.1.254 dest-port 23 control disable
timeout 5000

ip sla monitor schedule 2 life forever start-time now

show ip dhcp database

R6#**show ip dhcp database**
URL : flash:/bindings
Read : Never
Written : Never
Status : Database has changed. A file transfer to the agent is pending.
Delay : 300 seconds
Timeout : 300 seconds
Failures : 0
Successes : 0

DHCP on-Demand Pool

Verifying the import:

R1:
interface Serial 0/1
encapsulation ppp
ip address negotiated
ppp ipcp mask request
ppp ipcp dns request
no peer neighbor-route

interface Serial 1/2
encapsulation ppp
ip address 155.1.13.3 255.255.255.0
peer default ip address 155.1.13.1
ppp ipcp mask 255.255.255.0
ppp ipcp dns 155.1.146.4 155.1.146.6
no peer neighbor-route

ip dhcp pool ODAP_POOL
import all
origin ipcp

R1#**show ip dhcp import**
Address Pool Name: ODAP_POOL
Domain Name Server(s): 155.1.146.4 155.1.146.6

R1: show ip dhcp pool

Object Tracking

track 1 rtr 2
delay down 15 up 10

track 2 rtr 3

track 3 list boolean and
object 1
object 2

track 4 list boolean or
object 1
object 2

show track 1
Track 1
Response Time Reporter 2 state
State is Up
1 change, last change 00:05:10
Delay up 10 secs, down 15 secs
Latest operation return code: OK
Latest RTT (millisecs) 16
Tracked by:
Track-list 3
Track-list 4

show track 3
Track 3
List boolean and
Boolean AND is Down
3 changes, last change 00:01:45
object 1 Up
object 2 Down

show track 4
Track 4
List boolean or
Boolean OR is Up
2 changes, last change 00:00:30
object 1 Up
object 2 Down

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Services

HSRP

R1#
interface FastEthernet 0/0.146
standby 146 ip 155.1.146.**254**
standby 146 timers 1 3
standby 146 preempt
standby 146 authentication md5 key-string CISCO
standby 146 name VLAN146
standby 146 **priority 110**

Version 1
224.0.0.**2**
UDP port 1985

R2#
interface FastEthernet 0/1
standby 146 ip 155.1.146.**254**
standby 146 timers 1 3
standby 146 preempt
standby 146 authentication md5 key-string CISCO
standby 146 name VLAN146
standby 146 **priority 105**

standby version 2
224.0.0.**102**
UDP port 1985

show standby brief

show standby all

Output:

R4#**show standby all**
GigabitEthernet0/1 - **Group 146**
State is Standby
1 state change, last state change 00:00:38
Virtual IP address is 155.1.146.254
Active virtual **MAC** address is **0000.0c07.ac92**
Local virtual **MAC** address is **0000.0c07.ac92** (v1 default)
Hello time 1 sec, hold time 3 sec
Next hello sent in 0.984 secs
Authentication MD5, key-string
Preemption enabled
Active router is 155.1.146.6, priority 110 (expires in 2.164 sec)
Standby router **is local**
Priority 100 (default 100)
IP redundancy name is "VLAN146" (cfgd)

92 hex = 146 decimal

VRRP

R6:
interface FastEthernet 0/0.146
vrrp 146 **ip** 155.1.146.253
vrrp 146 timers advertise 3
vrrp 146 **authentication** CISCO

R4:
interface FastEthernet 0/1
vrrp 146 ip 155.1.146.253
vrrp 146 timers advertise 3
vrrp 146 authentication CISCO
vrrp 146 **priority 110**

SRC interface IP
DST 224.0.0.18
protocol 112

show vrrp all

Output:

R6#**show vrrp all**
GigabitEthernet0/0.146 - Group 146
State is Backup
Virtual IP address **is** 155.1.146.253
Virtual MAC address **is 0000.5e00.0192**
Advertisement interval is 3.000 sec
Preemption enabled
Priority is 100
Authentication text, string "**CISCO**"
Master Router is 155.1.146.4, **priority is 110**
Master Advertisement **interval is** 3.000 sec
Master Down interval is 9.609 sec (expires in 7.877 sec)

GLBP

SRC interface IP
DST 224.0.0.102
UDP 3222

R6:
interface g0/0.146
glbp 146 ip 155.1.146.252
glbp 146 timers 1 3
glbp 146 priority 110
glbp 146 preempt
glbp 146 weighting 10
glbp 146 name VLAN146
glbp 146 authentication md5 key-string CISCO
glbp 146 load-balancing weighted

AVG responds to ARP requests
R6 is elected AVG (R4 and R6 AVF)
Load distribution R4 and R6 in 2:1 ratio

1x

host-dependent
round-robin

R4:
interface g0/1
glbp 146 ip 155.1.146.252
glbp 146 timers 1 3
glbp 146 preempt
glbp 146 weighting 20
glbp 146 name VLAN146
glbp 146 authentication md5 key-string CISCO
glbp 146 load-balancing weighted

2x

R4#**show glbp**
GigabitEthernet0/1 - Group 146
State is Standby
1 state change, last state change 00:08:44
Virtual IP address is 155.1.146.252
Hello time 1 sec, hold time 3 sec
Next hello sent in 0.824 secs
Redirect time 600 sec, forwarder time-out 14400 sec
Authentication MD5, key-string
Preemption enabled, min delay 0 sec
Active is 155.1.146.6, priority 110 (expires in 2.580 sec)
Standby is local
Priority 100 (default)
Weighting 20 (configured 20), thresholds: lower 1, upper 20
Load balancing: weighted
IP redundancy name is "VLAN146"
Group members:
0026.0b57.b960 (155.1.146.6) authenticated
0026.0b57.ba61 (155.1.146.4) local
There are 2 forwarders (1 active)

Forwarder 1
State is Listen
MAC address is 0007.b400.9201 (learnt)
Owner ID is 0026.0b57.b960
Time to live: 14399.340 sec (maximum 14400 sec)
Preemption enabled, min delay 30 sec
Active is 155.1.146.6 (primary), weighting 10 (expires in 2.920 sec)
Forwarder 2
State is Active
1 state change, last state change 00:08:50
MAC address is 0007.b400.9202 (default)
Owner ID is 0026.0b57.ba61
Preemption enabled, min delay 30 sec
Active is local, weighting 20

Router Redundancy and Object Tracking

track 16 rtr 99

ip sla **monitor 99**
type tcpConnect dest-ipaddr 54.1.1.254 dest-port 23
control disable
timeout 5000
ip sla monitor schedule 99 life forever start-time now

interface Gi 0/0
standby 146 **track 16 decrement 20**

track 12 ip route 30.0.0.0/16 reachability

interface FastEthernet 0/1
vrrp 146 **track 12 decrement 20**

track 10 ip route 10.2.21.128/25 metric threshold
threshold metric up 20 down 50

If the metric goes beyond 50 the tracking object 10 is going invalid.
The metric has then to go below 20 to become active again. (Hysteresis)

track 10 ip route 10.2.21.128/25 metric threshold
threshold metric up 20 down 50

described

IRDP

IRDP

config

ICMP Router Discovery Protocol (**IRDP**) allows IPv4 hosts to locate routers that provide IPv4 connectivity to other (nonlocal) IP networks

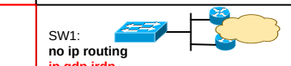
R5
interface FastEthernet 0/0
ip irdp
ip irdp address 155.1.58.5 **1000**
ip irdp maxadvertinterval 20
ip irdp minadvertinterval 10

Priorized

Instead using HSRP, VRRP, GLBP

R2:
interface Vlan 58
ip irdp
ip irdp address 155.1.58.8 **500**
ip irdp maxadvertinterval 20
ip irdp minadvertinterval 10

ICMP type 9 code 0
Router advertisement

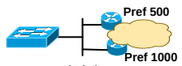


SW1:
no ip routing
ip gdp irdp

interface Vlan 58
ip address 155.1.58.7 255.255.255.0

R1
interface FastEthernet 0/0
ip irdp
ip irdp address 155.1.58.5 1000
ip irdp maxadvertinterval 20
ip irdp minadvertinterval 10

R2
interface Vlan 58
ip irdp
ip irdp address 155.1.58.8 500
ip irdp maxadvertinterval 20
ip irdp minadvertinterval 10



ip irdp

SW1#show ip route

Gateway	Using	Interval	Priority	Interface
155.1.58.5	IRDP	30	1000	Vlan58

SW2#**show ip irdp vlan 58**
Vlan58 has router discovery enabled

Advertisements will occur between **every 10 and 20** seconds.
Advertisements are **sent** with **broadcasts**.
Advertisements are **valid for 60 seconds**.
Default **preference** will be **0**.
Proxy for **155.1.58.8 with preference 500**.

Router ICMP Settings

stop sending ICMP messages about:
- Discarded packets
- ICMP messages to select a better next-hop,
- ICMP messages reporting subnets mask

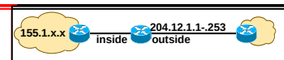
interface FastEthernet 0/0
no ip redirects
no ip unreachables
no ip mask-reply

R1#**show ip interface**
FastEthernet0/0 is up, line protocol is up
ICMP **redirects** are **never sent**
ICMP **unreachables** are **never sent**
ICMP **mask replies** are **never sent**
....

Rate-limit ICMP unreachables to 2 per-second globally

ip icmp rate-limit unreachable 500 ! <msec>

Basic NAT



ip nat pool VLAN43 204.12.1.1 204.12.1.253 prefix-length 24

ip access-list extended **NAT_TRAFFIC**
permit ip 155.1.0.0 0.0.255.255 any

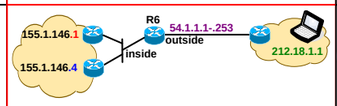
ip nat inside source list NAT_TRAFFIC pool VLAN43

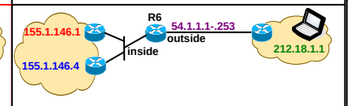
interface g0/0
ip nat outside

interface g0/1
ip nat inside

Basic NAT

verification



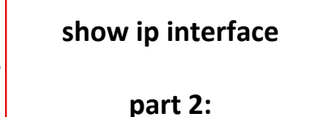


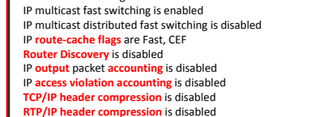
R6#show ip nat translations

Pro Inside global	Inside local	Outside local	Outside global
icmp 54.1.1.7:3	155.1.146.1:3	212.18.1.1:3	212.18.1.1:3
--- 54.1.1.7	155.1.146.1	---	---
icmp 54.1.1.6:3	155.1.146.4:3	212.18.1.1:3	212.18.1.1:3
--- 54.1.1.6	155.1.146.4	---	---

NAT Overload

(PAT, port address translation)





R6#show ip nat translations

Pro Inside global	Inside local	Outside local	Outside global
icmp 54.1.1.6:10	150.1.1.1:10	54.1.1.254:10	54.1.1.254:10
icmp 54.1.1.6:11	150.1.1.1:11	54.1.1.222:11	54.1.1.222:11
icmp 54.1.1.6:1	150.1.4.4:11	54.1.1.254:11	54.1.1.254:1
icmp 54.1.1.6:12	150.1.4.4:12	54.1.1.222:12	54.1.1.222:12

NAT overload
PAT addr 54.1.1.6

NAT with Route Maps

- If from Loopback PAT to 155.1.23.200
- If NOT from Loopback PAT to Serial0/1 addr

ip access-list standard **FROM_LOOPBACK**
permit 150.1.2.0 0.0.0.255

ip nat pool PPP_LOOPBACK_POOL 155.1.23.200 155.1.23.200 prefix-length 24

route-map NAT_OUT_PPP_**FROM_LOOPBACK** permit 10
match ip address **FROM_LOOPBACK**
match interface **Serial0/1**

route-map NAT_OUT_PPP_**NOT_FROM_LOOPBACK deny** 10
match ip address **FROM_LOOPBACK**
match interface **Serial0/1**

route-map NAT_OUT_PPP_**NOT_FROM_LOOPBACK** permit 20
match interface **Serial0/1**

ip nat inside source route-map
NAT_OUT_PPP_**FROM_LOOPBACK pool**
PPP_LOOPBACK_POOL **overload**

ip nat inside source route-map
NAT_OUT_PPP_**NOT_FROM**_LOOPBACK **interface Serial0/1**
overload

show ip interface

part 1:

R1#**show ip interface**
FastEthernet0/0 is up, line protocol is up
Internet address is 155.1.146.1/24
Broadcast address is 255.255.255.255
Address determined by setup command
MTU is 1500 bytes
Helper address is not set
Directed broadcast forwarding is disabled
Multicast reserved groups **joined**: 224.0.0.9
Outgoing access list is not set
Inbound access list is not set
Proxy ARP is enabled
Local Proxy ARP is disabled
Security level is default
Split horizon is enabled
ICMP redirects are never sent
ICMP unreachables are never sent
ICMP mask replies are never sent

show ip interface

part 2:

IP **fast switching** is enabled
IP fast switching on the same interface is disabled
IP Flow switching is disabled
IP **CEF switching** is enabled
IP CEF Fast switching turbo vector
IP multicast fast switching is enabled
IP multicast distributed fast switching is disabled
IP **route-cache flags** are Fast, CEF
Router Discovery is disabled
IP **output** packet **accounting** is disabled
IP **access violation accounting** is disabled
TCP/IP header compression is disabled
RTP/IP header compression is disabled
Policy routing is disabled
Network address translation is disabled
BGP Policy Mapping is disabled
WCCP Redirect outbound is disabled
WCCP Redirect inbound is disabled
WCCP Redirect exclude is disabled

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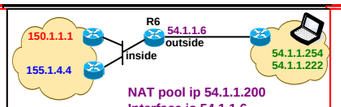
Services

How to troubleshoot NAT

With different pools / interface PATs

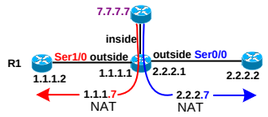


Route-Map matches Loopbacks to NAT 54.1.1.200, everything else to the interface with 54.1.1.6

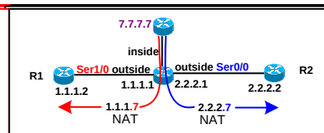
A good way to test is to use telnet:
Telnet 54.1.1.254 /source fa0/0
Telnet 54.1.1.254 /source Loopback

Once logged in, use WHO to verify the NAT'ed IP you have arrived with.

Static Policy NAT



Using Route-map for clarification



route-map TO_R1
match interface serial1/0

route-map TO_R2
match interface serial0/0

ip nat inside source static 7.7.7.7 1.1.1.7 route-map TO_R1
ip nat inside source static 7.7.7.7 2.2.2.7 route-map TO_R2

NAT Virtual Interface

NAT direction is always "inside" for NVI based NAT routing lookup is always performed before the translation after routing, packet source is translated

interface Serial 0/1/0
ip nat enable

interface FastEthernet 0/0
ip nat enable

To verify NVI disable CEF

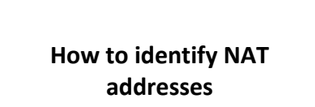
ip access-list standard VLAN8
permit 155.1.8.0 0.0.0.255

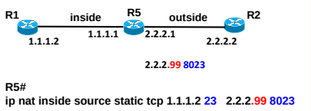
ip nat pool NVI_POOL 155.1.188.1 155.1.188.254 prefix 24 add-route

ip nat source list VLAN8 pool NVI_POOL

R5#show ip route static
S 155.1.188.0/24 [0/0] via 0.0.0.0, NVI0

Static NAT





R5:
interface Serial0/1/0
ip nat outside

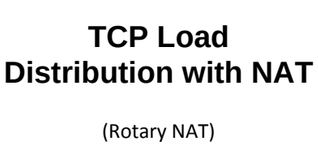
interface g0/0
ip nat inside

IP route used to trigger NAT

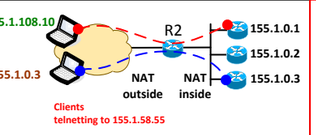
ip nat inside source static 1.1.1.2 2.2.2.9
ip nat outside source static 2.2.2.2 1.1.1.15

ip route 1.1.1.15 255.255.255.255 2.2.2.2

NAT with Overlapping Subnets



R1 and R2 use overlapping subnets, R1 hides its subnet behind 11.0.0.x



R1:
ip nat pool R2_MASQ 22.0.0.1 22.0.0.254 prefix-length 24

ip access-list extended R2_LOOPBACK1
permit ip 10.0.0.0 0.0.0.255 any

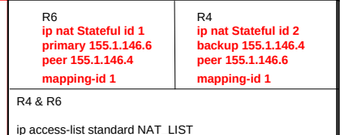
ip nat outside source list R2_LOOPBACK1 pool R2_MASQ
ip nat inside source static network 10.0.0.0 11.0.0.0 /24

ip route 11.0.0.0 255.255.255.0 Null 0
ip route 22.0.0.0 255.255.255.0 Serial 0/1

router rip
redistribute static

NAT Default Interface

(total portforwarding / PAT to single IP)



R2#
interface FastEthernet 0/0
ip nat inside

interface Serial 0/1/0
ip nat outside

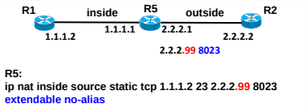
R5's IP will be translated to R2's Ser0/0 if accessing R3,R4 (overload)

ip access-list standard ALL
permit any

ip nat inside source list ALL interface Serial 0/0 overload
ip nat inside source static 1.1.1.1 interface Serial 0/0

Troubleshooting

Static NAT scenario



debug ip nat detail

NAT: i: icmp (1.1.1.2, 4) -> (1.1.1.15, 4) [9]
NAT: s=1.1.1.2->2.2.2.9, d=1.1.1.15 [9]

inside

NAT: s=2.2.2.9, d=1.1.1.15->2.2.2.2 [9]

outside

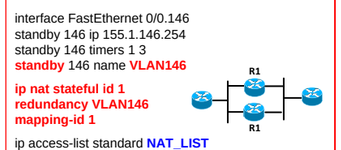
NAT*: O: icmp (2.2.2.2, 4) -> (2.2.2.9, 4) [9]
NAT*: s=2.2.2.2->1.1.1.15, d=2.2.2.9 [9]

NAT*: s=1.1.1.15, d=2.2.2.9->1.1.1.2 [9]

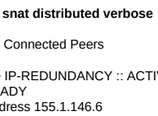
NAT with Overlapping Subnets

Solution 1: Bidirection NAT

Solution 2: NAT only on R2 performed, NO config on R1.



