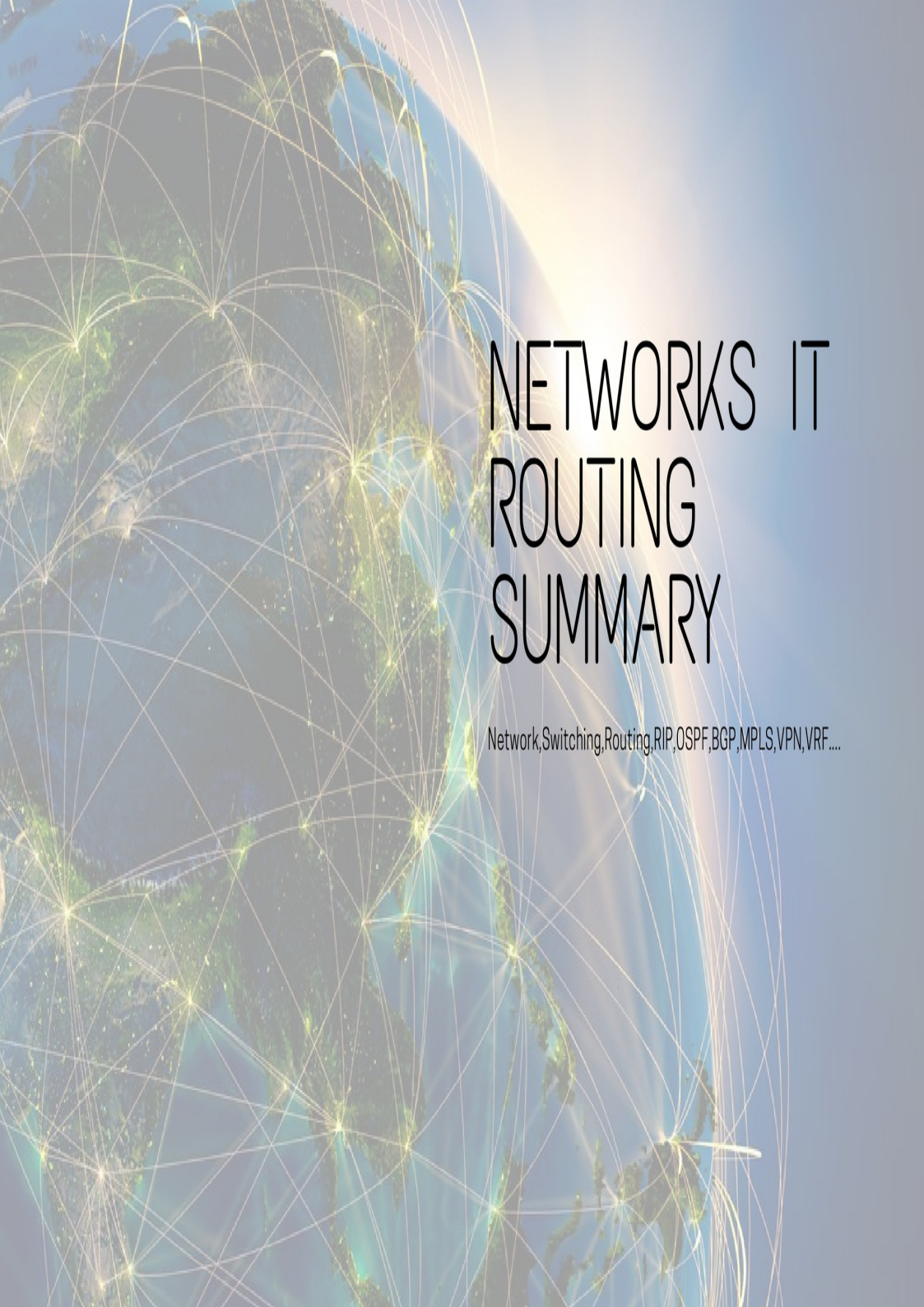


NETWORKS IT ROUTING SUMMARY

Network,Switching,Routing,RIP,OSPF,BGP,MPLS,VPN,VRF....

Session 1 Part 1
Network Models

* OSI Model:	→ Data Preperation ←	* TCP/IP Model:
L7: Application L6: Presentation L5: Session	Data	- Application
L4: Transport	Segment	- Transport
L3: Network	Packet	- Internet
L2: Data Link L1: Physical	Frame	- Network Access

⇒ **Application Layer:** each application has port number (0-1023).
HTTP (80), HTTPs (44), SMTP(25), FTP (20, 21), BGP(179), POP3 (110), Telnet, SSH, DHCP (67, 68), RIP(520), DNS(33).