Reversible NAT



interface FastEthernet 0/0
ip nat inside

interface Serial 0/1/0
ip nat outside

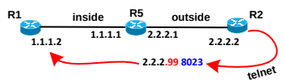
ip nat pool POOL 155.1.45.100 155.1.45.200 prefix-length 24

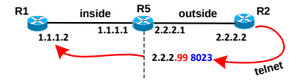
ip access-list standard INSIDE_HOSTS
permit 155.1.0.0 0.0.255.255
permit 150.1.0.0 0.0.255.255

route-map CREATE_EXTENDABLE_ENTRIES
match ip address INSIDE_HOSTS
match interface Serial0/1/0

ip nat inside source route-map
CREATE_EXTENDABLE_ENTRIES pool POOL reversible

Static PAT





R5#
ip nat inside source static tcp 1.1.1.2 23 2.2.2.99 8023

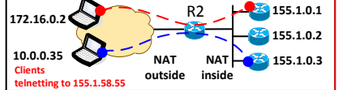
R2# telnet 2.2.2.99 8023

Login Prompt of R1

Telnet R2 to 2.2.2.99 8023 ➔ forwards to 1.1.1.2 23 (R1) through R5

TCP Load Distribution with NAT

(Rotary NAT)



R2#
ip nat pool ROTARY prefix-length 24 type rotary
address 155.1.0.1 155.1.0.1
address 155.1.0.2 155.1.0.2
address <start-ip> <end-ip>

ip access-list extended LOAD_BALANCE
permit tcp any host 155.1.58.55 eq telnet

ip nat inside destination list LOAD_BALANCE pool ROTARY

ip alias 155.1.58.55 23

Stateful NAT with Primary/Backup

Verification:

show ip snat distributed verbose
Stateful NAT Connected Peers
SNAT: Mode BACKUP
: State READY
: Local Address 155.1.146.4
: Local NAT id 2
: Peer Address 155.1.146.6
: Peer NAT id 1
: Mapping List 1
: InMsgs 15, OutMsgs 0, tcb 0x650FE6E0, listener 0x650FE22C

How to identify NAT addresses

Using

show ip alias

R5#
ip nat inside source static tcp 1.1.1.2 23 2.2.2.99 8023

R5#show ip alias
Address Type IP Address Port
Interface 1.1.1.1
Interface 2.2.2.1
Dynamic 2.2.2.99

TCP Load Distribution with NAT

(Rotary NAT)

show ip nat translations

Output:

R2#show ip nat translations

Pro	Inside global	Inside local	Outside local	Outside global
tcp	155.1.58.55:23	155.1.0.1:23	155.1.108.10:238	155.1.108.10:238
tcp	155.1.58.55:23	155.1.0.3:23	155.1.58.8:147	155.1.58.8:147

Stateful NAT with Primary/Backup

SNAT

Config:

R6	R4
ip nat Stateful id 1 primary 155.1.146.6 peer 155.1.146.4 mapping-id 1	ip nat Stateful id 2 backup 155.1.146.4 peer 155.1.146.6 mapping-id 1

R4 & R6

ip access-list standard NAT_LIST
permit 155.1.0.0 0.0.255.255

ip nat pool SHARED_POOL 155.1.254.1 155.1.254.254 prefix-length 24

ip nat inside source list NAT_LIST pool SHARED_POOL mapping 1

ip route 155.1.254.0 255.255.255.0 Null 0

Static NAT and IP Aliasing

R5:
ip nat inside source static tcp 1.1.1.2 23 2.2.2.99 8023
extendable no-alias

R5 does not respond to the ICMP echo packets since it has no local alias for the NAT address

show ip aliases
Address Type IP Address Port
Interface 1.1.1.1
Interface 2.2.2.1
Interface 2.2.2.99

Stateful NAT with HSRP

(SNAT)

config

interface FastEthernet 0/0.146
standby 146 ip 155.1.146.254
standby 146 timers 1 3
standby 146 name VLAN146

ip nat stateful id 1
redundancy VLAN146
mapping-id 1

ip access-list standard NAT_LIST
permit 155.1.0.0 0.0.255.255

ip nat pool SHARED_POOL 155.1.254.1 155.1.254.254 prefix-length 24

ip nat inside source list NAT_LIST pool SHARED_POOL mapping 1

ip route 155.1.254.0 255.255.255.0 Null 0

Used to inject to routing

Stateful NAT with HSRP

(SNAT)

verification

R6#show ip snat distributed verbose

Stateful NAT Connected Peers

SNAT: Mode IP-REDUNDANCY :: ACTIVE
: State READY
: Local Address 155.1.146.6
: Local NAT id 1
: Peer Address 155.1.146.4
: Peer NAT id 2
: Mapping List 1
: InMsgs 4, OutMsgs 0, tcb 0x44C999F8, listener 0x0

R2

Things that did not work in the lab:

Stateful NAT prim backup or Redundancy

Overlapping

Stateful with HSRP

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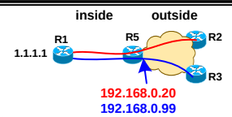
Services

Static Extendable NAT



R5#
ip nat inside source static 1.1.1.1 192.168.0.20 extendable
ip nat inside source static 1.1.1.1 192.168.0.99 extendable

R5#**show ip nat translations**

Pro	Inside global	Inside local	Outside local	Outside global
---	192.168.0.20	1.1.1.1	---	---
---	192.168.0.99	1.1.1.1	---	---

R2 or R3 can either Access R1 via 192.168.0.20 or 192.168.0.99

IP Precedence Accounting

01100000 = 96
First 3 bits of TOS field = IP precedence

interface Serial 0/0/0
ip accounting precedence input
ip accounting precedence output

R6#**show interfaces serial 0/0/0 precedence**
Serial0/0/0
Input
Precedence 0: **5 packets**, 520 bytes
Precedence 3: **5 packets**, 520 bytes
Precedence 6: **53 packets**, 4304 bytes
Output
Precedence 0: 7 packets, 608 bytes
Precedence 3: 5 packets, 520 bytes
Precedence 6: 24 packets, 7936 bytes

IP Output Packet Accounting

Config:

ip accounting-threshold 4096
Limit database to 4096 entries

ip accounting-transits 1
Set number of packets to 1 for any packets, not matching the accounting list (first packet of flow only)

ip accounting-list 155.1.0.0 0.0.255.255
Only account for packets going to 155.1.0.0/16

interface FastEthernet 0/0
ip accounting output-packets

IP Output Packet Accounting

Show output:

R1#**show ip accounting**

Source	Destination	Packets	Bytes
155.1.146.4	155.1.13.3	2	200
155.1.13.3	155.1.146.4	2	200
155.1.146.6	155.1.13.3	20	2000
155.1.13.3	155.1.146.6	20	2000

Accounting data age is 0
R1#

clear ip accounting
(stores the old accounting database into a checkpoint)

Checkpoint can be retrieved by:
show ip accounting checkpoint

IP Access Violation Accounting

- deny packets with an IP precedence of 4 coming from X coming from Ser0/0/0
- **Account for the packets denied by this policy**

access-list 101 deny ip any any precedence 4
access-list 101 permit ip any any

interface Serial 0/0/0
ip access-group 101 **in**
ip accounting access-violations

Does not work with named ACLs!

R6#show ip accounting access-violations

Source	Destination	Packets	Bytes	ACL
112.0.0.1	54.1.1.6	5	500	101

MAC Address Accounting

interface FastEthernet0/0
ip accounting mac-address input
ip accounting mac-address output

R1#**show interfaces Fa0/0 mac-accounting**
FastEthernet0/0
Input (510 free)
0026.0b57.ba61(161): 2 packets, 1092 bytes, last: 3564ms ago
0026.0b57.b960(163): 2 packets, 612 bytes, last: 6796ms ago
Total: 4 packets, 1704 bytes
Output (511 free)
0100.5e00.0009(86): 2 packets, 852 bytes, last: 9444ms ago
Total: 2 packets, 852 bytes

TCP Optimization

??????

Verify TCP operation:

show tcp brief all

TCB	Local Address	Foreign Address	(state)
856D54A0	54.1.1.6.60615	54.1.1.254.179	ESTAB

R6#show tcp tcb 856BE248
Connection **state is ESTAB**, I/O status: 1, unread input bytes: 0
Connection is **ECN Enabled**, **Mininum incoming TTL** 0,
Outgoing TTL 255
Local host: 155.1.146.6, **Local port:** 33209
Foreign host: 150.1.1.1, **Foreign port**: 23
Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0
Event Timers (current time is 0x1080595):

Timer	Starts	Wakeups	Next
Retrans	6	0	0x0
TimeWait	0	0	0x0
AckHold	3	1	0x0
SendWnd	0	0	0x0
KeepAlive	0	0	0x0
GiveUp	0	0	0x0
PmtuAger	0	0	0x0
DeadWait	0	0	0x0

IOS Small Services & Finger

service udp-small-servers
service tcp-small-servers
ip finger

TCP to **port 7**: **echo's all characters** sent back to prompt

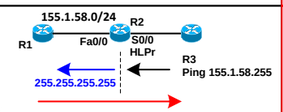
TCP to **port 9**: blackhole, **nothing** comes back

TCP to **port 13**: receive **Date and Time**, exists session

TCP to **port 19**: **CHARGEN**, does not stop!

TCP to **port 79**: list of currently **logged in Users**

Directed Broadcasts & UDP Forwarding



R2#
no ip forward-protocol udp bootps
no ip forward-protocol udp tftp
no ip forward-protocol udp time
no ip forward-protocol udp netbios-ns
no ip forward-protocol udp netbios-dgm
no ip forward-protocol udp tacacs
interface Serial 0/0
ip helper-address 155.1.58.255
interface FastEthernet 0/0
ip broadcast-address 155.1.58.255
ip directed-broadcast

(overrides the default of generating a 255.255.255.255, sending to 155.1.58.255 instead)

DRP Server Agent

- allow connections from Directors from VLAN 14
- authenticate with a password of CISCO

ip drp server
ip drp access-group 99
ip drp authentication key-chain DRP

key chain DRP
key 1
key-string CISCO

show ip drp

access-list **99** permit 155.1.146.0 0.0.0.255

WCCPv1 Web-Cache

access-list 199 deny ip 155.1.146.0 0.0.0.255 any
access-list 199 permit ip any any

ip wccp version 1
ip wccp web-cache redirect-list 199
ip wccp outbound-acl-check

interface FastEthernet 0/0.146
ip wccp web-cache redirect in

show ip wccp
show ip wccp interface

WCCPv2 Services

access-list 10 permit 155.1.58.100

access-list 20 permit 155.1.58.0 0.0.0.255

ip wccp version 2
ip wccp 50 group-address 224.0.1.100 redirect-list 20 group-list 10
password CISCO

interface FastEthernet 0/0
ip wccp 50 redirect in
ip wccp 50 group-listen

NBAR Protocol Discovery

interface Serial 0/0/0
ip nbar protocol-discovery

ip nbar custom HTTP_PROXY destination tcp 3128 8080
classify connections to HTTP proxy ports 3128 and 8080

ip nbar port-map ftp tcp 2121
Change ftp protocol mapping to port 2121

ip nbar custom TEST 0 ascii A destination tcp 3001
Match ASCII "A" in the beginning of a TCP segment flowing to the destination port 3001.

show ip nbar port-map

show ip nbar protocol-discovery
show ip nbar protocol-discovery protocol TEST

Netflow Ingress & Egress

Version 5

ip flow-capture vlan-id *(collect VlanIDs)*
ip flow-capture icmp *(collect ICMP too)*
ip flow-export version 5
ip flow-export destination 155.1.146.100 9999
ip flow-export version 5 origin-as
ip flow-cache entries 4096 *(DB max entries)*

interface Serial 0/0/0
ip flow ingress

Ingress: including the packets destined to the router itself, applied before ACLs and rate-limiting

Egress: does not include packets originated from the router itself **(used with MPLS, monitor leaving untagged traffic)**

Netflow Top Talkers

ip flow-top-talkers
top 10
sort-by packets
match source address 155.1.0.0 255.255.0.0
match protocol 1

Showing top talkers for ICMP traffic of hosts in 155.1.0.0/16

R4#show ip flow top-talkers

SrcIf	SrcIPaddress	DstIf	DstIPaddress	Pr	SrcP	DstP	Pkts
Et0/1	155.1.146.1	Et0/0	30.0.0.1		01	0000	0800 50

Netflow Aggregation Cache

Version 8

ip flow-aggregation cache destination-prefix
cache entries 1024
export destination 155.1.146.100 9998
mask destination minimum 8
Enabled

Don't summarize more than /8 in length

R4#**show ip cache flow aggregation destination-prefix**

Minimum destination mask is configured to /8

Dst If	Dst Prefix	Msk	AS	Flows	Pkts	B/Pk	Active
Null	204.0.0.0	/8	0	1	1	44	0.0
Gi0/0	204.12.1.0	/24	0	1	28	41	3.7
Gi0/1	155.1.146.0	/24	0	1	25	91	3.7

Netflow Random Sampling

Only samples every 10th packet in each flow

flow-sampler-map SAMPLER
mode random one-out-of 10

policy-map NETFLOW_MAP
class class-default
netflow-sampler SAMPLER

interface Serial 0/0/0
service-policy output NETFLOW_MAP

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Services

Netflow Input Filters

- Every packet is sampled for sources on VLAN 146
- Other packets should still be randomly sampled

```
ip access-list extended VLAN146
permit ip 155.1.146.0 0.0.0.255 any
permit ip any 155.1.146.0 0.0.0.255

class-map VLAN146
match access-group name VLAN146

policy-map NETFLOW_MAP
 class VLAN146
  netflow-sampler NORMAL
 class class-default
  netflow-sampler SAMPLER

flow-sampler-map NORMAL
mode random one-out-of 1

flow-sampler-map SAMPLER
mode random one-out-of 10

interface Serial 0/0/0
service-policy output NETFLOW_MAP
```

IP Event Dampening

```
dampening <half-life time> <start using> <start suppressing> <max suppress duration t> <enable restart suppression> <penalty value at restart>

interface Serial 0/0/0
dampening 30 1000 2000 60 restart 2000
```

- after a reload IP is not advertised into IGP for 30 seconds
- if connection flaps: it does not disappear for more than 60 seconds from the routing table no matter how much penalty it accumulates

To find default values:
int X
dampening
Do show dampening

DHCP Client options:

```
interface GigabitEthernet 0/0/1
 ip dhcp client client-id ascii my-test1
 ip dhcp client class-id my-class-id
 ip dhcp client lease 0 1 0
 ip dhcp client hostname host1
 no ip dhcp client request tftp-server-address
 ip address dhcp

int X
no ip address dhcp
ip address dhcp

Or

release dhcp
```

IOS Authoritative DNS Server

```
ip dns server
ip dns primary cisco.com soa ns.cisco.com ccie.com

ip dns primary <domain> soa <primary-srv> <DNS mailbox> <refresh t> <retry t> <Auth expire t> <Min TTL zone t>

ip host cisco.com ns 155.1.146.4
 (DNS srv local own entry)

ip host R4.cisco.com 150.1.4.4  155.1.146.4  155.1.45.4
All IPs which should be resolved to R4.cisco.com
```

NAT terminology:

Inside Local
Inside Global
Outside Global
Outside Local

Explained:

Address Classification	
Inside Local	An actual address assigned to an inside host
Inside Global	An inside address seen from the outside
Outside Global	An actual address assigned to an outside host
Outside Local	An outside address seen from the inside

IPv4 Address Pool for DMVPN Spokes

```
ip dhcp pool pool1
origin dhcp number 3
odap client client-id id1 interface gi0/0 target-server 192.168.10.1
origin dhcp subnet size initial /24 autogrow /24

First IP of first pool assigned to interface.
If second pool Is requested, a secondary IP will be created with the first IP address of the second pool on the same interface.
```

Router as DNS client

Using two DNS server in a round-robin fashion.

```
ip name-server 155.1.146.4 155.1.146.6

ip domain-lookup

ip domain round-robin

ip domain name cisco.com
complete all unqualified domain-names with the name "cisco.com".
```

Using CHARGEN to simulate TCP streams:

service tcp-small-servers
CHARGEN TCP Port 19

```
R1#show tcp brief
TCB     Local Address         Foreign Address       (state)
847557E4 1.1.1.1.19           2.2.2.2.27318         ESTAB
84BDB7A0 1.1.1.1.23           2.2.2.2.44491         ESTAB

R1#clear tcp tcb 847557E4
[confirm]
 [OK]

R2#
HIJKLMNOPQRSTUVWXYZ[\]^_`abcdefghijklmnopqrstuvwxyz{|}~ !"#$%&
IJKLMNOPQRSTUVWXYZ[\]^_`abcdefghijklmnopqrstuvwxyz{|}~ !"#$%&
```

First hop redundancy protocols

Attributes	HSRP	VRRP	GLBP
Standard			
Load Balancing			
IPv6 Support			
Transport			
Default Priority			
Default Hello			
Multicast Group			

HSRPv2 224.0.0.102

Attributes	HSRP	VRRP	GLBP
Standard	RFC 2281	RFC 3768	Cisco
Load Balancing	No	No	Yes
IPv6 Support	Yes	No	Yes
Transport	UDP/1985	IP/112	UDP/3222
Default Priority	100	100	100
Default Hello	3 sec	1 sec	3 sec
Multicast Group	224.0.0.2	224.0.0.18	224.0.0.102

DNS related commands:

show ip dns primary:

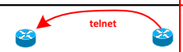
show hosts:

```
R4#show ip dns primary
Primary for zone cisco.com:
 SOA information:
 Zone primary (MNAME):  ns.cisco.com
 Zone contact (RNAME):  ccie.com
 Refresh (seconds):          21600
 Retry (seconds):            900
 Expire (seconds):           7776000
 Minimum (seconds):          86400
```

```
R4#show hosts

Host              Port  Flags      Age Type   Address(es)
cisco.com         NA    (perm, OK)   0 NS     155.1.146.4
                                      SOA      ns.cisco.com ccie.com
                                               0 21600 900 7776000 86400
R4.cisco.com      None  (perm, OK) 0   IP     150.1.4.4
                                               155.1.146.4
                                               155.1.45.4
```

Debug ip tcp transactions

Output:




```
R6#debug ip tcp transactions

Reserved port 0 in Transport Port Agent for TCP IP type 0
TCP0: state was LISTEN -> SYNRCVD [23 -> 155.1.146.1(64022)]
TCP: tcb 454C3FEC connection to 155.1.146.1:64022, peer MSS 536, MSS is 516
TCP: sending SYN, seq 62577531, ack 199749595
TCP0: Connection to 155.1.146.1:64022, advertising MSS 536
TCP0: state was SYNRCVD -> ESTAB [23 -> 155.1.146.1(64022)]
TCB454C3FEC setting property TCP_TOS (11) 448CB564

TCP322: state was ESTAB -> FINWAIT1 [23 -> 155.1.146.1(64022)]
TCP322: sending FIN
TCP322: state was FINWAIT1 -> FINWAIT2 [23 -> 155.1.146.1(64022)]
TCP322: state was FINWAIT2 -> TIMEWAIT [23 -> 155.1.146.1(64022)]
```

Enhanced Object Tracking

Track using weight

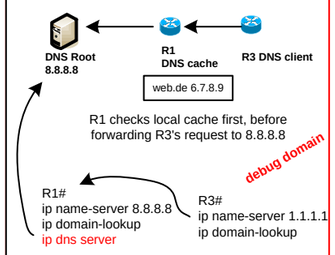
```
track 4 list threshold weight

object 1 weight 15
object 2 weight 20
object 3 weight 30

threshold weight up 30 down 10
```

Combination of Object 1 + 2 will cause Track 4 to be up. (15+20 = 35, up weight = 30)

Or if

Object 3 (30 and up weight = 30)

IOS Caching DNS Server



How to monitor interface based rate-limiting:

```
Config:
access-list 100 permit icmp any any

interface FastEthernet0/0
 ip address 183.1.17.1 255.255.255.0
 rate-limit output access-group 100 128000 12000 12000
conform-action transmit exceed-action drop
```

```
show interface fa0/0 rate-limit
FastEthernet0/0
  Output
    matches: access-group 100
      params:  128000 bps, 12000 limit, 12000 extended limit
      conformed 0 packets, 0 bytes; action: transmit
      exceeded 0 packets, 0 bytes; action: drop
      last packet: 27522152ms ago, current burst: 0 bytes
      last cleared 00:05:18 ago, conformed 0 bps, exceeded 0 bps
```

track timer

track interface

track line-protocol

show track CMDs

```
track timer {interface | ip route} <15 seconds>
(poll interval is default 15 seconds)

track interface ip routing
Tracks whether IP routing is enabled, tracking of an IP address on an interface that was acquired through DHCP or PPP IPCP

track line-protocol
Tracks the state of a line protocol

ip dhcp client route track <number>
Assign received IP address via DHCP to tracking object <number>
To be dynamically added to IP SLA

show track timers
show track brief
debug track
```

IOS DNS Spoofing

R2
If the connection to the DNS server 8.8.8.8 is lost, R2 responds to all DNS queries with the IP address of its Loopback0 interface

```
R2#
ip dns spoofing 2.2.2.2
ip name-server 8.8.8.8
ip domain lookup
ip dns server
```

```
R3#
ip name-server 2.2.2.2
ip domain lookup
```

DNS: No name-servers are accessible
DNS: Spoofing reply to query (id#7)

How to find a default IOS name, in case no local IOS is found,

Routers tries to TFTP for an image:

```
Rack1R1#reload

<Sent BREAK Sequence>

rommon 1 > confreg
Configuration Summary
enabled are:
load rom after netboot fails
console baud: 9600
boot: image specified by the boot system commands
or default to: cisco2-C2600
```

Enhanced Object tracking

Using percentage

```
track 4 list threshold percentage

object 1
object 2
object 3

threshold percentage up 51 down 10
exit

At least 51% of the 3 objects need to be up in order to make Track object 4 stay up.

R1#show ip route track-table
 ip route 0.0.0.0 0.0.0.0 Null0 track 4 state is [up]
```

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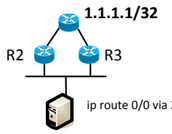
Services

R2#
int e0/0
ip address 20.0.0.2 255.255.255.0
vrrp ip 20.0.0.1
vrrp prio 125
mac-address 0000.1111.1111

R3#
int e0/0
ip address 20.0.0.3 255.255.255.0
vrrp ip 20.0.0.1
vrrp prio 120
mac-address 0000.2222.2222



ip route 0/0 via 20.0.0.1

How will the traceroute and show arp look like?

R5#**traceroute 1.1.1.1 numeric**
Type escape sequence to abort.
Tracing the route to 1.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
1 20.0.0.2 1 msec 0 msec 0 msec
2 12.1.1.1 12 msec * 13 msec

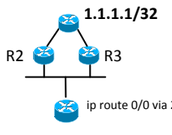
No ARP for 20.0.0.2 but traceroute shows 20.0.0.2 in the path!

HOST#show arp

Protocol	Address	Age (min)	Hardware Addr	Type	Interface
Internet	20.0.0.1	0	0000.5e00.0101	ARPA	Ethernet0/0
Internet	20.0.0.3	-	0000.3333.3333	ARPA	Ethernet0/0

R2#
int e0/0
ip address 20.0.0.2 255.255.255.0
vrrp ip 20.0.0.1
vrrp prio 125
mac-address 0000.1111.1111

R3#
int e0/0
ip address 20.0.0.3 255.255.255.0
vrrp ip 20.0.0.1
vrrp prio 120
mac-address 0000.2222.2222



ip route 0/0 via 20.0.0.1

How will the following output look like? show vrrp brief

R2#show vrrp brief

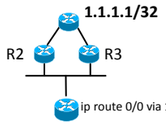
Interface	Grp	Pri	Time	Own	Pre	State	Master addr	Group addr
Et0/0	1	125	3531		Y	Master	20.0.0.2	20.0.0.1

R3#show vrrp brief

Interface	Grp	Pri	Time	Own	Pre	State	Master addr	Group addr
Et0/0	1	120	3570		Y	Backup	20.0.0.2	20.0.0.1

R2#
interface Ethernet0/0
mac-address 0000.2222.2222
ip address 10.1.1.2 255.255.255.0
glbp 1 ip 10.1.1.100
glbp 1 priority 150

R3#
interface Ethernet0/0
mac-address 0000.3333.3333
ip address 10.1.1.3 255.255.255.0
glbp 1 ip 10.1.1.100
glbp 1 priority 102



ip route 0/0 via 10.1.1.100

How will "show glbp brief" look on R2/R3?

(R2 listening for R3's Virtual MAC)

R2#show glbp brief

Interface	Grp	Fwd	Pri	State	Address	Active router	Standby router
Et0/0	1	-	150	Active	10.1.1.100	local	10.1.1.3
Et0/0	1	1	-	Active	0007.b400.0101	local	-
Et0/0	1	2	-	Listen	0007.b400.0102	10.1.1.3	-

(R3 listening for R2's Virtual MAC)

R3#show glbp brief

Interface	Grp	Fwd	Pri	State	Address	Active router	Standby router
Et0/0	1	-	102	Standby	10.1.1.100	10.1.1.2	local
Et0/0	1	1	-	Listen	0007.b400.0101	10.1.1.2	-
Et0/0	1	2	-	Active	0007.b400.0102	local	-

Which GLBP load-balancing method MUST be used in combination with SNAT ?

GLBP and SNAT requires

int fa0/x
glbp <1> load-balancing host-dependent

In this case a Host always receives the same ARP for its Gateway which is consistent with the NAT entry.

Explain GLBP

glbp <nr> weighting 110 lower 95 upper 105

track 22 interface fa0/x line-protocol

int fa0/2
glbp 1 **weighting track 22 decrement 20**
glbp 1 **weighting 110 lower 95 upper 105**
glbp 1 prio 119
glbp 1 preempt

- sets the weight to 110
- if the weight value due to a decrement goes lower than 95 the router will NO LONGER be an active forwarder.
- if the value goes over 105, it will start forwarding again.

110 – 20 = 90, stops forwarding

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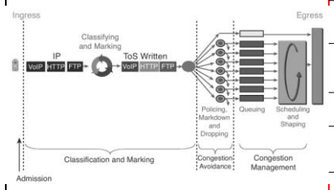
QoS

QoS Explained in one picture:



Tool	Max Number of Queue	Classification possibilities
Priority Queuing (PQ)		
Custom Queuing (CQ)		
Weighted Fair Queueing (WFQ)		
Class-Based WFQ (CBWFQ)		
Low Latency Queueing LLQ		
Modified Deficit Round-Robin		

Tool	Max Number of Queue	Classification possibilities
Priority Queuing (PQ)	4	IP ACL Input interface Fragments
Custom Queuing (CQ)	16	IP ACL Input interface Fragments
Weighted Fair Queueing (WFQ)	4096	Automatic, based on flows, SRC/DST, PORT
Class-Based WFQ (CBWFQ)	64	IP ACL NBAR Flows, SRC,DST, Port, Prot
Low Latency Queueing LLQ	N/A	IP ACL, NBAR, Flows SRC DST, port, and protocol
Modified Deficit Round-Robin	8	IP Precedence

QoS action Sub-commands Inside a policy map:

Set	Mark several fields inside headers
Bandwith	Reserve BW for a class CBWFQ
Priority	Reserve BW for LLW in CBWFQ
Shape	traffic in class to defined BW, bursts
Police	traffic in class to defined BW, bursts
Compress	performs TCP/RTP header compression/class

QoS Hold-Queue and Tx-Ring

- input software queue length of 10 packets
- output software queue length of 30 packets
- output hardware queue size to 15 packets

interface FastEthernet0/0
hold-queue 10 in
hold-queue 30 out
tx-ring-limit 15

R1#**show interfaces fastEthernet 0/0 | include queue**
Input queue: 0/**10**/0/0 (size/**max**/drops/flushes); Total output drops: 0
Output queue: 0/**30** (size/max)

show controllers fastEthernet 0/0 | include tx
tx_limited=0(15)

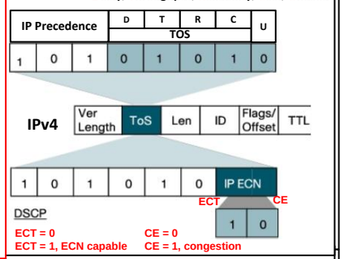
Field/Value	Binary	Name
Precedence 0	000	
Precedence 1	001	
Precedence 2	010	
Precedence 3	011	
Precedence 4	100	
Precedence 5	101	
Precedence 6	110	
Precedence 7	111	

Field/Value	Binary	Name
Precedence 0	000	Routine
Precedence 1	001	Priority
Precedence 2	010	Immediate
Precedence 3	011	Flash
Precedence 4	100	Flash Override
Precedence 5	101	Critic/ECP
Precedence 6	110	Internetwork control
Precedence 7	111	Network Control

QoS ToS field explained:

Using IP precedence Or DSCP

Delay, Throughput, Reliability, Cost, Unused



Input / Output Queuing explained:

- input queueing there is just one queue per interface, size of 75 packets by default (FIFO)

Two output queues by default.

- first output queue is the "software queue" queuing strategy can be defined. (FIFO, WFQ, CBWFQ)

- Second output queue is the transmit ring tx-ring is always FIFO.

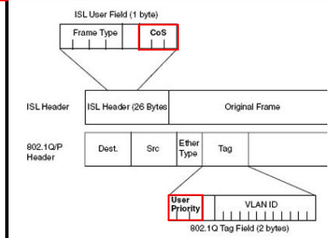
software output queue only starts to fill up when the tx-ring is full

Name of DSCP Class Selector	Binary	Precedence Value
Default	000000	
CS1	001000	
CS 2	010000	
CS 3	011000	
CS 4	100000	
CS 5	101000	
CS 6	110000	
CS 7	111000	

Name of DSCP Class Selector	Binary	Precedence Value
Default	000000	0
CS1	001000	1
CS 2	010000	2
CS 3	011000	3
CS 4	100000	4
CS 5	101000	5
CS 6	110000	6
CS 7	111000	7

QoS L2 markable fields:

ISL	CoS
802.1Q/P	User Priority



What are the different sources of Delay:

- Serialization Delay (fixed) $\frac{\text{bits sent}}{\text{Link speed}}$ = msec per packet
- Propagation delay (fixed) $\frac{\text{Length of Link (meters)}}{2.1 \times 10^8 \text{ meters/second}}$
- Queueing delay (variable) = time spent inside queues inside the device
- Forwarding / processing delay (variable) = ignored
- Shaping delay (variable)
- Network delay (variable)
- Codec delay (fixed)
- Compression delay (variable)

Range of DSCP	Binary	Precedence Value
	000xxx	0
	001xxx	1
	010xxx	2
	011xxx	3
	100xxx	4
	101xxx	5
	110xxx	6
	111xxx	7

Range of DSCP	Binary	Precedence Value
0-7	000xxx	0
8-15	001xxx	1
16-23	010xxx	2
24-31	011xxx	3
32-39	100xxx	4
40-47	101xxx	5
48-55	110xxx	6
56-63	111xxx	7

QoS Pre-classify Type of VPN

QoS pre-qualify configured on	Type of VPN
Interface tunnel	GRE and IPIP
Interface virtual-template	L2F and L2TP
Crypto map	IPSEC

QoS What fields can be marked?

- IP precedence [0 – 7]
- DSCP [0 – 63]
- 802.1P CoS [0 – 7]
- ISL priority
- ATM CLP
- Frame-Relay DE
- MPLS Experimental [0 – 7]
- QoS Group [1 - 99]

Drop probability within class

	Low drop Name/Dec/Bin	Medium Drop Name/Dec/Bin	High Drop Name/Dec/Bin
Class 1	AF11 / /	AF12 / /	AF13 / /
Class 2	AF21 / /	AF22 / /	AF23 / /
Class 3	AF31 / /	AF32 / /	AF33 / /
Class 4	AF41 / /	AF42 / /	AF43 / /

Calculation from AF numbers to decimal:

AFxy

8x +2y = decimal value **(AF41 = 34)**

Drop probability within class

	Low drop Name/Dec/Bin	Medium Drop Name/Dec/Bin	High Drop Name/Dec/Bin
Class 1	AF11 / 10 / 001010	AF12 / 12 / 001100	AF13 / 14 / 001110
Class 2	AF21 / 18 / 010010	AF22 / 20 / 010100	AF23 / 22 / 010110
Class 3	AF31 / 26 / 011010	AF32 / 28 / 011100	AF33 / 30 / 011110
Class 4	AF41 / 34 / 100010	AF42 / 36 / 100100	AF43 / 38 / 100110

Calculation from AF numbers to decimal:

AFxy

8x +2y = decimal value **(AF41 = 34)**

QoS pre-classify Crypto map

crypto map XXXX 10 ipsec-isakmp
....
qos pre-classify

show crypto map
...
QOS pre-classification

Interface tunnel 0
qos pre-classify

Interface virtual-template1
qos pre-classify

QoS What tools can be used to classify packets?

- IP ACLs
- Any markable fields PREC, DSCP, ...
- Input interface
- MAC address (SRC or DST)
- NBAR-enabled fields

QoS class-maps Match-all / match-any While matching DSCP / or IP Prec

class-map match-all WILL-NOT-WORK
match dscp 0
match dscp 1
No packet can have two DSCP markings

class-map match-all WILL-WORK
match dscp 1
Absolute match

class-map match-any WILL-WORK
match dscp 0
match dscp 1
OR

class-map match-any WILL-WORK
match dscp 0 1
OR

QoS Comparing QoS Queueing tools:

Feature	Definition	Qos Characteristic Affected
Classification	determination of queue	None
Drop policy	Tail drop, modified tail drop, WRED, ECN	Loss
Scheduling Inside queue	Inside queue mostly FIFO scheduling	Bandwith,delay jitter, loss
Scheduling Between ques	how queueing chooses queue for next packet	None
Max Queue Length	Max number of pkts in a single queue	Loss, delay

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QoS

QoS

Tx_limited=0(x) explained

Show controllers serial 0/0 | I tx_
Tx_limited=0(16)

Hardware queue holds 16 packets
0 = queue size not limited due to a queuing tool being enabled on interface

Int ser0/0
Priority-group 1

Show controllers serial 0/0 | I tx_
Tx_limited=1(2)

TX ring is 2
(1) =length is automatically limited as result of queuing configured.

Int ser0/0
tx-ring-limit 1

show controllers serial 0/0 | I tx_
tx_limited=0(1)

No queuing, but tx limited to 1 packet

show queue serial 0/0

Explained:

R1#show queue serial 0/0
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
Conversations 0/1/256 (active/max active/max total)
Reserved Conversations 0/0 (allocated/max allocated)
Available Bandwidth 1158 kilobits/sec

Current WFQ Size / max total = hold queue, global limit of buffers / threshold ??? / count of tail drops

If active = 0 no conversations / max currently active / absolute max

Reserved conversation == RSVP flow reservation

	WFQ	CBWFQ	LLQ
Requires complex classification			
Uses MQC			
Prefers low volume, high IPP flows			
Experiences problems with Large numbers of flows			
Can reserve bandwith per queue			
Provide low delay, low jitter queing			

	WFQ	CBWFQ	LLQ
Requires complex classification	No	Yes	Yes
Uses MQC	No	Yes	Yes
Prefers low volume, high IPP flows	Yes	not flow based	
Experiences problems with Large numbers of flows	Yes	No*	No
Can reserve bandwith per queue	No	Yes	Yes
Provide low delay, low jitter queing	No	No	Yes

*WFQ inside CBWFQ class-default, can have problems

QoS

show interface ser0/0 | i (Que|que)

With Fair-queue

With FIFO (no fair-queue)

sh int ser0/0 | i (Que|que)

Default: fair-que

R1#sh int ser0/0 | i (Que|que)
Broadcast queue 0/64, broadcasts sent/dropped 261/0, interface broadcasts 267
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)

FIFO (no fair-queue)
R1#sh int ser0/0 | i (Que|que)
Broadcast queue 0/64, broadcasts sent/dropped 257/0, interface broadcasts 263
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)

QoS

WFQ:

show queueing fair

R1#show queueing fair
Current fair queue configuration:

Interface	Discard threshold	Dynamic queues	Reserved queues	Link queues	Priority queues
Serial0/0	64	256	0	8	1
Serial0/1	64	256	0	8	1

Alternatives:

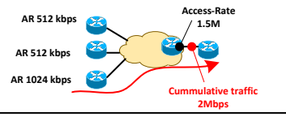
show queueing custom
show queueing fair
show queueing priority
show queueing random-detect

QoS

When to use traffic shaping:

Shaping is always a egress function

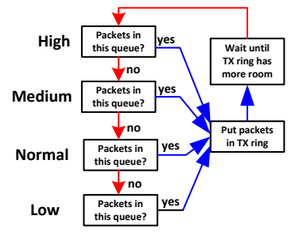
- shaping slows down its sending rate, so that packets are not discarded
- use shaping if the other device opposite is policing
- can be used in case of speed mis-matches
- Can help solve Egress blocking:



QoS

(PQ) Scheduling Logic

Priority Queue



QoS

CBWFQ

Details:

- For Queues with less drop sensitive traffic WRED is a good option
- CBWFQ supports 64 queues, queue lengths depends on router model
- Class-Default configured automatically
- "queue-limit 30" sets maximum queue size to 30 / queue

Drop policy:	Tail drop or WRED
Number queues:	64
Scheduling inside Single queue	FIFO on 63 queues, FIFO or WFQ on class-default queue
Max. Queue length	depends on router

QoS

Shaping terminology

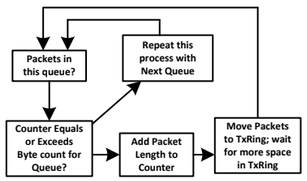
Tc	Time interval in msec, over which the Bc can be sent. Tc = Bc/CIR
Bc	Commited burst size in bits. Amount of traffic that can be sent over one Tc
CIR	Commited information rate, in bits/sec
Shaped Rate	in bits per second
Be	Excess burst size in Bits. Number of bits beyond Bc can be send after a period of inactivity

QoS

Custom Queuing Logic

(CQ)

- 16 queues available
- guarantees minimum Bw for each queue
- Bandwith % for Queue X = (byte count for Queue X)/Sum of Bytes for all queues



CQ does not provide great service for delay/jitter sensitive traffic!

QoS

WRED configuration:

WRED config

policy-map X
class class-default
random-detect dscp-based

R1(config-pmap-c)#random-detect ?

discard-class	parameters for each discard-class value
discard-class-based	Enable discard-class-based WRED as drop policy
dscp	parameters for each dscp value
dscp-based	Enable dscp-based WRED as drop policy
ecn	explicit congestion notification
exponential-weighting-constant	weight for mean queue depth calculation
prec-based	Enable precedence-based WRED as drop policy
precedence	parameters for each precedence value

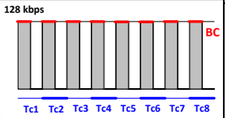
QoS

Shaping formulas:

Bursts only in the first Tc!!

Bc = Tc * CIR

Tc = Bc/CIR



Tc = Bc/Shaped rate (1 sec = 1000 msec / 8 Tc = 125 msec per Tc)

Bc = Tc * Shaped rate

AR 128Kbps, Shaped to 64K In each Tc, 8000 bits are sent (Bc)

Access Rate 128 kbps
Shaping down to 64 bkps
Default Tc is 125 msec (1 sec = 1000 msec / 8 = 125 msec)

Bc = Tc * Shaped rate
Bc = 0.125 sec * 64000bit/s = 8000 bits

8000/128000 = 62.5ms

QoS

Weighted Fair Queuing (WFQ)

Logic explained

Poor for Voice

- classifies packets based on flows
- Flow consists of all packets have same SRC/DST IP addrs and port numbers
- weighted based on precedence
- Favers low-volume, higher-precedence flows
- each flow uses a different queue up to 4096 queues per interface

If WFQ empties a flow's queue, it removes the queue.

In WFQ number of queues changes rapidly. **show queue**

Precedence 7 traffic gets 8 times more bandwith than 0: (7 + 1) / (0 + 1) = 8
Precedence 3 traffic gets 4 times more bandwith than 0: (3 + 1) / (0 + 1) = 4

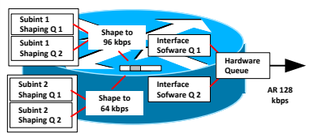
QoS

CBWFQ default values:

- class-default receives per default 25% of bandwidth
- max-reserved-bandwith of 75%, meaning a policy-map can not define more than 75% of bandwidth on that interface.

QoS

Fancy Shaping:



QoS

Weighted Fair Queue WFQ

Sequence Numbers explained:

Precedence	ToS Value	Weight
0	0 (0x00)	32768
1	32 (0x20)	16384
2	64 (0x40)	10920
3	96 (0x60)	8192
4	128 (0x80)	6552
5	160 (0xA0)	5456
6	192 (0xCx)	4680
7	224 (0xE0)	4096

Calculating WFQ Sequence Number (Finish Time FT):

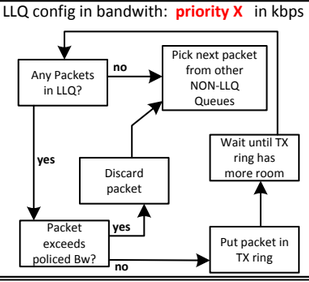
Weight = 32384 / (IP Precedence +1)

Previous_SN + (Weight * new_packet_length) = SN

QoS

CBWFQ with LLQ logic

LLQ config in bandwith: priority X in kbps



QoS

Policing explained:

Policing, each token = 1 byte, therefore if police rate is 128000bps = 16000 bytes per second.

Every second policing replenish 16000 tokens back into the bucket.
Therefore, in 0.1 second, policing replenish 1600 tokens into the buckets.

If the number of **bytes of the packets** is **less or equal** then the **number of tokens**, **packet conforms.**

If the number of bytes of the **packet is greater then the number of tokens**, the packet **exceeds the contract**.
Performs **configured actions, without removing tokens**!

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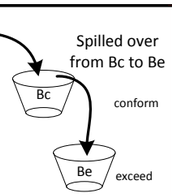
QoS

QoS
Dual Token Bucket
(single rate)

Bc tokens placed in token bucket
1 byte = 1 token
If 128Kbps policed,
Every second 16000 bytes are refiled
After 0.1 sec 1600 bytes/tokens refilled into Bc bucket



If bytes of incoming packet <= Bc = conforms
If bytes of incoming packet <= Be = exceeds
If bytes of packet greater than Bc+Be = violates

Overview of
Single-rate / Dual-rate
Two/three color policing

Single-rate	two-color policing	single token bucket	conform/exceed
Single-rate	three-color policing	two token buckets	conform/exceed/ violate
Dual-rate	three-color policing	two token buckets	PIR, CIR rates

QoS
Which TCP Flags can be used for congestion avoidance:

TCP Flags:
000 **Reserved: not set**
0 **Nonce: not set**
0 **Congestion Window Reduced (CWR): not set**
1 **ECN-Echo: set**
0 **Urgent: not set**
1 **Acknowledgement: Set**
0 **Push: not set**
0 **Reset: not set**
0 **Syn: not set**
0 **Fin: not set**

R1-config#**ip tcp ecn**

show tcp tcb 123456A |**i ECN**
Connection is ECN Enabled

debug ip tcp ecn

WRED: random-detect ecn

QoS
Dual Token Bucket
(dual rate)

- two sending rates, but only guarantee the smaller one Tc, Bc, as with Single Rate
- Peak Information Rate (PIR): maximum sending rate. Bursts that exceed CIR but remain under PIR are allowed. May be marked for more aggressive discarding.
- Be: maximum size of the packet burst, accepted to sustain in the PIR rate

Type of Policing Configuration	signs in the police command	defaults
Single Rate Single bucket Two color		
Single Rate Dual bucket Three color		
Dual Rate Dual bucket Three color		

Type of Policing Configuration	signs in the police command	defaults
Single Rate Single bucket Two color	No violate action No Be, No PIR configured	Bc = CIR/32 Be = 0
Single Rate Dual bucket Three color	No PIR configured violate-action and or Be configured	Bc = CIR/32 Be = Bc
Dual Rate Dual bucket Three color	PIR configured	Bc = CIR/32 Be = PIR/32

QoS
TCP ECN / CWR Flag
Explained:

TCP Flags:
000 **Reserved: not set**
0 **Nonce: not set**
0 **Congestion Window Reduced (CWR): not set**
1 **ECN-Echo: set**
....

- **initial TCP SYN** handshake includes the addition of **ECN-echo capability** and **Congestion Window Reduced (CWR) capability flags** to negotiate capabilities.
- When the **TCP sender receives a packet with the ECN-echo flag set** in the TCP header, the sender will adjust its congestion **window** as if it **had undergone fast recovery** from a single lost packet.
- **Next** sent **packet** will set the **TCP CWR flag**, to indicate to the **receiver that it has reacted to the congestion**

QoS
Shaping example
Token Bucket / Bc / Be / Tc / tokens per Tc
Pointed out using
show policy-map interface X:

interface Serial0/0
bandwidth 64
fair-queue
service-policy output SHAPE

policy-map SHAPE
class class-default
shape average 64000

R1**#sh policy-map interface** ser0/0

Serial0/0
Service-policy output: SHAPE

Class-map: class-default (match-any)
8 packets, 1636 bytes
30 second offered rate 0 bps, drop rate 0 bps
Match: any
Traffic Shaping — Tokens added per Tc

Target/Average Rate	Token Bucket Byte Limit	Bc Sustain bits/int	Be Excess bits/int	Tc Interval (ms)	Increment (bytes)
64000/64000	2000	8000	8000	125	1000

Adapt	Queue Active Depth	Packets	Bytes	Packets Delayed	Bytes Delayed	Shaping Active
-	0	4	1584	0	0	no

TCP windowing:

- Receiver window or Advertised window
Grants sender the right to send x bytes, before requiring an acknowledgement.
- Congestion window CWND
Field never sent, is calculated by the TCP sender.
Varies in size much more quickly, designed to react to congestion.
If a TCP sender does not receive a ACK in time, the CWND is set to a single packet.
- SSTRESH is set to 50% of the CWND value before the lost segment. CWND grows at exponential rate during slow start.
- If a packet is lost, the TCP sender decides to use the receiver window or CWND, which ever is smaller at the time.