⇒ **Transport Layer:** each protocal has protocal number.
MSS(Maximum Sequance Size): 1460 byte.
= Maximum Data Part Size

* Segmentation.
* Addressing " Session number (1024 : 65535) ".
* CRC

⇒ Internet Layer : end to end control.

IPv4 (Protocal no. 4) IPv6 (Protocal no. 41)

ICMP (Protocal no. 1), OSPF (Protocal no. 89), EIGRP (Protocal no. 88)

MTU (Maximum Transfer Unit) = 1500 byte.
= Maximum Packet Size

Address Contains: Source IP, destination IP and protocol number

Address Size = 20 byte (Can be extend to 60 byte to increase Frame size to 64 byte ...)

⇒ Network Access Layer: Cable and Card. In LAN "ethernet, WiFi". In WAN "X.25, FR, ATM, PPP, HDLC, PPPOA, PPPOE, WiMAX".

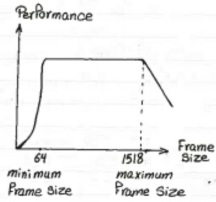
Address Contains: Source MAC, destination MAC.

Address Size: 14 byte — Tail size: 4 byte.

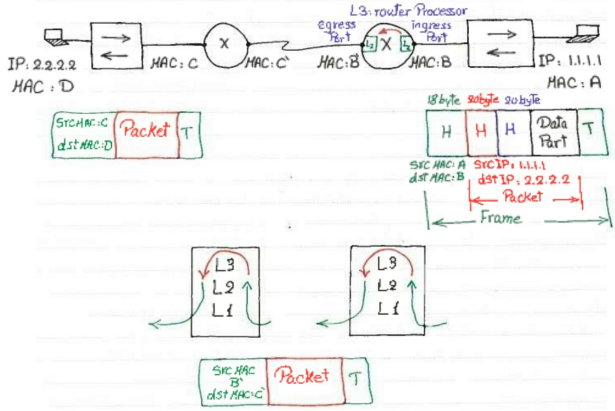
Maximum Frame Size = 1518 byte.

Layer 7: 3H+T Data between users.
Layer 3: 2H+T Packet between networks (end to end).
Layer 2: H+T Frame Inside networks (hop to hop).

Ideal time 64 bit between each Frame...



Session 1 Part 2
Router Process



Session 1 Part 3

Routed Protocol: It is protocol that carries user data traffic from end to end. ex: IPv4, IPv6, TCP, UDP

Routing Protocol: It is exchange of information between routers, so as each router tell others about networks it can reach to build routing table. ex: RIPv2, EIGRP, OSPF, BGP

Session 1 Part 4
Routing Procedure

1. Check that the IOS Supports the required routing protocols.
   (Config) # router Protocol
   OR (Config-router) #
   # Show version
   # Show flash ____.bin

2. Activate Router Processor.
   IPv4 : active by default ... (Config) # ip routing
   IPv6 : disable by default ... (Config) # ipv6 unicast-routing

3. Run Routing Protocol on router interfaces.
   (Config) # router Protocol
   (Config-router) # network ip of interface ⇒ create routing
   OR ...
   (Config) # interface ___
   (Config-router) # ip Protocol } ⇒ Activate routing

Session 2 Part 1
Routing Procedure

1. Check IOS.
2. Enable Router Processor.
3. Run Routing Protocal.
   - Create routing Process.
   - Activate routing Process on interface.
4. Exchange of updates.
   Send / receive
5. Form Routing Table. ※Show ip route

Protocal		Network (Prefix)	Mask (Prefix-length)	Distance	vector
Connected	C				interface + IP of next hop
Static	S				
RIP	R				
OSPF	O				
EIGRP	D				
isis	i				
IGR	I				

[Administrative Distance / Metric]

- Connect = 0
- "interface, IP of next hop" Static = 0, 1
- "hop" RIP = 120
- "BW" OSPF = 110
- internal, external, Summary "BDRIP" EIGRP = 90, 170, 5
- "Cost" isis = 115
- external, internal BGP = 20, 200

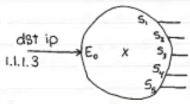
Metric: Hop, BW, Delay, Reliability, Load (Congestion), MTU