QoS
WRED configuration:
Class-based
Interface based:

Per interface:
interface Ser0/0
random-detect dscp-based
random-detect **dscp af21 50 60**
random-detect **dscp af31 20 30**

show queueing int X

Per Class:
policy-map X
class class-default
random-detect dscp-based <value> <min-thres> <max-thres> <mark-prob-denominato>

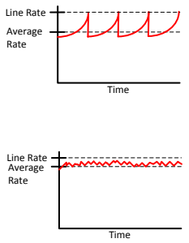
show policy-map x

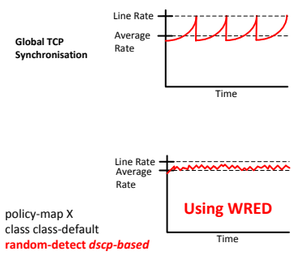
Random-detect exponential-weighting-constand X
Default is 9, the smaller the number the more quickly WRED will react to changes in the Q

show queue

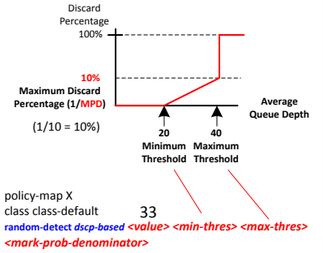
Shaping and latency-sensitive traffic:

If you are sending latency-sensitive traffic, you should set Bc to drive the calculation of Tc down to 10 msec!



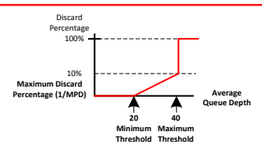


policy-map X
class class-default
random-detect *dscp-based*

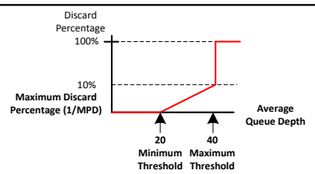


policy-map X
class class-default 33
random-detect dscp-based <value> <min-thres> <max-thres> <mark-prob-denominator>

QoS
Dual Token Bucket
(dual rate)

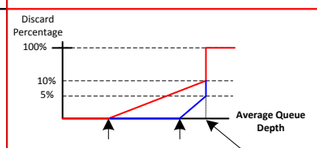


QoS
Explain WRED profiles

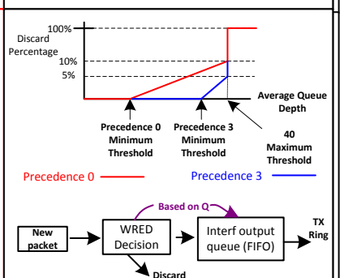


Default WRED profile for Precedence 0

Set the max percentage of packets discarded by WRED by setting the Mark Probability Denominator (MPD). MDP of 10 = 1/10 = maximum discard rate is 10 %



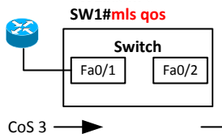
Explain WRED profiles for
Precedence 0 and Precedence 3



QoS
Configuring a switch with only
mls qos:

Switches have QoS disabled by default.
If **only mls qos** is **enabled**, the switch will remove incoming markings -> **stripping existing markings**

SW1#conf t
SW1#mls qos

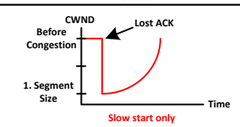


Term	Meaning
Actual queue depth	
Average queue depth	
Minimum Threshold	
Maximum Threshold	
Mark Probability Denominator	
Exponential Weighting constant	
No Drop	
Random Drop	
Full Drop	

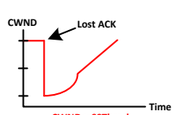
RED Terminology

Term	Meaning
Actual queue depth	number of packets in a queue
Average queue depth	calculated measurement
Minimum Threshold	No pkts discarded if blow minimum
Maximum Threshold	Pkts discarded if average above threshold
Mark Probability Denominator	max % of packets discarded when average queue depth falls in min/max
Exponential Weighting constant	the larger the number, the slower the change in the av. Queue depth
No Drop	average below minimum threshold
Random Drop	between min and max threshold
Full Drop	Q depth exceeds max threshold, All Packets are dropped

QoS
The difference between
TCP Slow start
and
Slow start and congestion avoidance



Slow start only



CWND > SSThresh
Slow Start and Congestion Avoidance

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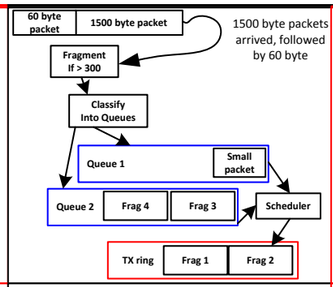
QoS

QoS

MLP LFI Queuing



QoS

show mls qos map cos-dscp

Modification and Output:

SW2#**show mls qos map cos-dscp**
Cos-dscp map:
cos: 0 1 2 3 4 5 6 7
---
dscp: 0 8 16 24 32 40 48 56

SW2(config)#**mls qos map cos-dscp 0 8 16 26 32 46 48 56**

SW2#**show mls qos map cos-dscp**
Cos-dscp map:
cos: 0 1 2 3 4 5 6 7
---
dscp: 0 8 16 26 32 46 48 56

Codec	speech samples per packet	Voice Payload	Packets/ Second	Total Bandw. Per Call
G.711				
G.711				
G.729				
G.729				

Codec	speech samples per packet	Voice Payload	Packets/ Second	Total Bandw. Per Call
G.711	20 ms	160 bytes	50pps	80 kbps
G.711	30 ms	240 bytes	33pps	74 kbps
G.729	20 ms	20 bytes	50pps	24 kbps
G.729	30 ms	30 bytes	33pps	19 kbps

QoS

MLP LFI

Calculation fragment size / maximum delay

You want a maximum serialization delay of 10 ms:

Max-delay in 0.x seconds * bandwith in bits = frag size

Bandwith = configured value with the **bandwith command**.

ppp multilink fragment delay X

Example:

56Kbps with 10 ms delay makes fragment sizes of 70 bytes:

56000 bit * 0.1 sec = 560 bits/10 msec or 70 bytes/**10msec**

QoS

show mls qos interface X

Output:

SW2#**show mls qos interface fa0/1**
FastEthernet0/1
QoS is disabled. When QoS is enabled, following settings will be applied
trust state: not trusted
trust mode: not trusted
trust enabled flag: ena
COS override: dis
default COS: 0
DSCP Mutation Map: Default DSCP Mutation Map
Trust device: none
qos mode: port-based

QoS

Weighted Fair Queuing (WFQ)

fair-queue 16 128 8

Queue length:
16 congestive discard threshold
128 number of conversations (flows)
8 reserved converstations for RSVP

A conversation is a unidirectional sequence of packets matching the same SRCIDST. Ports

Tx ring as small as possible to trigger WFQ more quickly to kick in.
tx-ring-limit 1

Reserved Queues used for control-plane and L2 keepalive traffic

interface Serial0/1/0
clock rate 128000
bandwidth 128
tx-ring-limit 1
fair-queue 16 128 8
hold-queue 256

Hold-queue (Q length default 75, up to 4096)

QoS

PPP MLP LFI / multilink interleave

Configuration:

Interface [dialer0, virtual-template]
! Enables multilink
ppp multilink

! Enables interleaving of unfragmented frames
ppp multilink interleave

! Defines fragent size based on bandwith/time formula
ppp multilink fragment delay

! Disables MLP fragmentation
ppp multilink fragment disable

! Configure on each interface of MLP bundle
ppp multilink group <GRP-number>

show ppp multilink
ip rtp priority (voice in PQ)
show queueing int

QoS

mls qos trust [x, y]

switchport priority extended cos X

switchport priority extended trust

Explained:

mls qos trust CoS [pass-through]

Pass-through**: **Prevents** switch from **overwriting** the original **DSCP values** sourced **from** the **CoS-to-DSCP map.

mls qos trust [device cisco-phone, dscp]

mls qos trust device cisco-phone used with
switchport priority extended cos <value>
Overwrites original CoS value received from ethernet port of the phone.

mls qos trust device cisco-phone used with
switchport priority extend trust
Trusts the markings sent on the phone's ethernet port of the attached PC

QoS

Normalize the packet flows

interface Serial0/1/0
clock rate 128000
bandwidth 128
ip mtu 156

Normalize packet flows, so that each IP packet takes **no more than 10ms** to be sent **on 128 Kbps link**

*Bitrate of link * time-limit in msec = bit/sec*
128000 bits / sec *** 0.010 = 1248** bits/sec
1248 / 8 = **156 bytes** = **MTU size**

QoS

PPP MLP LFI / multilink interleave

Configuration:

Interface Multilink 9
bandwith 128
ip address 1.2.3.4 255.255.255.0
fair-queue
ppp multilink
multilink-group 9

int serial0/1
bandwith 128
no ip address
encapsulation ppp
ppp multilink
multilink-group 9

interface multilink 9
ppp multilink fragment-delay 10
ppp multilink interleave

show int multilink 9 | i Output queue
Output queue: 27/1000/64/1405/164 (size/max total/ threshold/drops/interleaves)

QoS

mls qos cos

mls qos cos override

explained

mls qos cos <value>
Attaches specified CoS value to all untagged frames received.

mls qos cos override
Overwrites the original CoS value received

interface FastEthernet0/1
mls qos cos 3
mls qos cos override

Will set untagged frames to 3, and will override tagged frames to 3!

SW2#show mls qos int fa0/1
FastEthernet0/1
trust state: cos override
trust mode: cos override
trust enabled flag: ena
COS override: ena
default COS: 3
DSCP Mutation Map: Default DSCP Mutation Map
Trust device: none
qos mode: port-based

Alternative:
Trust incoming cos, set untagged to 4

int x
mls qos cos 4
mls qos trust cos

MTU's explained:

Mtu

ip mtu

mpls mtu

mtu	**maximum packet length the interface can support, oversized packets may not be interpreted correctly on the other end**
ip mtu	**fragments an IP packet if the packet arriving exceeds the value configured**
mpls mtu	**fragments the MPLS labled packet if the labeled packet arriving exceeds the value configured**

QoS

MLP Multilink

Difference of

Fragment-delay and

interleave

Interface Multilink 9
bandwith 128
ppp multilink
multilink-group 9
ppp multilink fragment-delay 10

defines
Frag Size

int serial0/1
bandwith 128
encapsulation ppp
ppp multilink
multilink-group 9

Defines frag size to be serialized in 10 msec, dependend on bandwith statement

Interface Multilink 9
ppp multilink
multilink-group 9
ppp multilink fragment-delay 10
ppp multilink interleave

int serial0/1
encapsulation ppp
ppp multilink
multilink-group 9

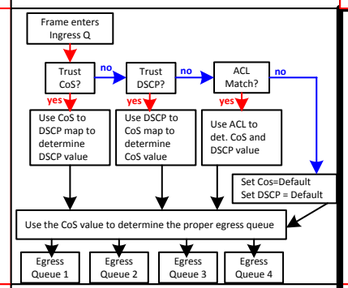
Interleaves smaller packets
Frag 2 | Voice | Frag 1

QoS

Congestion Management

On a 2950 with 1 ingress and

4 egress transmit queues



QoS

show queueing fair

Output:

WFQ

R5#**show queueing fair**
Current fair queue configuration:

Interface	Discard threshold	Dynamic queues	Reserved queues	Link queues	Priority Q
Serial0/0/0	64	256	0	8	1
Serial0/1/0	16	128	8	8	1

QoS

Configuring class based header compression:

Header compression on interface:

class-map match-all **COMPRESS-IP**
match ip address 101

class-map match-all **COMPRESS-TCP**
match ip address 199

policy-map COMPRESSING
class **COMPRESS-IP**
compression header ip
class **COMPRESS-TCP**
compression header ip tcp

interface Serial
Encapsulation ….
ip tcp header-compression [passive | iphc-format | ietf-format]
ip rtp header-compression [passive, …]

QoS

LAN policing

Explained:

police rate-bps burst-byte exceed-action [drop, dscp <value>]
Rate-bps: average receive rate the policer will accept
Burst-byte: acceptable values 4096, 8192,… in kbps

Policy-map POLICE-ME
Class FTP
Set ip dscp 18
police 500000 8192 exceed-action dscp 0

Legacy RTP Reserved Queue

100% of the link bandwidth is reserved for RTP traffic in the UDP port range 16384 – 32767.

making WFQ aware of voice bearer traffic

interface Serial 0/1/0
no hold-queue out
fair-queue
max-reserved-bandwidth 100
ip rtp reserve 16384 16383 128

ip rtp reserve ***<Starting UDP Port> <Port-Range> <Bandwidth>***
(UDP 16384 to 32767 for 128kbps)

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

Colin

http://www.flashcardguy.ch

QoS

Legacy RTP Reserved Queue

Verification:

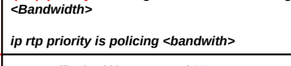
```
interface Serial0/1/0
 bandwidth 128
max-reserved-bandwidth 100
ip rtp reserve 16384 16383 128

R4#show queueing fair
Current fair queue configuration:

 Interface         Discard  Dynamic  Reserved  Link   Priority
                   threshold queues   queues    queues q
Serial0/0/0          64       256      0         8      1
Serial0/1/0          64       32       1         8      1
```

To verify IP RTP

Configure IP SLA sourcing G.729 like packet stream.

```
R1#
ip sla monitor 1
type jitter dest-ipaddr 155.1.45.5 dest-port 16384
codec g729a
timeout 1000
frequency 1

ip sla monitor schedule 1 life forever start-time now

R2#
rtr responder
ip sla responder
```

responder



Mon SRC

show ip sla monitor statistics X

output

```
R6#show ip sla monitor statistics 1
Round trip time (RTT)   Index 1
        Latest RTT: 12 ms
Latest operation start time: *03:02:53.955 UTC Tue Apr 8 2014
Latest operation return code: OK
RTT Values
        Number Of RTT: 1000
        RTT Min/Avg/Max: 9/12/85 ms
...
        Source to Destination Jitter Min/Avg/Max: 0/2/61 ms
        Destination to Source Jitter Min/Avg/Max: 0/1/12 ms
Packet Loss Values
        Loss Source to Destination: 0          Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 0    Packet Late Arrival: 0
Voice Score Values
        Calculated Planning Impairment Factor (ICPIF): 11
MOS score: 4.06
Number of successes: 13
...
```

Legacy RTP Prioritization

```
interface Serial0/1/0
 bandwidth 128
 no ip address
 fair-queue
 max-reserved-bandwidth 100
 ip rtp priority 16384 16383 128
```

IP RTP Priority feature differs from the IP RTP Reserve in that the priority queue has a WFQ weight of zero, meaning that the WFQ always services it first.

ip rtp priority <Starting UDP Port> <Port Range> <Bandwidth>

ip rtp priority is policing <bandwith>

Legacy Custom Queueing

```
- VoIP traffic should be guaranteed 30%
- File transfers from VI146 60%
- remaining 10% for ICMP, should not exceed 10 pkts in any
  queue in any time.
- RIP packets in system prio Q

access-list 100 permit tcp 155.1.146.0 0.0.0.255 eq www any
access-list 101 permit icmp any any

queue-list 1 protocol ip 0 udp 520
queue-list 1 protocol ip 1 lt 65
queue-list 1 protocol ip 2 list 100
queue-list 1 protocol ip 3 list 101
queue-list 1 default 3
queue-list 1 queue 3 limit 10
queue-list 1 queue 1 byte-count 320
queue-list 1 queue 2 byte-count 640
queue-list 1 queue 3 byte-count 104

interface Serial 0/1/0
custom-queue-list 1
```

packets with a size less than 65 bytes are matched in queue 1

Ratio Calculation is a bit tricky, normalization etc...

Legacy Custom Queueing with Prioritization

(not recommended, as to no way to limit the priority queues)

```
access-list 100 permit tcp 155.1.146.0 0.0.0.255 eq www any
access-list 101 permit icmp any any

queue-list 1 protocol ip 0 udp 520
queue-list 1 protocol ip 1 lt 65
queue-list 1 protocol ip 2 list 100
queue-list 1 protocol ip 3 list 101
queue-list 1 default 3
queue-list 1 queue 3 limit 10
queue-list 1 queue 1 byte-count 320
queue-list 1 queue 2 byte-count 640
queue-list 1 queue 3 byte-count 104

interface Serial 0/1/0
custom-queue-list 1

queue-list 1 lowest-custom 2
```

Priorize RTP traffic over RIP packets

`lowest-custom` option tells the round robin scheduler with witch Queue to start

Legacy Priority Queueing

Configuration:

not very helpful for VoIP deployments

```
- RIP packets first, second RTP VoIP
- If no RIP or VoIP traffic, than Web traffic first
- Last ICMP traffic
- Queue-Size High 5, Medium 40, Normal 60, Low 80 pkts

----------

access-list 102 permit udp any any range 16384 32767
access-list 103 permit icmp any any

priority-list 1 protocol ip high udp rip
priority-list 1 protocol http normal
priority-list 1 protocol ip medium list 102
priority-list 1 protocol ip low list 103
priority-list 1 queue-limit 5 40 60 80

interface Serial 0/1/0
priority-group 1
```

sends the most important traffic flow completely before it moves to the next important flow

Legacy Priority Queueing

show interface X

Output:

```
Rack1R4#show interfaces s0/1/0
Serial0/1/0 is up, line protocol is up
.....
  Queueing strategy: priority-list 1
  Output queue (queue priority: size/max/drops):
  high: 0/5/0, medium: 0/40/0, normal: 0/60/18754, low: 0/80/0

----------

access-list 102 permit udp any any range 16384 32767
access-list 103 permit icmp any any

priority-list 1 protocol ip high udp rip
priority-list 1 protocol http normal
priority-list 1 protocol ip medium list 102
priority-list 1 protocol ip low list 103
priority-list 1 queue-limit 5 40 60 80

interface Serial 0/1/0
priority-group 1
```

show queue serial 0/1/0 0 = high
show queue serial 0/1/0 1 = med
show queue serial 0/1/0 2 = norm
show queue serial 0/1/0 3 = low

QoS

Legacy Custom Queueing

using show interface X

Output:

```
R4#show interfaces serial 0/1/0
....
 Last input 00:00:05, output 00:00:03, output hang never
 Last clearing of "show interface" counters 02:15:06
 Input queue: 0/75/0/0 (size/max/drops/flushes); Total
output drops: 18763
  Queueing strategy: custom-list 1
  Output queues: (queue #: size/max/drops)
   0: 0/20/0 1: 0/20/0 2: 0/20/18754 3: 0/10/0 4: 0/20/0
   5: 0/20/0 6: 0/20/0 7: 0/20/0 8: 0/20/0 9: 0/20/0
   10: 0/20/0 11: 0/20/0 12: 0/20/0 13: 0/20/0 14: 0/20/0
   15: 0/20/0 16: 0/20/0
 5 minute input rate 0 bits/sec, 0 packets/sec
 5 minute output rate 0 bits/sec, 0 packets/sec
 .....
```

Queue Number

QoS

Legacy Custom Queueing

Show queueing custom

Output:

```
- VoIP traffic should be guaranteed 30%
- File transfers from VI146 60%
- remaining 10% for ICMP, should not exceed 10 pkts in any
  queue in any time.
- RIP packets in system prio Q

R4#show queueing custom
Current custom queue configuration:

List  Queue  Args
1     3      default
1     0      protocol ip      udp port rip
1     1      protocol ip      lt 65
1     2      protocol ip      list 100
1     3      protocol ip      list 101
1     1      byte-count 320
1     2      byte-count 640
1     3      byte-count 104 limit 10
```

Legacy Random Early Detection

```
- avoid tail drop, by randomly dropping packets before
output queue overflows (hold-queue size set to 10
packets) (NOT weighted, no different profiles)

interface Serial0/1/0
random-detect
random-detect exponential-weighting-constant 4
random-detect precedence 6 11 12
hold-queue 10 out

R4#show interfaces serial 0/1/0
...
  Queueing strategy: random early detection(RED)
...
```

Max threshold pkts
Min threshold pkts
Precedence

Legacy Flow-Based Random Early Detection

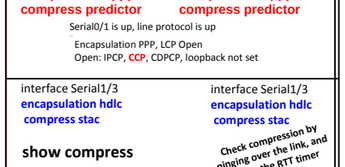
config

```
flow-based RED:
- maximum number of flows to 16
- average flow depth scale factor to 2
- FIFO queue depth to 10 packets

average queue size per flow, Avg=Q/N.  (queue size
Q divided by number of currently active flows)

interface Serial0/1/0
random-detect
random-detect flow
random-detect flow count 16
random-detect flow average-depth-factor 2
hold-queue 10 out

  show queueing random-detect
  Mean queue depth: 0
  Max flow count: 16 Average depth factor: 2
  Flows (active/max active/max): 0/0/16
```

Legacy Flow-Based Random Early Detection

diagram

NewMaxThreshold = MinThreshold + (MaxThreshold-MinThreshold)/2.



Selective Packet Discard

```
- enable selective packet discard in aggressive mode
- increase input queue
- set memory headroom for IGP packets to 150 Buffers
- set headroom for BGP packets should be set to 120
  packets
- Start dropping low-priority packets randomly when the
  input queue is 50% full

spd extended-headroom 150
spd headroom 120
ip spd mode aggressive
ip spd queue max-threshold 150
ip spd queue min-threshold 75

interface FastEthernet 0/0
hold-queue 150 in
```

IGPs initialy land here
BGP initialy lands here

SPD Extended Headroom Q is emptied before the spd headroom Queue

Selective Packet Discard

Normal / Aggressive mode

show ip spd

Output:

```
Normal mode
treats malformed packets as it would treat regular IP
packets. -> hold queue, random drop.
Agressive mode:
malformed packets dropped as soon as hold queue grows
above min threshold. -> unconditional drop

R1#show interface fastEthernet 0/0
...
  Input queue: 0/150/0/0 (size/max/drops/flushes); Total
output drops: 0
...
R1#show ip spd
Current mode: normal.
Queue min/max thresholds: 75/150, Headroom: 120, Extended
Headroom: 150
IP normal queue: 0, priority queue: 0.
SPD special drop mode: aggressively drop bad packets
```

Payload Compression on Serial Links

```
-Predictor" compression algorithm uses a minimum of CPU
 cycles on the router, but needs more memory

Predictor only on PPP          Stacker only on HDLC

interface Serial0/1            interface Serial0/1
encapsulation ppp              encapsulation ppp
compress predictor             compress predictor

Serial0/1 is up, line protocol is up
  Encapsulation PPP, LCP Open
  Open: IPCP, CCP, CDPCP, loopback not set

interface Serial1/3            interface Serial1/3
encapsulation hdlc             encapsulation hdlc
compress stac                  compress stac

show compress
```

Check compression by pinging over the link, and watch the RTT timer

Generic TCP/UDP Header Compression

```
- maximum of 16 concurrent RTP and TCP sessions
- R5 only optimizes if it detects optimized traffic from R4

R4 active  R5 passive

interface Serial0/1/0
ip tcp header-compression
ip tcp compression-connections 32
ip rtp header-compression
ip rtp compression-connections 32

interface Serial0/1/0
ip tcp header-compression passive
ip tcp compression-connections 32
ip rtp header-compression passive
ip rtp compression-connections 32
```

show ip tcp header-compression
show ip rtp header-compression

Help me create more flashcards:

Simply press this button and send me your credit cards regards!

Ranging 5 bucks to unlimited!

Donate

Thanks for appreciating my efforts

Colin

http://www.flashcardguy.ch

QoS

Generic TCP/UDP Header Compression

show ip tcp header-compression

output

```
R5#show ip tcp header-compression
TCP/IP header compression statistics:
  Interface Serial0/1/0 (compression on, VJ, passive)
    Rcvd:    94 total, 93 compressed, 0 errors, 0 status msgs
             0 dropped, 3 buffer copies, 0 buffer failures
    Sent:    96 total, 93 compressed, 0 status msgs, 0 not
             predicted
             3243 bytes saved, 677 bytes sent
             5.79 efficiency improvement factor
Connect: 32 rx slots, 32 tx slots,
             1 misses, 0 collisions, 0 negative cache hits, 32 free
             contexts
             98% hit ratio, five minute miss rate 0 misses/sec, 0 max

show ip tcp header-compression serial 0/1/0 detail
  IP source: 150.1.4.4, IP destination: 155.1.45.5
  TCP source: 23, TCP destination: 37587
  Last packet   received is VJcompressed-tcp and last sequence
received is 0
```

QoS

Legacy CAR for Admission Control

(Designed for packet remarking / policing)

- Traffic up to **256Kbps** should be **marked** with an **IP precedence of 1**
- **Exceeding traffic** should be **marked** with an IP **precedence of 0**
- use average traffic **burst size of 4000 bytes**

access-list 111 permit ip host 155.1.146.1 any

interface FastEthernet0/1
rate-limit input access-group 111 256000 4000 4000 conform-action set-prec-transmit 1
exceed-action set-prec-transmit 0

(continue to next rate-limit statement..)

QoS

MQC Bandwidth Reservations and CBWFQ

- **set total size of MQC buffer to 512**
- http from vlan 146 with IP Prec 0 should be guaranteed 32Kbps
- Limit FIFO Q for http to 16 pkts, IP Prec 0 traff to 24 pkts
- all other traffic run WFQ, dynamic flows start dropping if they reach 32 packets

```
policy-map SERIAL_LINK
 class VOICE
  class HTTP
   bandwidth 32
   queue-limit 16
  class SCAVENGER
   bandwidth 32
   queue-limit 24
 class class-default
  fair-queue
  queue-limit 32
```

```
interface Serial 0/1/0
bandwidth 128
max-reserved-bandwidth 100
no fair-queue
hold-queue 512 out
```

To use FIFO instead WFQ:
class class-default
bandwidth 96

MLP Link Fragmentation and Interleaving

- **maximum serialization delay is 10ms**
- **bandwidth of the link is 128Kbps.**
- **Encapsulation ppp**
- **PPP multilink with interleaving**

```
interface Virtual-Template1
bandwidth 128
ip address 155.1.45.4 255.255.255.0
fair-queue
ppp multilink fragment delay 10
ppp multilink interleave

multilink virtual-template 1

interface Serial0/1/0
bandwidth 128
no ip address
encapsulation ppp
load-interval 30
ppp multilink
```

fragment size should be based upon the physical rate of the link (clock rate) not the logical bandwidth

QoS

Legacy CAR for Admission Control

Config / show commands

access-list 111 permit ip host 155.1.146.1 any

interface FastEthernet0/1
rate-limit input access-group 111 256000 4000 4000 conform-action set-prec-transmit 1
exceed-action set-prec-transmit 0

show interfaces fastEthernet 0/1 rate-limit
FastEthernet0/1
Input
matches: access-group 111
params: 256000 bps, 4000 limit, 4000 extended limit
conformed 3841 packets, 3885702 bytes; action: set-prec-transmit 1
exceeded 24 packets, 24336 bytes; action: set-prec-transmit 0
last packet: 20ms ago, current burst: 3928 bytes
last cleared 00:02:21 ago, **conformed 219000 bps, exceeded 1000 bps**

CBWFQ weight / conversation numbers:

Conversation Numbers	CBWFQ Weight	Description
Below 2^N	32384/(IPP+1)	Used for automatic classification of dynamic WFQ Queues. Configurable via *fair-queue* command under "class-default".
2^N...2^N+7	1024	Link Queues. There are 8 conversations used to queue routing updates (marked as *PAK_PRIORITY* internally) and Layer 2 keepalives.
2^N+8	0	Priority queue which maps directly to legacy WFQ IP RTP Priority. Typically used for VoIP bearer traffic. CBWFQ polices this flow using a configurable token bucket procedure to ensure it does not starve other queues.
Above 2^N+8	Const*IntfBW/ClassBW OR RSVP flow weight	These conversations are used for user-defined traffic classes. Each class has its own FIFO queue and configurable queue depth. In addition, RSVP flows use the same range of conversation numbers.

QoS

show ppp multilink

Output:

```
Rack1R4#show ppp multilink

Virtual-Access2, bundle name is R5
  Endpoint discriminator is R5
  Bundle up for 00:18:36, total bandwidth 128, load 190/255
  Receive buffer limit 12192 bytes, frag timeout 1000 ms
  Interleaving enabled
    0/0 fragments/bytes in reassembly list
    0 lost fragments, 0 reordered
    0/0 discarded fragments/bytes, 0 lost received
    0x7EC3 received sequence, 0xFC9C sent sequence
  Member links: 1 (max not set, min not set)
    Se0/1/0, since 00:18:34, 160 weight, 152 frag size
No inactive multilink interfaces
```

QoS Oversubscription with Legacy CAR and WFQ

- 64Kbps that R4 receives from R1 and R6
- Traffic from R1 and R6 should be allowed up to 128Kbps each total
- Traffic above 128Kbps should be dropped
- Averaging time interval of 200ms.

If below 64K set prec 1, continue, If between 64 and 128 set prec 0, over 128 drop

access-list 111 permit ip host 155.1.146.1 any
access-list 116 permit ip host 155.1.146.6 any

interface FastEthernet0/1
rate-limit input access-group 111 64000 3200 3200 conform-action set-prec-transmit 1 exceed-action **continue**
rate-limit input access-group 111 128000 3200 3200 conform-action set-prec-transmit 0 exceed-action drop

rate-limit input access-group 116 64000 3200 3200 conform-action set-prec-transmit 1 exceed-action **continue**
rate-limit input access-group 116 128000 3200 3200 conform-action set-prec-transmit 0 exceed-action drop

interface Serial 0/1/0
fair-queue
clock rate 128000

If R1 and R6 transmit, share 128K at 64/64

CBWFQ weight / conversation numbers:

Constant:

The "N" constant	Number of dynamic Flows	CBWFQ constant "Const"
4	16	64
5	32	64
6	64	57
7	128	30
8	256	16
9	512	8
10	1024	4
11	2048	2
12	4096	1

QoS

PPP Multilink

show ppp multilink

show interface virtual-access x

show interface serial x

Output:

```
R4#show ppp multilink
Interleaving enabled
Se0/1, since 00:13:44, 160 weight, 152 frag size

R4#show interface virtual-access 2
MLP Bundle vaccess, cloned from Virtual-Template1
Output queue: 6/1000/64/0/8445 (size/max total/threshold/drops/interleaves)
Conversations 2/3/256 (active/max active/max total)
Reserved Conversations 0/0 (allocated/max allocated)

R4#show interface serial 0/1/0
Link is a member of Multilink bundle Virtual-Access2
Queueing strategy: weighted fair [suspended, using FIFO]
FIFO output queue 0/10, 3 drops

show queueing interface virtual-access 2
```

QoS

Legacy CAR for Rate Limiting

- **drop** traffic in **excess** traffic **of 256Kbps**
- committed burst of **384Kbps**
- excess burst of **768Kbps**

interface FastEthernet 0/0
rate-limit input 256000 48000 96000 conform-action transmit exceed-action drop

show interfaces fastEthernet 0/0 rate-limit

(The TCP receiver's window size for TCP flows tends to be around *Traffic_Rate * RTT)*

QoS

MQC Bandwidth Percent

```
policy-map SERIAL_LINK
class HTTP
bandwidth percent 25
class SCAVENGER
bandwidth percent 25
```

configured **bandwidth percent** values in all classes of a policy-map cannot exceed the **max-reserved-bandwidth**

It is **not possible to mix bandwidth** with **bandwidth percent** commands!

QoS
Legacy Generic Traffic Shaping

config

Scheduler using WFQ!

- **limit the rate of packets going towards** R4's 99.99.99.0/24 **to 128Kbps**
- **Shaping interval of 10msec**, **disable extended burst**
- Limit shapers **queue size** to 1024 packets

access-list **199** permit ip any **99.99.99.0** 0.0.0.255

interface FastEthernet 0/0
traffic-shape group 199 128000 1280 0 **1024**

(1280*8)/128000 = 0.08 sec

traffic-shape rate *<CIR> <Bc> <Be> <QueueLimit>*
traffic-shape group *<ACL> <CIR> <Bc> <Be> <QueueLimit>*

show traffic-shape

QoS

Legacy CAR Access-Lists

- **rate limit packets going out to MAC address** X of MAC-ACL
- **rate-limite packets** towards X **having IPPrec set to 1,2,4** to **256Kbps**

access-list rate-limit 100 000d.2846.8f21

interface FastEthernet 0/0
rate-limit output access-group rate-limit 100 **128000** 8000 8000 conform-action transmit exceed-action drop

access-list rate-limit 0 mask 16

binary 1 means to check, binary 0 ignore 0x16 (00010110)

interface FastEthernet 0/0.67
rate-limit output access-group rate-limit 0 128000 8000 8000 conformaction
transmit exceed-action drop

QoS

MQC LLQ and Remaining Bandwidth Reservations

```
policy-map SERIAL_LINK
class VOICE
priority 27
class HTTP
bandwidth remaining percent 33
class SCAVENGER
bandwidth remaining percent 33
```

If http is not using its share, during congestion, scavenger could us it.

(if there are 32 (25) dynamic queues, then the LLQ conversation is number 40, weight value of 0, is serviced first)

HDLC overhead of **7 bytes**, **60 bytes** of layer 3 **VoIP Payload = 27 Kbps**
(67 bytes/packet * 50 packets/**second * 8 bits**/byte = 26800bps)

QoS
Legacy Generic Traffic Shaping

config / show cmd

access-list **199** permit ip any **99.99.99.0** 0.0.0.255

interface FastEthernet 0/0
traffic-shape group 199 128000 1280 0 **1024**

R6#**show traffic-shape**

Interface		Gi0/0.146							
	Access	Target	Byte	Sustain	Excess	Interval	Increment	Adapt
VC	List	Rate	Limit	bits/int	bits/int	(ms)	(bytes)	Active
-	104	128000	160	1280	0	10	160	-

R6#show traffic-shape statistics

	Acc.	Queue	Packets	Bytes	Packets	Bytes	Shaping
I/F	List	Depth			Delayed	Delayed	Active
Fa0/0	104	2	15365	21690	14962	2156	yes

QoS

MQC Classification and Marking

- Http from vlan 146 marked with IP Prec 2
- VoIP range 16384-32767 packet size <60 byte marked EF
- ICMP packets >1000 bytes should be dropped
- All other incoming with Prec 0 to be marked with 1

```
ip access-list extended HTTP
permit tcp 155.1.146.0 0.0.0.255 eq www any

ip access-list extended VOICE
permit udp any any range 16384 32767

class-map HTTP
match access-group name HTTP

class-map match-all LARGE_ICMP
match protocol icmp
match packet length min 1001

class-map match-all VOICE
match access-group name VOICE
match packet length min 60 max 60

class-map match-all SCAVENGER
match input-interface Fa0/1
match ip precedence 0

policy-map SERIAL_LINK
class VOICE
set ip dscp ef
class HTTP
set ip precedence 2
class LARGE_ICMP
Drop
class SCAVENGER
set ip precedence 1
```

QoS

MQC WRED

start dropping packets when average queue size is between 4-16
drop 1 of 4 packets when queue size reaches the max

```
policy-map SERIAL_LINK
class HTTP
random-detect
random-detect precedence 2 4 16 4

Precedence
minimum-thresshold in pkts
max-threshold in pkts
Mark propability denominator
```

ability to use random drop per flow, not per whole queue

```
show policy-map int x
```

class	Transmitted pkts/bytes	Random drop pkts/bytes	Tail drop pkts/bytes	Minimum thresh	Maximum thresh	Mark prob
2	713/4089	16/9280	0/0	4	16	1/4
3	0/0	0/0	0/0	26	40	1/10

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QoS

MQC Dynamic Flows and WRED

- activate random drops for unclassified traffic's **dynamic flows**
- set for IP Prec 1 thres min 1 max 40
- propability of 25% packet discard

```
policy-map SERIAL_LINK
class class-default
fair-queue
no queue-limit
random-detect
random-detect precedence 1 1 40 4
```

two ways to enable WRED within class-default:
1. `bandwidth` reservation statement - **turning** the class's queue **into a FIFO queue** - and then **enabling RED**
2. enable RED with WFQ

MQC WRED with ECN

- overall effect of TCP ECN is better performance, as compared to simple packet drops and slow start.
- changing the **exceed** action **from** random **drop to ECN marking**

```
policy-map SERIAL_LINK
class HTTP
random-detect ecn
random-detect precedence 2 4 16 4
```

QoS MQC Class-Based Generic Traffic Shaping (GTS)

config

- shape rate on vlan 146 to 384 Kbps
- shape rate on vlan 67 to 512 Kbps
- burst interval Be of 20ms

Bc = CIR * Tc / 1000
512000 * 20msec / 1000 = 10240

```
policy-map SHAPE_VLAN146
class class-default
shape average 384000 7680

policy-map SHAPE_VLAN67
class class-default
shape average 512000 10240

interface FastEthernet 0/1.146
service-policy output SHAPE_VLAN146

interface FastEthernet 0/1.67
service-policy output SHAPE_VLAN67
```

QoS MQC Class-Based Generic Traffic Shaping (GTS)

Config and output:

Bc = CIR * Tc / 1000
384000 * 20msec / 1000 = 7680

```
policy-map SHAPE_VLAN146
class class-default
shape average 384000 7680

interface FastEthernet 0/1.146
service-policy output SHAPE_VLAN146

show policy-map interface fastEthernet 0/0.146
Service-policy output: SHAPE_VLAN146
  Class-map: class-default (match-any)
  65844 packets, 28003483 bytes
  5 minute offered rate 334000 bps, drop rate 0 bps
  Match: any
  Traffic Shaping
    Target/Average   Byte   Sustain   Excess   Interval  Increment
      Rate           Limit  bits/int  bits/int  (ms)     (bytes)
    384000/384000    1920   7680      7680     20       960
Adapt Queue  Packets  Bytes    Packets  Bytes   Shaping
Active Depth Delayed  Delayed  Active
-      6     65838    279907   56930    270858  yes
```

QoS MQC Class-Based GTS and CBWFQ

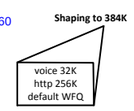
(configuring the shaper's queues)

No 75% rule, you may want to define a separate class for control plane traffic

- 32Kbps of priority for IP pkts size of 60 bytes with a Bc of 4000 byte
- guarantee 256 Kbps of shaped http traffic
- default class uses WFQ

```
class-map VOICE
match packet length min 60 max 60

ip access-list extended HTTP
permit tcp any eq 80 any

class-map HTTP
match access-group name HTTP

policy-map CBWFQ
class VOICE
priority 32 4000
class HTTP
bandwidth 256
class class-default
fair-queue

policy-map SHAPE_VLAN146
class class-default
shape average 384000 7680
service-policy CBWFQ
```

Shaping to 384K



QoS MQC Class-Based GTS and CBWFQ

Configuring the shaper's queues

QoS MQC Peak Shaping

(ios bug for show cmd)

60 bytes VoIP packet size (G.729)
18 bytes overhead for an Ethernet header
4 bytes of VLAN tag

at 50 packets per second =

(60+18)*50*8 = 31200bps or 312Kbps

QoS MQC Single-Rate Three-Color Policer

Config:

- meter incoming HTTP traffic:
- if less than 128K set IP Prec 1,
  if exceeds 128K then set IP Prec of 0 (using inactivity)
- drop violating traffic

Ensure burst durations of 200ms and 300ms

```
ip access-list extended HTTP
permit tcp any eq 80 any

class-map HTTP
match access-group name HTTP

policy-map POLICE_VLAN146
 class HTTP
  police 128000 3200 4800
   conform-action set-prec-transmit 1
  exceed-action set-prec-transmit 0
   violate-action drop

interface FastEthernet 0/1
service-policy input POLICE_VLAN146
```

Be (exceed) is used as extra credit for periods of long inactivity

QoS MQC Single-Rate Three-Color Policer

Config / show output:

```
class HTTP
 police 128000 3200 4800
  conform-action set-prec-transmit 1
 exceed-action set-prec-transmit 0
  violate-action drop

Class-map: HTTP (match-all)
 1245 packets, 1786990 bytes
 30 second offered rate 127000 bps, drop rate 0 bps
 Match: access-group name HTTP
 police:
   cir 128000 bps, bc 3200 bytes, be 4800 bytes
  conformed 1241 packets, 1780934 bytes; actions:
    set-prec-transmit 1
  exceeded 4 packets, 6056 bytes; actions:
    set-prec-transmit 0
  violated 0 packets, 0 bytes; actions:
    drop
  conformed 127000 bps, exceed 0 bps, violate 0 bps
```

show policy-map interface

QoS MQC Hierarchical Policers

(nested service-policies)

```
policy-map POLICE_VLAN146
 class HTTP
  police 128000 3200 4800
   conform-action transmit
   exceed-action set-prec-transmit 0
   violate-action drop
   service-policy SUBRATE_POLICER

policy-map SUBRATE_POLICER
 class FROM_R1
  police 64000 3200 4800
   conform-action set-prec-transmit 1
   exceed-action set-prec-transmit 0
   violate-action set-prec-transmit 0
 class FROM_R6
  police 64000 3200 4800
   conform-action set-prec-transmit 1
   exceed-action set-prec-transmit 0
   violate-action set-prec-transmit 0
```

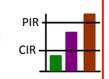
128K
64K
64K

QoS

MQC Two-Rate Three-Color Policer

- CIR 64Kbps PIR 128Kbps
- CIR*400ms for Bc/Be PIR*200ms for Bc/Be
- conform action set IP Prec 1, transmit
- exceed action set IP Prec 0, transmit
- violate action drop

```
policy-map POLICE_VLAN146
class HTTP
service-policy SUBRATE_POLICER

policy-map SUBRATE_POLICER
class FROM_R1
police cir 64000 bc 3200 pir 128000 be 6400
conform-action set-prec-transmit 1
exceed-action set-prec-transmit 0
violate-action drop

class FROM_R6
police cir 64000 bc 3200 pir 128000 be 6400
conform-action set-prec-transmit 1
exceed-action set-prec-transmit 0
violate-action drop
```



Four configurable parameters CIR, PIR, Bc, Be
Bc/Be have independent fill-rate

QoS MQC Header Compression

```
policy-map SERIAL_LINK_OUT
 class VOICE_BEARER
  priority 24
  compression header ip rtp
 class TCP
  compression header ip tcp

show policy-map interface serial1/2
...
compress:
header ip rtp
UDP/RTP (compression on, IPHC, RTP)
...

In combination with priority queues: base your
calculations on compressed packet sizes
```

show ip rtp header-compression

Catalyst QoS Port-Based Classification

(3560 models treats IPv6 as "IP" traffic, 3550 as "non-IP" traffic)

```
mls qos
interface FastEthernet 0/1
mls qos trust dscp

Trust CoS bits in 802.1p header for encapsulated vlans.
For native vlan apply the CoS value of 1 (CDP, etc.)

interface FastEthernet 0/6
mls qos trust cos
mls qos cos 1

interface FastEthernet 0/4
mls qos trust ip-precedence
mls qos cos 2

Force CoS 4 on all packets

interface FastEthernet 0/5
mls qos cos 4
mls qos cos override
```

If mls qos configured, but no trust, incoming marked packets will be reset to 0

Will map CoS 4 to DSCP 44
mls qos map cos-dscp 0 8 16 26 44 46 48 56

QoS

Catalyst QoS CoS port-based classification

```
If the incoming packet is IP, the switch will if configured
trust fist DSCP or IP Precedence then CoS.

If no CoS value had been set, it will set the default CoS
value if not specified differently via

mls qos CoS 4        (the CoS-to-DSCP map will map the
                      value accordingly into the DSCP field)

Mls qos trust CoS:   if NO 802.1q header, default CoS
                      value of interface is applied

mls qos cos override  will override any incoming packet.
```

QoS

Catalyst

```
show mls qos interface
fastEthernet 0/6
statistics
```

output

```
show mls qos interface fastEthernet 0/6 statistics
FastEthernet0/6
dscp: incoming
-------------------------------
0 - 4 :      0   0   0   0   0
5 - 9 :      0   0   0   0   0
10 - 14 :   35   0   0   0   0
15 - 19 :    0   0   0   0   0
20 - 24 :    0   0   0   0   0
25 - 29 :    0   0   0   0   0
30 - 34 :    0   0   0   0   0
35 - 39 :    0   0   0   0   0
40 - 44 :    0   0   0  22   0
45 - 49 :    0   0   0   0   0
50 - 54 :    0   0   0   0   0
55 - 59 :    0   0   0   0   0
60 - 64 :    0   0   0   0   0
```

QoS

Catalyst 3550 monitor mode:

```
interface FastEthernet 0/1
mls qos monitor packets
interface FastEthernet 0/4
mls qos monitor dscp 0 16 26 46 48
clear mls qos interface fastEthernet 0/4 statistics

SW4#show mls qos int fa0/4 statistics
FastEthernet0/4
Ingress
  dscp: incoming   no_change  classified policed   dropped (in pkts)
  0 :    2          2          0          0         0
  ...
  48:    402        402        0          0         0
Others:  0          0          0          0         0
Egress
  dscp: incoming   no_change  classified policed   dropped (in pkts)
  0 :    404        n/a        n/a        0         0
  ...
  48:    0          n/a        n/a        0         0
Others:  11         n/a        n/a        0         0
```

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QoS

Catalyst QoS Marking Pass-Through

Used to "tunnel" one type of QoS marking through your network, while using the other type.