ARP Table ※Show arp

IP of next hop	MAC

Session 2 Part 2
Routing Table Search

1. Longest bit match (longest Prefix length).
2. Least admin. distance.
3. Least Metric.



O	1.1.1.16 /30	S_5	[110/40]	1.1.1.16 ~ 1.1.1.19
R	1.1.1.0 /28	S_1	[120/5]	1.1.1.0 ~ 1.1.1.15
O	1.1.1.0 /26	S_2	[110/50]	1.1.1.0 ~ 1.1.1.63
D	1.0.0.0 /8	S_3	[90/24,000,000]	1.0.0.0 ~ 1.255.255.255
S^*	0.0.0.0 /0	S_4	[0/0]	0.0.0.0 ~ 255.255.255.255

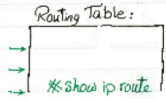
↘ last resort

IP equal, loadsharing (loadBalancing)... 4paths by default, max 16 or more by configuration.

⇒ (Config-router)※ maximum-paths ※

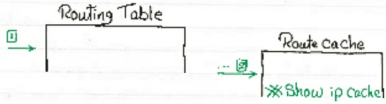
Session 2 Part 3
Routing Generations

1. Process routing:
   normal routing ≡ SlW Search ≡ Sequential Search.
   forward thousands of PPS



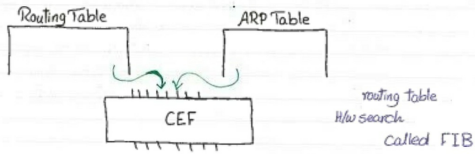
2. Fast Switching:

route caching ≡ route once & switch many.
Forward tens of thousands PPS.



3. CEF switching:

Cisco Express Forwarding → Pointer Search.
Forward millions of PPS.



Forwarding Info Base

CEF Table "adjacency table"

index	network / mask	vector	MAC
Hash Code = Label			

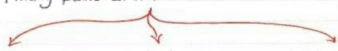
※Show ip cef

Session 2 Part 4

Routing classification

Static Routing: Building routing table manually. IP only one path exists to dst (if network is simple).

Dynamic routing : Build routing table automatically using algo, If network is complex / many paths exist .



IGP / EGP

Interior Gateway Protocal / Inside AS	Exterior Gateway Protocal / Between As
ex:	ex:
RIP_1, RIP_2	EGP, BGP
ISIS, OSPF	
IGRP, EIGRP	

Classfull/Classless Protocals

Doesn't Send mask in Updates	Understand Subnetting
ex:	ex:
RIP_1	RIP_2, ISIS
IGRP.	OSPF, EIGRP
EGP	BGP

Distance vector : exchange routing table without mask
ex: RIP_1 , IGRP
Advanced Distance vector: exchange routing table with mask using multicast
ex: RIP_2 , EIGRP
Link state : exchange LSA with mask using multicast
ex: OSPF , ISIS
Path vector : exchange routing table with rich attributes. ex: BGP, EGP

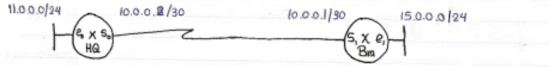
Session 3 Part 1

Static Routing

IF only one path exists to dst.

Advantage: Save resources (CPU, memory and BW).

Disadvantage: Admin over head.



	network/mask	vector	distance		network/mask	vector	distance
C	11.0.0.0/24	e_0	0	C	15.0.0.0/24	e_1	0
S	15.0.0.0/24	S_0	0	S	11.0.0.0/24	S_1	0

HQ(Config)# ip route 15.0.0.0 255.255.255.0 S_0

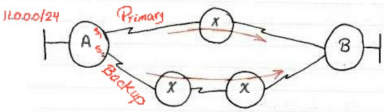
Branch(Config)# ip route 11.0.0.0 255.255.255.0 S_1

⇒ (Config)# ip route network mask vector [distance]

vector: interface name / IP of next hop

default distance = 0 / default distance = 1

Example 1: Primary/Backup Paths.



A(Config)# ip route 15.0.0.0 255.255.255.0 S_1 — Primary Path

A(Config)# ip route 15.0.0.0 255.255.255.0 S_2 10 — Backup Path/Floating

Example 2: Equal Loadsharing / Load Balance.

A(Config)# ip route 15.0.0.0 255.255.255.0 S_1

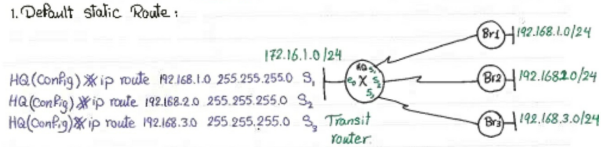
A(Config)# ip route 15.0.0.0 255.255.255.0 S_2

Example 3 : Unequal Loadsharing / LoadBalancing .