Classify CoS values, but do not change the DSCP value in IP packets.

no mls qos rewrite ip dscp

Trust DSCP but do not change previous set CoS values:

Have DSCP set to 46
But have CoS at 2

Interface fa0/1
mls qos trust dscp pass-through cos
mls qos trust cos pass-through dscp

How to troubleshooting QoS

Markings / Classification

```
SW1#ping
Protocol [ip]:
Target IP address: 150.1.6.6
Repeat count [5]: 10
Datagram size [100]: 1000
Timeout in seconds [2]: 0
Extended commands [n]: y
Source address or interface: 150.1.7.7
Type of service [0]: 160
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 10, 1000-byte ICMP Echos to 150.1.6.6, timeout is 0 seconds:
Packet sent with a source address of 150.1.7.7
.....!.
Success rate is 10 percent (1/10), round-trip min/avg/max = 9/9/9 ms
```

DSCP 40 — ping

access-list 100 permit icmp any any dscp 40
access-list 100 permit ip any any
clear access-list counters

Fill in the blanks (Dezimal)

TOS	DSCP	IP-PREC

TOS	DSCP	IP-PREC	TOS	DSCP	IP-Prec
0	0	0	96	24	3
4	1	0	104	26	3
8	2	0	112	28	3
12	3	0	120	30	3
16	4	0	128	32	4
32	8	1	136	34	4
40	10	1	144	36	4
48	12	1	152	38	4
56	14	1	160	40	5
64	16	2	176	44	5
72	18	2	184	46	5
80	20	2	192	48	6
88	22	2	224	56	7

QoS

Catalyst QoS ACL Based Classification & Marking

set DSCP under non-IP traffic. The switch computes the respective CoS value using DSCP-to-CoS table.

mls qos rewrite ip dscp

```
mac access-list extended IPX
permit any any 0x8137 0x0

class-map match-all IPX
match access-group name IPX

policy-map CLASSIFY
class IPX
set dscp ef
class-default
trust CoS
```

Set DSCP, trust CoS on 3550

(Trust cos on class default)

QoS

Catalyst 3550 Per-Port Per-VLAN Classification

Make sure that classification only affects Vlan 146 of a trunk port:

trunk
Vlans 1,9,20,146
Service-policy applied

```
ip access-list extended ICMP
permit icmp any any

class-map ICMP
match access-group name ICMP

class-map VLAN_146_ICMP
match vlan 146
match class-map ICMP

policy-map PER_PORT_PER_VLAN
class VLAN_146_ICMP
set dscp CS3
```

Must be the first statement in class-map!

Second layer class-map ICMP is only allowed to have 1 match criteria

QoS

Catalyst 3560 Per-VLAN Classification

```
mls qos

interface FastEthernet 0/1
mls qos vlan-based
switchport-mode trunk

Interface Fa0/22
no mls qos vlan-based

policy-map PER_VLAN
class TCP
set dscp ef

interface VLAN 146
service-policy input PER_VLAN
```

Inherit QoS settings from SVI per port

Disable Vlan based QoS per port

show mls qos interface fa0/4 statistics

QoS

Catalyst QoS Port-Based Policing and Marking

Rate-Limit to 128Kbps allow 10msec of burst generated by a full 100Mbps interface rate.

100Mbps*10ms/8 = 125000

```
policy-map POLICE
class class-default
police 128000 125000

interface FastEthernet 0/1
service-policy input POLICE
```

Police ICMP and remark exceeding traffic to 8

```
policy-map POLICE_INBOUND
class ICMP
trust dscp
set cos 2
police 64000 16000 exceed-action policed-dscp-transmit

mls qos map policed-dscp 0 16 24 26 to 8
```

QoS

Show mls qos int fa0/x statistics

Output

Ingress policing / marking

```
SW4#show mls qos interface fastEthernet 0/4 statistics
FastEthernet0/4
Ingress
dscp: incoming no_change classified policed dropped (in pkts)
0 :      1142      1         1         0         0
8 :         0      0         0         0         0
16:         0      0      1141       731       0
Others:     1      0         0         0         0
Egress
dscp: incoming no_change classified policed dropped (in pkts)
0 :      1746     n/a       n/a       0         0
8 :         0     n/a       n/a       0         0
16:         0     n/a       n/a       0         0
Others:    84     n/a       n/a       0         0
```

all incoming packets are DSCP 0, switch classifies them to CS2 (16), some are policed due to exceeding rates

Catalyst 3560 Per-Port Per-VLAN Policing

```
interface FastEthernet 0/13
mls qos vlan-based

class-map TRUNKS
match input-interface FastEthernet 0/13

policy-map INTERFACE_POLICY
class TRUNKS
police 128000 16000 exceed policed-dscp-transmit

policy-map VLAN_POLICY
class IP_ANY
set dscp af21
service-policy INTERFACE_POLICY

interface Vlan 146
service-policy input VLAN_POLICY
```

Catalyst QoS Aggregate Policers

Aggregate ICMP and IPX to 128Kbps, drop exceeding

```
mls qos
mls qos aggregate-policer AGG128 128000 16000 exceed-action drop

policy-map POLICE_AGGREGATE
 class ICMP
  police aggregate AGG128
 class IPX
  police aggregate AGG128
 class class-default
  set dscp cs1

interface FastEthernet 0/1
service-policy input POLICE_AGGREGATE
```

Catalyst QoS DSCP Mutation

DSCP 40 → DSCP 40 → DSCP 46

QoS DSCP mutation maps come in handy on the border of two QoS domains that use different markings

```
mls qos

mls qos map dscp-mutation MUTATION 0 to 8
mls qos map dscp-mutation MUTATION 26 to 24
mls qos map dscp-mutation MUTATION 40 to 46

interface FastEthernet 0/4
mls qos trust dscp
mls qos dscp-mutation MUTATION
```

Advanced HTTP Classification with NBAR

HTTP transfers of files with extensions ".bin", ".text" and ".taxt" are limited to 256Kbps:

```
class-map match-all EXTENSION
match protocol http url "*.bin|*.t[ea]xt"

policy-map SHAPE
class EXTENSION
shape average 256000

interface FastEthernet 0/0.146
service-policy output SHAPE
```

Per-Tunnel QoS for DMVPN

QoS Profile

Configuring NHRP Group **on a Spoke:**
int tunnel X
ip nhrp group GROUP

Config NHRP mapping **on HUB:**

```
int tunnel X
 ip nhrp map group GROUP-1 service-policy output
SERVICE-POLICY-1
 ip nhrp map group GROUP-2 service-policy output
SERVICE-POLICY-2

show policy-map multipoint [tunnel <nr>]
show ip nhrp group-map GROUP
Show tunnel endpoints
show dmvpn detail | I (NHRP group|service-policy)
```

R1 — SW1 — SW2 — R2 (TRUNK)

How to setup the easiest possible QoS lab:

Have R1 send all packets with a CoS of 4

R2 should monitor all CoS classifications

R1 — SW1 — SW2 — R2 (TRUNK)

R1#ping 10.0.0.2

int fa0/0
service-policy outbound SET-DSCP-1

policy-map SET-DSCP-1
class class-default
set dscp 1

Why does R2 not see any packets with DSCP 1 via

show policy-map interface ?

R2#
int fa0/0
service-policy PMAP-MONITOR

policy-map PMAP-MONITOR
class COS0
...
class COS7
class DSCP-0-7

class-map match-all COS0
match cos 0
class-map match-all COS1
match cos 1
...
class-map match-all COS7
match cos 7

class-map match-any DSCP-0-7
match dscp default 1 2 3 4 5 6 7

Create a DSCP mutation map which changes inbound DSCP 1 to 60.

Verify using

show mls qos maps dscp-mutation:

d1 d2 — d2 Most specific outgoing DSCP value → 60 → Output dscp
d1 Most specific incoming DSCP value

SW2#sh mls qos maps dscp-mutation

Dscp-dscp mutation map:
TST:

d1 :	d2 0	1	2	3	4	5	6	7	8	9
0 :	00	60	02	03	04	05	06	07	08	09
1 :	10	11	12	13	14	15	16	17	18	19
2 :	20	21	22	23	24	25	26	27	28	29
3 :	30	31	32	33	34	35	36	37	38	39
4 :	40	41	42	43	44	45	46	47	48	49
5 :	50	51	52	53	54	55	56	57	58	59
6 :	60	61	62	63						

Dscp-dscp mutation map:

d1 :	d2 0	1	2	3	4	5	6	7	8	9
0 :	00	01	02	03	04	05	06	07	08	09
1 :	10	11	12	13	14	15	16	17	18	19
2 :	20	21	22	23	24	25	26	27	28	29
3 :	30	31	32	33	34	35	36	37	38	39
4 :	40	41	42	43	44	45	46	47	48	49
5 :	50	51	52	53	54	55	56	57	58	59
6 :	60	61	62	63						

show mls qos !!

mls qos map dscp-mutation TST 1 to 60

mls qos rewrite ip dscp

interface Fa0/16
mls qos trust dscp
mls qos dscp-mutation TST

R1 — SW1 — SW2 — R2 (TRUNK)

R1#
int fa0/0.100
encapsulation dot1q 100
ip address 10.0.0.1 255.255.255.0
service-policy output PMAP-COS-OUT

policy-map PMAP-SET-COS
class class-default
set cos 4

On switches either "no mls qos" or trust cos!

ping R2 from R1, show policy-map interface, use clear counters, after tests

R2#
int fa0/0.100
encapsulation dot1q 100
ip address 10.0.0.2 255.255.255.0
service-policy input PMAP-COS
policy-map PMAP-SET-COS
class COS-0
...
class COS-7

R2#
class-map COS-0
match cos 0
...
class-map COS-4
match cos 4
...

R2#show policy-map interface FastEthernet0/0

Service-policy input: PMAP-MONITOR

Class-map: COS0 (match-all)
6 packets, 708 bytes
30 second offered rate 0 bps
Match: cos 0

Class-map: DSCP-0-7 (match-any)
0 packets, 0 bytes
30 second offered rate 0 bps
Match: dscp default (0) 1 2 3 4 5 6 7

First match here:

Entry stays 0!!

policy-map PMAP-MONITOR
class COS0
class COS1
class COS2
class COS3
class COS4
class COS5
class COS6
class COS7
class DSCP-0-7

R1 — SW1 — Fa0/x SW2 — R2 (TRUNK)
DSCP 5 → CoS 6

map DSCP 5 to CoS 6

R1 — SW1 — Fa0/x SW2 — R2 (TRUNK)
DSCP 5 CoS 0 → DSCP 5 CoS 6

map DSCP 5 to CoS 6

SW2:

DSCP remains 5, but L2 CoS modified from 0 to 6 !!

```
mls qos

int fa0/x
mls qos trust dscp

mls qos map dscp-cos <DSCP-value> to <CoS-Value>

mls qos map dscp-cos 5 to 6
```

DSCP 5 to CoS 6:
mls qos map dscp-cos 5 to 6

SW2#show mls qos maps dscp-cos

Dscp-cos map:

d1 :	d2 0	1	2	3	4	5	6	7	8	9
0 :	00	00	00	00	00	05	00	00	01	01
1 :	01	01	01	01	01	02	02	02	02	02
2 :	02	02	02	03	03	03	03	03	03	03
3 :	03	03	04	04	04	04	04	04	04	04
4 :	05	05	05	05	05	05	05	06	06	06
5 :	06	06	06	06	06	07	07	07	07	07
6 :	07	07	07							

DSCP 0,1,2,3,4,5,6,7
DSCP 8,9,10,11,12,13,14,15
DSCP 16,17,18,19,20,21,22,23
DSCP 24,25,26,27,28,29,30,31
DSCP 32,33,34,35,36,37,38,39
DSCP 40,41,42,43,44,45,46,47
DSCP 48,49,50,51,52,53,54,55
DSCP 56,57,58,59,60,61,62,63

1 CoS value = 8 DSCP values

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QoS

show mls qos maps dscp-cos

Explained:

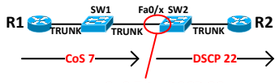
```
SW2#show mls qos maps dscp-cos
Dscp-cos map:
 d1 : d2 0 1 2 3 4 5 6 7 8 9
 ---------------------------------------
 0 :  00 00 00 00 00 00 00 00 01 01
 1 :  01 01 01 01 01 01 02 02 02 02
 2 :  02 02 02 02 03 03 03 03 03 03
 3 :  03 03 04 04 04 04 04 04 04 04
 4 :  05 05 05 05 05 05 05 05 06 06
 5 :  06 06 06 06 06 06 07 07 07 07
 6 :  07 07 07 07
```

8 DSCP values map to 1 CoS Value

DSCP 0-7 = Cos0
DSCP 8-15 = Cos 1
DSCP 16-23 = CoS 2
DSCP 24-31 = CoS 3
DSCP 32-39 = CoS 4
DSCP 40-47 = CoS 5
DSCP 48-55 = CoS 6
DSCP 56-63 = CoS 7

```
SW2#show mls qos maps dscp-cos
Dscp-cos map:
 d1 : d2 0 1 2 3 4 5 6 7 8 9
 ---------------------------------------
 0 :  DSCP 0 - 7          8,9
 1 :  DSCP 10-15          DSCP 16-19
 2 :  02 02 02 02 03 03 03 03 03 03
 3 :  03 03 04 04 04 04 04 04 04 04
 4 :  05 05 05 05 05 05 05 05 06 06
 5 :  06 06 06 06 06 06 07 07 07 07
 6 :  07 07 07 07
```

CoS to DSCP mapping:



Default:

```
SW1#show mls qos maps cos-dscp
 Cos-dscp map:
    cos:   0 1 2  3  4  5  6  7
    ---------------------------------------
    dscp:  0 8 16 24 32 40 48 56
```

```
conf terminal
mls qos
mls qos map cos-dscp 0 8 16 24 32 40 48 22
 int fa0/x
mls qos trust cos
```

Mapped incoming CoS 7 to DSCP 22:

```
SW1#show mls qos maps cos-dscp
 Cos-dscp map:
    cos:   0 1 2  3  4  5  6  7
    ---------------------------------------
    dscp:  0 8 16 24 32 40 48 22
```

Incoming CoS value

DSCP of Outgoing ptks

IP Precedece to DSCP mapping:

Default:

```
SW1# show mls qos map ip-prec-dscp
 IpPrecedence-dscp map:
  ipprec:  0 1 2 3 4 5 6 7
  ---------------------------------------
   dscp:   0 8 16 24 32 40 48 56
```

```
 conf t
 mls qos
 mls qos map ip-prec-dscp 0 8 16 24 32 7 48 56
 int fa0/x
 mls qos trust ip-precedence
```

```
SW1#show mls qos maps ip-prec-dscp
 IpPrecedence-dscp map:
  ipprec:  0 1 2 3 4 5 6 7
  ---------------------------------
   dscp:   0 8 16 24 32  7 48 56
```

Incoming IP Prec

DSCP of Outgoing ptks

Outbound policing and match source-mac address!

Two solutions:

```
access-list 701 permit 0000.1111.1111   0000.0000.0000

class-map match-all SRV1
 match access-group 701

policy-map OUT
 class SRV1
   police 1000 conform-action transmit  exceed-action drop

Int fa0/x
Service-policy output OUT
```

```
class-map match-all SRV2
 match source-address mac 0000.2222.2222

class-map match-all QOS-GRP-2
 match qos-group 2

policy-map IN
 class SRV2
  set qos-group 2

Int fa0/1  (inbound)
service-policy input IN
```

```
policy-map OUT
 class QOS-GRP-2
  police cir 2000000  conform-action
  transmit  exceed-action drop

Int fa0/2  (outbound)
service-policy input OUT
```

Time-based QoS:

Policing http traffic out fa0/0 on weekdays from 11:00 to 15:00

```
access-list 102 permit tcp any eq www any time-range QOS
access-list 102 permit tcp any any eq www time-range QOS

time-range QOS
 periodic weekdays 11:00 to 15:00

class-map match-all TIME
 match access-group 102

policy-map OUT
 class TIME
   police 10000 conform-action transmit  exceed-action drop

interface FastEthernet0/0
 service-policy output OUT
```

What is the difference between shape average And shape peak ?

Shape average config:

```
policy-map OUT
 class class-default
 shape average 16000 64000 0
```

Only Bc used per Tc

Shape peak config:

```
policy-map OUT
 class class-default
 shape average 16000 64000 64000
```

Will set Bc = Be Each Tc Bc+Be will be used!

How to configure Shape average:

Shape to 16000 bps 8000 byte Bc

Tc = Bc/Cir
4 sek = 64000 / 16000 or 4000 msec
64000 = 8000 byte (8000bytes *8 -> in bits)

```
policy-map OUT
 class class-default
 shape average 16000 64000 0
```

int fa0/x
service-policy output OUT

"Be" has to be set to 0, if not it will be set to the same value as Bc!

```
R1#show policy-map in
FastEthernet0/0
 Service-policy output: OUT
  Class-map: class-default (match-any)
    65 packets, 18223 bytes
    5 minute offered rate 0 bps, drop rate 0 bps
    Match: any
    Traffic Shaping
          Target/Average   Byte  Sustain  Excess   Interval  Increment
            Rate           Limit bits/int bits/int  (ms)      (bytes)
          16000/16000      8000  64000    0        4000      8000

     Adapt  Queue     Packets  Bytes     Packets  Bytes     Shaping
     Active Depth                       Delayed  Delayed   Active
     -      0        1        60        0        0         no
```

Shape average explained:

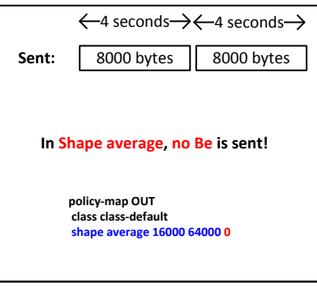
```
policy-map OUT
 class class-default
 shape average 16000 64000 0

int fa0/x
service-policy output OUT
```

Be, must be set to 0
Bc
CIR

Tc = Bc/CIR 4 sec = 64000 / 16000

Bc = 8000 byte or 64000 bit/s
CIR = 16000 bit/s



In Shape average, no Be is sent!

```
policy-map OUT
 class class-default
 shape average 16000 64000 0
```

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Embedded packet capture

Embedded Packet capture **EPC**	**monitor capture** MYCAP buffer circular packets 1000 monitor capture MYCAP buffer size 10 monitor capture MYCAP interface Gig0/0/1 in monitor capture MYCAP access-list MYACL monitor capture MYCAP start monitor capture MYCAP stop monitor capture MYCAP export bootflash:EPC1.pcap show monitor capture CAP parameter show monitor cap CAP buffer show monitor capture CAP buffer **dump** show monitor capture CAP buffer **brief** show monitor caputure CAP buffer **detail**				

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What do you do if you see the following: R1(config)#int ser0/1 R1(config-if)#ip address 130.4.0.1 255.255.255.0 **Bad mask /24 for address 130.4.0.1**	R1(config)#int ser0/1 R1(config-if)#ip address 130.4.0.1 255.255.255.0 **Bad mask /24 for address 130.4.0.1** R1(config-if)#do sh run | i subnet-zero **no ip subnet-zero** R1(config-if)#**ip subnet-zero <- Solution** R1(config)#int ser0/1 R1(config-if)#ip address 130.4.0.1 255.255.255.0				
How to detect a MFR MultiLink bundle member is not active:	**show ppp multilink interface Multilink1314** Multilink1314 Bundle name: R14 Remote Endpoint Discriminator: [1] R14 Local Endpoint Discriminator: [1] R13 Bundle up for 03:17:26, total bandwidth 4632, load 1/255 Receive buffer limit 36000 bytes, frag timeout 1000 ms 0/0 fragments/bytes in reassembly list 0 lost fragments, 387 reordered 0/0 discarded fragments/bytes, 0 lost received 0x1472 received sequence, 0x1487 sent sequence Member links: 3 active, 1 inactive (max not set, min not set) Se1/3, since 03:17:26 Se1/1, since 03:17:26 Se1/0, since 03:17:26 **Se1/2 (inactive)** **Ser1/2** ppp multilink group 1413				
	show spanning-tree blockedports Show ALL frame-relay map				
TCL test script	**show ip alias** ***copy output of all IPs in the lab in a txt file*** **tclsh** **foreach ip {** **150.1.1.1** **150.1.2.2** **} { ping $ip source loopback 0** **}**	**Some IOS do not support TCL scripts, use a macro instead:**	**conf t** **macro name PINGS** **do ping 150.1.1.1 source lo0** **do ping 150.1.2.2 source lo0** **@** **SW(config)#macro global apply PINGS**		
IRDP	advertise themselves as default gateways for hosts on VLAN58 using ICMP messages R5: interface FastEthernet 0/0 **ip irdp** **ip irdp address 155.1.58.5 1000** ip irdp **maxadvertinterval** 20 ip irdp **minadvertinterval** 10 *R5 prio higher* SW2: interface Vlan 58 ip irdp ip irdp address 155.1.58.8 **500** ip irdp maxadvertinterval 20 ip irdp minadvertinterval 10 *Not using HSRP/ VRRP/GLBP For first hop redundancy*				

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Frame-Relay

Inverse-ARP and LMI

Pinging the broadcast addr problem:

R4#
interface Serial0/0
encapsulation frame-relay
ip address 54.1.1.6 255.255.255.0

R5#
interface Serial6
encapsulation frame-relay

interface Serial6.51 point-to-point
ip address 54.**1.3.254** 255.255.255.0
frame-relay interface-dlci 51

interface Serial6.100 point-to-point
ip address 54.**1.2.254** 255.255.255.0
frame-relay interface-dlci 100

interface Serial6.101 point-to-point
ip address 54.**1.1.254** 255.255.255.0
frame-relay interface-dlci 101

R4# ping 255.255.255.255

Reply to request 0 from 54.1.2.254, 76 ms
Reply to request 0 from 54.1.1.254, 108 ms
Reply to request 0 from 54.1.3.254, 92 ms

Configuration of the different Frame-Relay encapsulation types:

interface serial4/2
encapsulation frame-relay [**cisco** / ietf]

Default is **Cisco**

What does one have to keep in mind while changing a Frame-Relay sub-interface type from

Ser0/1.22 point-to-point

To a

Ser0/1.22 point

Conf t
Int ser0/1.22 point-to-point

Int ser0/1.22 multipoing

RELOAD

Frame-Relay

Troubleshooting commands

`show frame-relay pvc [101]`

`show frame-relay map`

`show frame-relay lmi`

`debug frame-relay lmi`

Output of

Show frame-relay lmi

```
R1#show frame-relay lmi

LMI Statistics for interface Serial1/2 (Frame Relay DTE) LMI TYPE = CISCO
  Invalid Unnumbered info 0                Invalid Prot Disc 0
  Invalid dummy Call Ref 0                 Invalid Msg Type 0
  Invalid Status Message 0                 Invalid Lock Shift 0
  Invalid Information ID 0                 Invalid Report IE Len 0
  Invalid Report Request 0                 Invalid Keep IE Len 0
  Num Status Enq. Sent 144                 Num Status msgs Rcvd 145
  Num Update Status Rcvd 0                 Num Status Timeouts 0
```

Where does one specify sub-interface Frame-Relay DLCI information?

interface Serial3/1.304 **point-to-point**

frame-relay interface-dlci 304

interface Serial3/1.304 **multipoint**

frame-relay interface-dlci 304

Frame-Relay

Configuration
using LMI and Inverse arp

Customer:

```
interface Serial0/0
encapsulation frame-relay
ip address 54.1.1.6 255.255.255.0
```

Service Provider side:

```
interface Serial1/6
 no ip address
 encapsulation frame-relay
 clock rate 64000
 frame-relay intf-type dce

interface Serial1/6.101 point-to-point
 ip address 54.1.1.254 255.255.255.0
 frame-relay interface-dlci 101
```

Turning Frame-Relay LMI autosense off by:

`Int ser0/x`

`frame-relay lmitype` *lmi-type*

cisco
ansi
Q933a

Also configure a keepalive of 10 seconds when fixing the LMI type via:

keepalive 10

Why does one don't create a static ip map entries for frame-relay point-to-point interfaces

it is always assumed that the end point of the point-to-point connection automatically resides on the same subnet as the start point.

(There is only one destination.)

Inverse-Arp is not necessary too.

Show frame-relay map

`All is good, DLCI is active`

```
R1#sh frame-relay map
Serial0/0 (up): ip 155.1.0.5 dlci 105(0x69,0x1890), static,
              broadcast,
              CISCO, status defined, active
```

`Status deleted, re-do mapping and reload the router.`

```
R1#sh frame-relay map
Serial0/1 (down): ip 155.1.0.5 dlci 105(0x69,0x1890), static,
              broadcast,
              CISCO, status deleted
```

`show frame-relay route`

```
SW#show frame-relay route
Input Intf      Input Dlci      Output Intf     Output Dlci     Status
Serial1/0       102             Serial1/1       201             active
Serial1/1       201             Serial1/0       102             inactive
```

Turning a router into a Frame-Relay Switch

frame-relay switching

interface Serial4/1
encapsulation frame-relay
clockrate 64000
frame-relay intf-type dce

frame-relay route **304** interface Serial4/3 403

304 is the local Ser4/1 DLCI

frame-relay map ip 155.1.0.5 105 broadcast

And pings to 255.255.255.255

R1#ping 255.255.255.255

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 255.255.255.255,
timeout is 2 seconds:

Reply to request 0 from 155.1.0.5, 88 ms
Reply to request 1 from 155.1.0.5, 88 ms
Reply to request 2 from 155.1.0.5, 88 ms
Reply to request 3 from 155.1.0.5, 88 ms
Reply to request 4 from 155.1.0.5, 124 ms

This is how it should be, no other host. from another DLCI answers the ping to the broadcast.

Define Inverse ARP

resolve a next hop network protocol address to a local DLCI value

Show frame-relay pvc

```
Router#show frame-relay pvc
PVC Statistics for interface Serial3/0 (Frame Relay DTE)

                Active      Inactive      Deleted      Static
  Local              1             0            0           0
  Switched           0             0            0           0
  Unused             0             0            0           0
```

What kind of Frame-relay encapsulations are there?

Enable / disable

Frame-Relay inverse-arp

Disable:

Int ser0/x
no frame-relay inverse-arp ip [DLCI 100]

Enable:

Int ser0/x
frame-relay inverse-arp ip [DLCI 100]
End

clear frame-relay inarp interface Ser0/x

What types of DLCI assignments are there on Frame-Relay networks?

Global and local DLCI assignments

Local is usually used.

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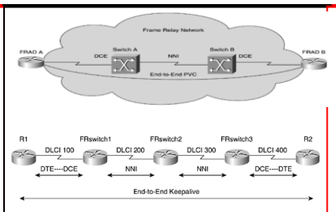
Frame-Relay

What does Frame-Relay NNI mode do generally?



End-to-End PVC keepalive to signal the DLCI status

Cisco proprietary protocol

How to monitor the status of a Frame-Relay End-to-End keepalive session?

show frame-relay end-to-end keepalive

```
R4#show frame-relay end-to-end keepalive

End-to-end Keepalive Statistics for Interface Serial1 (Frame Relay DTE)

DLCI = 300, DLCI USAGE = LOCAL, VC STATUS = ACTIVE (EEK UP)

SEND SIDE STATISTICS

Send Sequence Number: 220,      Receive Sequence Number: 221
Configured Event Window: 3,     Configured Error Threshold: 2
Total Observed Events: 229,     Total Observed Errors: 6
Monitored Events: 3,            Monitored Errors: 0
Successive Successes: 3,        End-to-end VC Status: UP

RECEIVE SIDE STATISTICS

Send Sequence Number: 222,      Receive Sequence Number: 225
Configured Event Window: 3,     Configured Error Threshold: 2
Total Observed Events: 227,     Total Observed Errors: 3
Monitored Events: 3,            Monitored Errors: 0
Successive Successes: 3,        End-to-end VC Status: UP
```

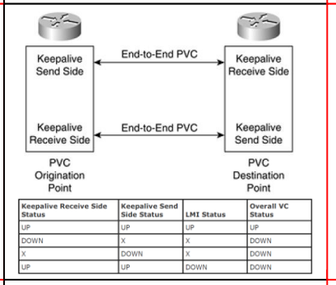
How many **virtual templates** can exist on a Router typically?

How many **virtual interfaces** can exist on a Router typically?

- 25 virtual template interfaces
- 300 virtual interfaces

Frame-Relay NNI send and receive side

Status's



Keepalive Receive Side Status	Keepalive Send Side Status	LMI Status	Overall VC Status
UP	UP	UP	UP
DOWN	X	X	DOWN
X	DOWN	X	DOWN
UP	UP	DOWN	DOWN

Enabling Frame-Relay End-to-End Keepalive:

(Customer Side)

All options described

interface Serial0/1.100 point-to-point
frame-relay interface-dlci 100
class FRAME_EEK

map-class frame-relay FRAME_EEK

frame-relay end-to-end keepalive **mode bidirectional**
frame-relay end-to-end keepalive **event-window send 10**
frame-relay end-to-end keepalive **success-events send 5**
frame-relay end-to-end keepalive **error-threshold {send/receive}** *count*
frame-relay end-to-end keepalive **timer {send | receive} interval**

Event-Window, number of latest events to use the check routine on, last 10.

Success-window, consecutive success events required to change from DOWN to UP status. (5 OKs)

Error-threshold, number of errors needed to change from UP to DOWN status

PPP over Frame Relay Applied to DLCI 101

Config:

interface serial 3/0
no ip address
encapsulation frame-relay
!
interface serial 3/0.1 point-to-point
frame-relay interface-dlci 101 ppp virtual-template1
!
interface Virtual-Template1
ip unnumbered loopback0
ppp authentication chap
!
interface loopback 0
ip address 172.16.1.1 255.255.255.252

What types of Frame Relay End-to-End Keepalive Modes are there?

Bidirectional Mode

Request Mode

Reply Mode

Passive-Reply Mode

debug frame-relay end-to-end keepalive event

output

```
1w5d: EEK SUCCESS (request, Serial2/1.100 DLCI 100)
1w5d: EEK SUCCESS (reply, Serial2/1.100 DLCI 100)
1w5d: EEK SUCCESS (request, Serial2/1.100 DLCI 100)
1w5d: EEK receiver timeout (Serial2/1.100 DLCI 100)
1w5d: EEK stopped (Serial2/1.100 DLCI 100)
```

PPP over Frame Relay:

Output of

show frame-relay pvc Command of DLCI 101

```
R1#show frame-relay pvc 101

PVC Statistics for interface Serial1 (Frame Relay DTE)

DLCI = 101, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial1.1

input pkts 50           output pkts 46          in bytes 2067
out bytes 1987          dropped pkts 0          in pkts dropped 0
out pkts dropped 0              out bytes dropped 0
in FECN pkts 0          in BECN pkts 0          out FECN pkts 0
out BECN pkts 0         in DE pkts 0            out DE pkts 0
out bcast pkts 2        out bcast bytes 502
pvc create time 00:03:37, last time pvc status changed 00:03:37Bound to Virtual-Access2
 (up, cloned from Virtual-Template1)
```

Enabling Frame-Relay End-to-End Keepalive:

(ISP Side)

interface Serial1/1
encapsulation frame-relay
frame-relay lmi-type ansi
frame-relay intf-type nni
frame-relay route 200 interface Serial4/1 100

How to **check ATM side** between a FRF8.1 to Frame relay connection

show atm vc inter atm4/0/0 1 32

VPI = 1
VCI = 32

```
Interface: ATM4/0/0, Type: t1suni
VPI = 1 VCI = 32
Status: UP
Time-since-last-status-change: 04:40:13
Connection-type: PVC
Cast-type: point-to-point
Packet-discard-option: disabled
Usage-Parameter-Control (UPC): pass
Wrr weight: 2
Number of OAM-configured connections: 0
.....
.....
```

PPP over Frame Relay

Client negotiating for IP

Server offering IP config

PPPoFR "Client"

interface **Virtual-Template1**
ip address negotiated

interface Serial1.1 point-to-point
frame-relay interface-dlci 101 **ppp Virtual-Template1**

PPPoFR "DHCP Server"

interface Virtual-Template22
ip unnumbered Loopback0
peer default ip address pool LOCAL-DHCP-POOL-NAME

interface Serial1.1 point-to-point
frame-relay interface-dlci 101 ppp Virtual-Template22

Frame-Relay End-to-End types and their detailed description:

Frame-Relay End-to-End keepalive types:

Bidirectional:
Send side sends, then goes into receive mode, then back to send mode. → Ping-Pong between the two Nodes.

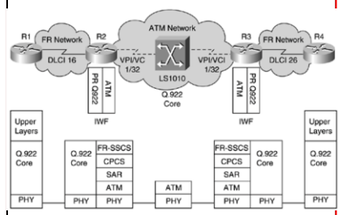
Request Mode:
Only send enabled

Reply Mode:
Only replies to received messages

Passive Reply-Mode
Only responds, does not track errors or adjusts timers.

FRF.5 Frame Relay to ATM Network Interworking

Picture



debug ppp negotiation

How to know if PPP LCP and NCP have been successful?

LCP successful:

Vi1 LCP: State is Open

Vi1 PPP: Phase is UP [0 sess, 0 load]

Now each NCP can start negotiate, like IPCP:

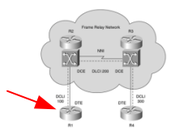
Vi1 IPCP: State is Open

Enabling Frame-Relay End-to-End Keepalive:

(Customer Side)

map-class frame-relay **FRM-RLY**
frame-relay end-to-end keepalive mode [**bi-directional]**

interface Serial0/1.100 point-to-point
frame-relay class FRM-RLY



FRF.8.1 Translation Mode

ATM to Frame-relay configuration

FRF.8.1 Translation Mode **Frame-Relay to ATM Cloud**

Frame-Relay **ATM enabled**

Frame-Relay-RTR#
interface Serial0/0
no ip address
encapsulation frame-relay IETF

interface Serial0/0.16 point-to-point
ip address 172.16.1.1 /24
frame-relay interface-dlci 16

ATM-RTR#
interface ATM0
no ip address
no atm ilmi-keepalive

interface ATM0.1 multipoint
ip address 172.16.1.2 /24
pvc 1/32
protocol ip 172.16.1.1 broadcast
encapsulation aal5snap

debug frame-relay ppp

debug frame-relay ppp

once working and once faulty

debug frame-relay ppp

PPPoFR working

```
FR-PPP: process on Virtual-Access1, #out-pkts=497
FR-PPP: process on Virtual-Access1, #out-pkts=498
FR-PPP: process on Virtual-Access1, #out-pkts=499
FR-PPP: process on Virtual-Access1, #out-pkts=500
```

PPPoFR faulty

```
FR-PPP: encaps failed for FR VC 101 on Serial1 down
FR-PPP: input- Serial1 vc or va down, pak dropped
```

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Frame-Relay

debug ppp authentication

Successful session

debug ppp authentication

Vi1 CHAP: O CHALLENGE id 24 len 28 from "R2"
Vi1 CHAP: I CHALLENGE id 24 len 28 from "R3"
Vi1 CHAP: O RESPONSE id 24 len 28 from "R2"
Vi1 CHAP: I RESPONSE id 24 len 28 from "R3"
Vi1 CHAP: O SUCCESS id 24 len 4
Vi1 CHAP: I SUCCESS id 24 len 4

Show frame-relay multilink detailed

R1#show frame-relay multilink detailed

Bundle: MFR0, State = up, class = A, fragmentation disabled
BID = MFR0
No. of bundle links = 2, Peer's bundle-id = MFR0
Bundle links:

Serial0, HW state = up, link state = Up, LID = Serial0
Cause code = none, Ack timer = 4, Hello timer = 10,
Max retry count = 2, Current count = 0,
Peer LID = Serial4/3, RTT = 4 ms
Statistics:
Add_link sent = 2, Add_link rcv'd = 1,
Add_link ack sent = 1, Add_link ack rcv'd = 2,
Add_link rej sent = 0, Add_link rej rcv'd = 0,
Remove_link sent = 0, Remove_link rcv'd = 0,
Remove_link_ack sent = 0, Remove_link_ack rcv'd = 0,
Hello sent = 1105, Hello rcv'd = 1106,
Hello_ack sent = 1106, Hello_ack rcv'd = 1105,
outgoing pak dropped = 0, incoming pak dropped = 0

Serial3, HW state = up, link state = Up, LID = Serial3
Cause code = none, Ack timer = 4, Hello timer = 10,
Max retry count = 2, Current count = 0,
Peer LID = Serial3/3, RTT = 4 ms
Statistics:
.....

What is important when using frame-relay compression?

It needs to be configured End-to-End!

debug ppp authentication

Failed session

Debug ppp authentication (failed session)

%LINK-3-UPDOWN: Interface Virtual-Access1, changed state to up
Vi1 PPP: Treating connection as a dedicated line
Vi1 CHAP: O CHALLENGE id 25 len 28 from "R2"
Vi1 CHAP: I CHALLENGE id 25 len 28 from "R3"
Vi1 CHAP: O RESPONSE id 25 len 28 from "R2"
Vi1 CHAP: I RESPONSE id 25 len 28 from "R3"
Vi1 CHAP: O **FAILURE** id 25 len 25 msg is "MD/DES **compare failed**"

MFR BID and LID configuration of MFR / FRF.16 configurations

BID Bundle Identifier

LID Link Identifier

R1(config)#interface mfr0
R1(config-if)#frame-relay multilink **bid M-LINK-BID-ID**
(Shut / no shut)

R1(config)#interface Serial0
R1(config-if)#frame-relay multilink **lid REMOTE_LINK_1**

R1(config-if)#interface Serial3
R1(config-if)#frame-relay multilink **lid REMOTE_LINK_2**

Configuring Frame-Relay
FRF.9 **payload compression:**

Physical or multipoint interface:

frame-relay map *protocol protocol-address dlci* payload-compress FRF9 stac [*hardware-options*]

Interface Serial0/1 (or multipoint)

frame-relay map ip x.x.x.x DLCI **payload-compression frf9 stac**

Logical Sub-Interface

frame-relay payloadcompress FRF9 stac [*hardware-options*]

interface Serial3/0.200 point-to-point
frame-relay payload-compression frf9 stac software

Enabling Frame Relay SVC on the Physical interface

Frame-Relay SVC on physical interface:

interface serial4/2
encapsulation frame-relay
map-group svc_group
frame-relay svc

MFR / FRF.16

Sub-interface config details

Interface Serial 0/1

frame-relay multilink hello 10 [in seconds]
frame-relay multilink retry 4 [in seconds]
frame-relay multilink ack 2

default values are 10 seconds, 4 seconds, and 2 tries

TCP/IP Header Compression over Frame Relay

interface Serial2/3
ip address x.x.x.1 255.255.255.0
encapsulation frame-relay
frame-relay ip tcp header-compression
frame-relay map ip z.z.z.2 100 broadcast
frame-relay map ip x.x.x.3 101 broadcast **nocompress**

interface Serial2/3.200 multipoint
ip address x.x.x.x.x 255.255.255.0
frame-relay map ip x.x.x.z 300 CISCO **tcp header-compression passive**

explicitly configured for **DLCI 100 active compression** mode, 101 inherited compression disabled by **nocompress**, **passive** compression **on DLCI 200**

Enabling Frame Relay SVC on a Point-to-Point Subinterface

interface serial1/0
encapsulation frame-relay
frame-relay svc

interface serial1/0.99 point-to-point
map-group svc_group

MFR / FRF.16 debug commands:

debug frame-relay multilink

debug frame-relay multilink control

Details about **TCP/IP Header Compression**

Frame-Relay **Cisco** encapsulation needs to be used.

Serial0/1
encapsulation frame-relay **cisco**

Active and Passive modes, active is default.

show idb

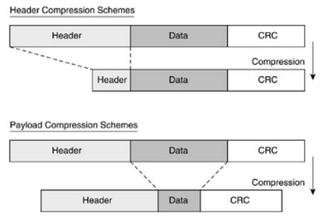
interface descriptor block (IDB), which consists of hardware IDB and software IDB

maximum number of IDBs that a platform can support

hardware IDB controls the physical interface, whereas the software IDB controls the Layer 2 encapsulation.

Frame Relay Compression

header compression versus payload compression



Can be configured per physical or per logical sub-interface

RTP header compression

CRTP

interface Serial2/3
ip address 172.16.1.1 255.255.255.0
encapsulation frame-relay
frame-relay map ip 172.16.1.2 100 broadcast
frame-relay ip rtp header-compression
!
interface Serial2/3.200 multipoint
ip address 192.168.1.1 255.255.255.0
frame-relay map ip 192.168.1.2 300 **CISCO rtp header-compression passive**

Default Mode is active

FRF.16 Multilink configuration

R1#
interface MFR0

interface MFR0.1 point-to-point
ip address 172.16.1.1 255.255.255.0
frame-relay interface-dlci 103

interface Serial0
no ip address
encapsulation frame-relay MFR0

interface Serial3
no ip address
encapsulation frame-relay MFR0

R2#
interface MFR0
frame-relay intf-type dce
!
interface Serial3/0
encapsulation frame-relay
frame-relay intf-type dce

interface Serial3/3
encapsulation frame-relay MFR0

interface Serial4/3
encapsulation frame-relay MFR0
!
connect MFR MFR0 103 Serial3/0 301

Frame Relay **Cisco Proprietary Payload Compression** configuration

Frame-Relay compression:

Using DLCI 100

interface Serial3/0 (or multipoint)
encapsulation frame-relay
frame-relay map ip X.X.X.X 100 **payload-compression packet-by-packet**

interface Serial3/0.**200 point-to-point**
frame-relay interface-dlci 200
frame-relay payload-compress packet-by-packet

Verifying and Monitoring Frame Relay Compressions

show compress

R1#**show compress**
Serial3/2
Software compression enabled
uncompressed bytes xmt/rcv 1089240/1200
1 min avg ratio xmt/rcv 5.564/0.049
5 min avg ratio xmt/rcv 5.563/0.051
10 min avg ratio xmt/rcv 5.563/0.051
no bufs xmt 0 no bufs rcv 0
resyncs 0
Additional Stacker Stats:
Transmit bytes: Uncompressed = 0 **Compressed = 189045**
Received bytes: Compressed = 920 Uncompressed = 0

show interface
(reduced traffic rate 30sec)

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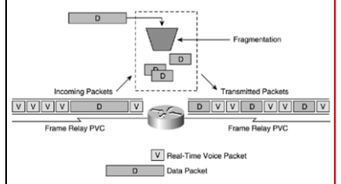
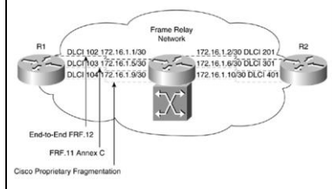
Frame-Relay

What types of header compressions are there for Frame-Relay?	**Cisco Proprietary Payload Compression (per-packet)**
	FRF.9 Payload Compression
	TCP/IP Header Compression
	CRTP, RTP compression
		Frame-Relay fragmentation and interleaving
		Explained as a picture
				What is an easy method for removing broadcast traffic for unused DLCI's which are not avoided by disabling Inverse-arp for those DLCI's?	Configure them on an unused sub-interface, for example Ser0/0.999
					`interface Serial0/0`
					`encapsulation frame-relay`
					`ip address 155.1.200.3 255.255.255.0`
					`!`
					`interface Serial0/`**`0.999`** `multipoint`
					`NO IP ADDRESS`
					`frame-relay interface-dlci 401`
					`frame-relay interface-dlci 402`
					DLCI's 401, 402 are not used, and are placed into a unused sub-int ser0/0.999,
					Now one does not receive any Broadcast traffic for those DLCI's once pinging 255.255.255.255 while not disabling Inverse-Arp for those DLCI's.

Show frame relay-map, checking for header-compression:	`R1#`**`show frame-relay map`** Serial3/2.100 (up): point-to-point dlci, dlci 100(0x64,0x1840), broadcast status defined, active, **RTP Header Compression (inherited), connections: 256**	How is Frame-Relay FRF.12 fragmentation configured? End-to-End FRF.12 Fragmentation is configured on a per-PVC basis using a Frame Relay map class Map-class X **Frame-relay fragment** *fragment_size*		How to disable LMI on Frame-Relay (for Back-to-Back configs)	`interface Serial0/1` **`no keepalive`**

`show frame-relay ip rtp header-compression interface Ser0/0`
Output:
	`R1#`**`show frame-relay ip rtp header-compression interface Serial3/2`**
	DLCI 100 Link/Destination info: point-to-point dlci
	Interface Serial3/2: (passive, compression on)
	Rcvd: 703 total, 699 compressed, 2 errors
	2 dropped, 0 buffer copies, 0 buffer failures
	Sent: 716 total, 713 compressed,
	27073 bytes saved, 115527 bytes sent
	1.23 efficiency improvement factor
	Connect: 101 rx slots, 101 tx slots,
		show frame-relay fragment
		Output:
			`R2#`**`show frame-relay fragment`**
			interface dlci frag-type frag-size in-frag out-frag dropped-frag
			Serial3/3 200 end-to-end 100 0 0 0
				Frame-Relay Back-to-Back Configuration.	`R1#`
					`interface Serial0/1`
					`ip address 155.1.45.`**`4`** `255.255.255.0`
					`encapsulation frame-relay`
					`no keepalive`
					`frame-relay map ip` `155.1.45.`**`5`** `514 broadcast`
					Disabling LMI via "no keepalive"
					`R2#`
					`interface Serial0/1`
					`ip address 155.1.45.`**`5`** `255.255.255.0`
					`encapsulation frame-relay`
					`no keepalive`
					`clock rate 64000`
					`frame-relay map ip` `155.1.45.`**`4`** `514 broadcast`

Frame Relay IP RTP Priority configuration	interface Serial3/2
	no ip address
	encapsulation frame-relay
	frame-relay traffic-shaping
	!
	interface Serial3/2.100 point-to-point
	ip address 172.16.1.1 255.255.255.252
	frame-relay interface-dlci 100
	class SHAPING
	frame-relay ip rtp header-compression
	!
	map-class frame-relay SHAPING
	frame-relay cir 38400
	frame-relay bc 4800
	frame-relay be 0
	no frame-relay adaptive-shaping
	frame-relay fragment 250
	frame-relay ip rtp priority 16384 16383 1024
		show frame-relay fragment interface ser0/x DLCI-NR
		Output:
			`R2#`**`show frame-relay fragment interface Serial3/3 200`**
			`fragment size 100 fragment type end-to-end`
			`in fragmented pkts 20 out fragmented pkts 20`
			`in fragmented bytes 1140 out fragmented bytes 1140`
			`in un-fragmented pkts 0 out un-fragmented pkts 0`
			`in un-fragmented bytes 0 out un-fragmented bytes 0`
			`in assembled pkts 10 out pre-fragmented pkts 10`
			`in assembled bytes 1040 out pre-fragmented bytes 1040`
			`in dropped reassembling pkts 0 out dropped fragmenting pkts 0`
			`in timeouts 0`
			`in out-of-sequence fragments 0`
			`in fragments with unexpected B bit set 0`
			`in fragments with skipped sequence number 0`
			`out interleaved packets 0`
				Back to back indication on
				Show frame-relay PVC output:
					DLCI = 514, DLCI USAGE = LOCAL, **PVC STATUS = STATIC**, INTERFACE = Serial0/1/0
					input pkts 228 output pkts 233 in bytes 23712
					out bytes 24232 dropped pkts 0 in pkts dropped 0
					out pkts dropped 0 out bytes dropped 0
					in FECN pkts 0 in BECN pkts 0 out FECN pkts 0
					out BECN pkts 0 in DE pkts 0 out DE pkts 0
					out bcast pkts 0 out bcast bytes 0
					5 minute input rate 0 bits/sec, 0 packets/sec
					5 minute output rate 0 bits/sec, 0 packets/sec
					pvc create time 00:14:29, last time pvc status changed 00:12:48
					PVC STATUS = **STATIC** = **Back-to-Back**
					PVC STATUS = ACTIVE = learned via LMI or via frame-relay intf-DLCI command.

What types of Frame Relay Fragmentation are available?	**Cisco proprietary** **FRF.11 Annex C** **FRF.12 Frame Relay Fragmentation**	Frame Relay fragmentation types per DLCI, picture		**Frame Relay Broadcast Queue**	`interface Serial0/0` **`frame-relay broadcast-queue 100 256000 36`** <100> Queue size for broadcasts 100 packets <256000> Byte rate per sec. <36> Max. packets/S broadcasts
serialization delay formula:	serialization delay = frame size (in bits) / link bandwidth (in bits/sec) (a 1500-byte frame takes approximately 214 ms to leave the router on a 56-kbps line.)	LMI and Inverse-arp Describe their tasks	LMI dynamically discovers the DLCI / PVCs per interface. Inverse-Arp discovers the mapped IP associated to the learned DLCI number.	**`show frame-relay ip [tcp/rtp] header-compression:`**	**`R5#`**`show frame-relay ip tcp header-compression` DLCI 501 Link/Destination info: ip 155.1.100.1 Interface Serial0/0.100 DLCI 501 (**compression on,** VJ) **Rcvd:** 67 total, **65 compressed**, 0 errors, 0 status msgs 0 dropped, 0 buffer copies, 0 buffer failures **Sent:** 46 total, **43 compressed**, 0 status msgs, 0 not predicted 1473 bytes saved, 435 bytes sent 4.38 efficiency improvement factor Connect: 256 rx slots, 256 tx slots, 2 misses, 0 collisions, 0 negative cache hits, 255 free contexts 95% hit ratio, five minute miss rate 0 misses/sec, 0 max

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Frame-Relay

PPP over Frame Relay (PPPoFR)

Order of implementation:

First create the Virtual-Template:

```
interface Virtual-Template99
 ip address 155.1.0.5 255.255.255.0
```

Second, bind the Virtual-Template to the DLCI

```
interface Serial0/0/0
 no ip address
 encapsulation frame-relay
 frame-relay interface-dlci 501 ppp Virtual-Template99
```

Log message appears:
Virtual-Access1, changed state UP

Frame-Relay Switching

Show connection out:

```
R3#show connection all

ID    Name      Segment 1      Segment 2        State
==========================================================
1     R1_R2     Se1/2 132      Se1/3 231        UP
```

Show interface virtual-access

Output:

```
Rack1R1#show interface virtual-access2
Virtual-Access2 is up, line protocol is up
Hardware is Virtual Access interface
Internet address is 155.1.0.1/24
MTU 1500 bytes, BW 100000 Kbit, DLY 100000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, LCP Open
Open: IPCP
PPPoFR vaccess, cloned from Virtual-Template1
Vaccess status 0x44
Bound to Serial0/0 DLCI 105, Cloned from Virtual-Template1,
loopback not set
Keepalive set (10 sec)
DTR is pulsed for 5 seconds on reset
Last input 00:02:00, output never, output hang never
Last clearing of "show interface" counters 00:02:17
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output
drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
```

Enable CDP over Frame-Relay

Interface Serial 0/1
Encapsulation frame-relay
cdp enable

Make sure Broadcast is enabled

PPP over Frame-Relay

Virtual-access interfaces can be seen via connected routes:

```
R5#
interface Virtual-Access1
 ip address 155.1.0.5 255.255.255.0
```

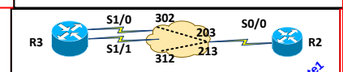
```
R5#show ip route connected
     155.1.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       155.1.0.0/24 is directly connected, Virtual-Access1
C       155.1.0.1/32 is directly connected, Virtual-Access1
```

R1# (the **neighbour**)

```
interface Virtual-Access1
 ip address 155.1.0.1 255.255.255.0
end
```

PPP Multi Link via Frame-Relay

Using CHAP



username Rack1R3 password CISCO

interface **Multilink1**
ip address 174.1.23.2 255.255.255.0
ppp multilink
ppp multilink group 1

interface Serial0/0
encapsulation frame-relay
no frame-relay inverse-arp

interface Serial**0/0.203** point-to-point
frame-relay interface-dlci 203 **ppp Virtual-Template1**

interface Serial**0/0.213** point-to-point
frame-relay interface-dlci 213 **ppp Virtual-Template1**

interface **Virtual-Template1**
ppp multilink
ppp multilink group 1
ppp authentication chap

Bridging over Frame Relay

Config:

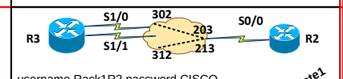
```
bridge 1 protocol ieee

interface FastEthernet0/0
bridge-group 1
!
interface Serial0/0
encapsulation frame-relay
frame-relay map bridge 205 broadcast
bridge-group 1
!
```

Check if you can see the spanning tree root over the Frame-Relay Bridge!

PPP Multi Link via Frame-Relay

Using CHAP



username Rack1R2 password CISCO

interface **Multilink1**
ip address 174.1.23.3 255.255.255.0
ppp multilink
ppp multilink group 1

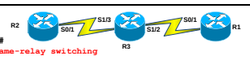
interface Serial**1/0**
encapsulation frame-relay
no frame-relay inverse-arp
frame-relay interface-dlci 302 **ppp Virtual-Template1**

interface Serial**1/1**
encapsulation frame-relay
no frame-relay inverse-arp
frame-relay interface-dlci 312 **ppp Virtual-Template1**

interface **Virtual-Template1**
ppp multilink
ppp multilink group 1
ppp authentication chap

Frame-Relay Switching

config




```
R3#
frame-relay switching

interface Serial 1/2
clock rate 64000
encapsulation frame-relay
frame-relay intf-type dce
no shutdown

interface Serial 1/3
clock rate 64000
encapsulation frame-relay
frame-relay intf-type dce
no shutdown

connect R1_R2 Serial 1/2 132 Serial 1/3 231
```

Frame-Relay Switching

```
R1:
interface Serial 0/1
encapsulation frame-relay
ip address 155.1.12.1
255.255.255.0
```

```
R2#
interface Serial 0/1
encapsulation frame-relay
no frame-relay inverse-arp
ip address 155.1.12.2
255.255.255.0
frame-relay map ip 155.1.12.1 231
```

Frame-Relay Switching

Show frame-relay pvc

Checking SWITCHING USAGE

```
R3#show frame-relay pvc | inc SWI

DLCI = 132, DLCI USAGE = SWITCHED, PVC STATUS = ACTIVE, INTERFACE = Serial1/2

DLCI = 231, DLCI USAGE = SWITCHED, PVC STATUS = ACTIVE, INTERFACE = Serial1/3
```

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CCIE RS Version 5 study approach:

1. Identify the scope / estimate your know how

Use a training partner to identify all necessary topics for CCIE RS version 5 such as INE, IPExpert etc.. In my example I have used INE's detailed expanded study blue print.

Copy it into an Excel spreadsheet and start going trough it, this will take a while to go through but its worth it. Be very honest with yourself, if you don't know the command by hart or have an idea, you do NOT know it and all the sub-commands associated with it...

http://blog.ine.com/2009/05/12/ccie-rs-4x-expanded-study-blueprint/

	15.3MT topic	unknown	read about it	configured 1-2	intermediate	confident
1. LAN Switching						
1.1. VLANs & Trunking						
1.1.1. Standard VLANs						
1.1.2. Extended VLANs						
1.1.3. VLAN Database						
1.1.4. Access Ports						
1.1.5. 802.1q Trunk Ports						
1.1.6. 802.1q Native VLAN						
1.1.7. Dynamic Trunking Protocol (DTP)						
1.1.8. Trunking Allowed List						
VTP 1						
VTP 2						
VTP 3						
1.2.2. VTP Authentication						

2. Estimate your efforts

	Hours, still to do:	Calculated hours in total
Reading CCIE books	76	581
INE Vol 1 Tasks	0	321
INE Vol 2 Tasks	60	60
INE Vol 3 Tasks	40	40
INE Vol 4 Tasks	40	40
INE 3x MOCK LABs	24	24
Nabriks Bootcamp	60	60
	Hours, still to do:	**Calculated hours in total**
Total hours	**240**	**1125**

calculated at 1.7 Labs per hour

Work day	8	hours
Day	24	hours
Working week	40	hours
Week	168	hours
Work-month	160	hours
Month	672	hours

Study time:
3 days during the week 12 hours
1 day weekend 8 hours
---
20 hours / week

4x 20 = **80 hours per month**
12x 80 = **960 hours per year**

3. Start learning the involved technology (CCIE book list)

Book Title	Pages	already read
CCIE Routing and Switching - Official Certification Guide	1080	1080
Cisco LAN Switching	960	960
Frame Relay Solutions Guide	412	412
CCIE Routing TCP/IP Vol I	936	936
CCIE Routing TCP/IP Vol II	976	976
Cisco OSPF Command and Configuration Handbook	528	-
Cisco BGP-4 Command and Configuration Handbook	400	-
Internet Routing Architectures	528	528
Troubleshooting IP Routing Protocols	912	912
MPLS Fundamentals	672	672
MPLS and VPN Architectures Vol II	504	504
Cisco QoS	768	768
End-to-End QoS Network Design: Quality of Service in LANs, WANs, and VPNs	760	150
CCIE Practical Studies Vol I	1366	-
CCIE Practical Studies Vol II	1032	-
Developing IP Multicast Networks, Vol I	592	592
Deploying IPv6 Networks	672	672
Network Security Technologies and Solutions	912	912
CCIE Version 5 Certification guide Vol 1 and Vol 2	not available	
Pages in total	**11612**	10084

Calculated based on an average of 20 pages per hour.
(depends on your speed)

Read through the books, use a highlighter/marker and take personal notes of the books.
Initially the book may take you around 40 hours to go through, but later you can refresh the entire book in 4 hours.
I had to have physical books as I get tired too fast reading on a screen, plus sitting in the sun staring in a screen is not much fun..

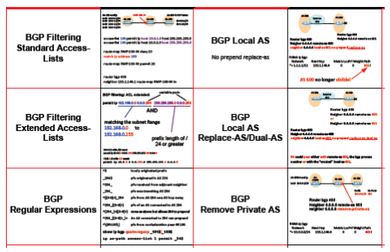
Required effort rated at reading **20 pages per hour**: **580 hours**
All books, **6 hours** of reading each **day**: **97 days**
Reading all, 6 hours / day in month: **3.2 month**

If you are really, really sure you know all technologies, skip the books and start going through the entire IOS configuration guides.

4. Repeat going through your notes

Create you own set of notes / study repetition method.
Or use my set of APP FREE ccie rs version 5 learning study flash cards to repeat what you learned so far and keep the information fresh.

http://colin.cant.ch/projects/Visio-CCIE_Lernkarten_v11.pdf



5. start learning using the Cisco docCD

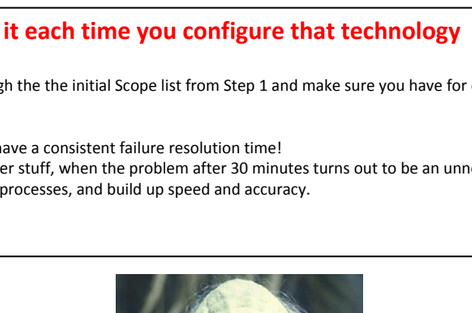
http://www.cisco.com/c/en/us/support/ios-nx-os-software/ios-software-release-15-3-3-m/model.html

I recommend going through the entire DocCD of version 15.3MT (configuration guides, not command reference) or what ever your future version for the CCIE is.
Browse through it and take notes where things are, can be commands, can be technologies, basically hints for yourself.
Then instead of using Google to find the right page on the docCD search within your own created docCD overview and then directly jump into the section you are interested in. This will speed up your lookup time for commands/technologies initially, plus it makes you aware where to find things over time without Google.
The more lab hours you spend the more you will remember this tip written here..
Plus during the lab if you know the feature name/technology but forgot the details, you find the right page within 30 seconds. Giving you another 5 minutes to answer that question.

- Additional and Legacy Protocols
  - ISO CLNS Configuration Guide
    - ISO
    - router isis
  - Terminal Services Configuration Guide
    - Line
    - Modem
- Broadband Access Aggregation and DSL Configuration Guide
  - PPP over Ethernet Client
    - pppoe-client dial-pool-number
    - interface dialer
    - show vpdn session
  - Providing Session Limit Support
    - bba-group pppoe global
    - sessions per-mac limit
    - sessions per-vlan limit
    - snmp-server enable traps pppoe

This document just serves the purpose to CTRL-F:

http://colin.cant.ch/projects/IOS-15.3T-docCD-overview-v3.xls



6. Lab, lab, lab, and more lab....

Use a training partners workbook, there are plenty out there find one, stick to it, and don't jump from one vendor to another during your studies.

7. Bootcamps

I have visited the 5 day bootcamp performed by Narbik, the most increadible Cisco instructor I have ever met.

I had re-visited his 10 day bootcamp for a minor upgrade fee, his re-takes of the same bootcamp / version are for free and he encourages people to do so.

I highly recommend re-taking his class, the first time you go, you will have a serious buffer overflow in terms of content and quality of information received.

The second time you attend his class, you will be able to sip up details you could not process / digest the first time.

I have attended many Cisco courses in my past, but this is unlike anything you have ever seen before!
His memory is sensational and he knows every command / formula / ethertype etc... by hart and never needs to look up a thing in a PDF or similar.
In addition, I find his way of teaching and personality very entertaining in terms of how he delivers his class etc. Be prepared for long hours, frustrating GOOD labs which make you remember what you did wrong or what alternatives you have in each situation. It will open your eyes in terms of how protocols really work...

Narbiks training: http://micronicstraining.com/

8. create a process for each technology etc, follow it each time you configure that technology

Once you have gained the "entire" picture in terms of technologies, go through the the initial Scope list from Step 1 and make sure you have for each item / technology a process in place which you follow each time you configure it.
Or best, create you own set of cards!
Follow your process EVERY TIME from the beginning to the end and you will have a consistent failure resolution time!
You do NOT want to place a hip-shot assumption and waist time on upper layer stuff, when the problem after 30 minutes turns out to be an unnoticed speed mis-match or a "mac-address static drop" or similar. Keep following your created processes, and build up speed and accuracy.
You will know when it is time to go!

On your lab date X

Good luck, I wish!

and may the force be with you!