A(Config)# ip route 15.0.0.0 255.255.255.192 S_2 (0-63) longest Speed match...
A(Config)# ip route 15.0.0.0 255.255.255.0 S_1 (0-255)

Session 3 Part 2
Default Route

1. Default static Route :



HQ(Config)# ip route 192.168.1.0 255.255.255.0 S_1
HQ(Config)# ip route 192.168.2.0 255.255.255.0 S_2
HQ(Config)# ip route 192.168.3.0 255.255.255.0 S_3 Transit router

Stub routers

Br3(Config)# ip route 0.0.0.0 0.0.0.0 S_3
Br2(Config)# ip route 0.0.0.0 0.0.0.0 S_2
Br1(Config)# ip route 0.0.0.0 0.0.0.0 S_1
} Gateway of last resort the worst bit match

network/mask vector distance
S* 0.0.0.0/0 S_3 0

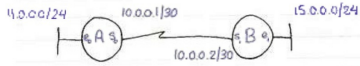
2. Default Dynamic Route :

BGP B* RIP R* OSPF O* ISIS i*
EIGRP D*

=> (Config-router)# default-information originate
=> (Config-router)# ip default-network 0.0.0.0

All routing Protocal on HQ except EIGRP ...

Session 3 Part 3
Routing Information Protocal



C 11.0.0.0/24 e_0 0
C 10.0.0.1/30 S_0 0
C 15.0.0.0/24 e_0 0
C 10.0.0.2/30 S_1 0

RIPv2 Configuration :

(Config) # router rip — send V1 and receive V1&V2 (default version)
(Config-router) # version 2 — To send & receive the same version.
(Config-router) # network _____ — IP of interface.
↳ Classfull command default WCH cannot be change.

Use splithorizon : route learnt from interface should never be advertised back on interface.

Wide Card Mask (WCM) : 0 ≡ exactly match , 1 ≡ Don't care .

(Config-router) # passive-interface _____ — interface name
To stop send update from interface

@ Change :
Periodic Update every 30 sec ... keep alive
Invalid Time 180 sec = 3 update ... Tragered update ... Poisoned reverse.

A(Config) # router rip
A(Config-router) # version 2
A(Config-router) # network 11.0.0.0
A(Config-router) # network 10.0.0.1

B(Config) # router rip
B(Config-router) # version 2
B(Config-router) # network 15.0.0.0
B(Config-router) # network 10.0.0.2

RIPv2 Characteristic :-

1. It is advanced Distance vector . exchange of routing tables

2. Send updates using multicast 224.0.0.9 . Periodically 30 sec

3. Classless protocal. (Support FLSM & VLSM, Summarization and CIDR)

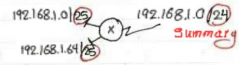
FLSM (fixed length subnet Mask).
VLSM (variable length subnet Mask).
Summarization :
→ default auto-summary :
class C ⇒ /24 .
class B ⇒ /16
class A ⇒ /8
→ by Configuration (no auto-summary)...

→ by Configuration (manual summary)...

(Config)# interface S0

(Config-if)# ip summary-address rip | Summary 192.168.1.0 | mask 255.255.255.0

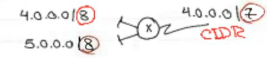
(Config)# router rip
(Config-router)#version 2



(Config-router)# no auto-summary

CIDR (supernetting) : major networks ما بقى
→ no need to disable auto-summary

(Config-if)# ip summary-address rip 4.0.0.0 254.0.0.0



4. Optinal Support Authentication.
   by default null by configuration clear text
   Hashed MD5

5. Use Bellman Ford algorithm. to calculate best Path.

6. Symbol in routing table "R".

7. Metric is hop. maximum hop is 15, 16 is ∞)

8. Admin Distance = 120.

9. Support equal load sharing.
   by default 4 Paths. by configuration maximum 16 or more.

RIP ng (next generation) : Every thing the same RIPv2 except for,

- used for IPv6.
- Multicast FF02::9
- Auto-Summary not available (N/A).

Configuation:

(Config)# ipv6 unicost-routing
(Config)# ipv6 router rip HSBC (name)
} Activite Process

(Config)# interface S0

(Config-if)# ipv6 rip HSBC

OSPF v2 Characteristic :- Open Shortest Path First
open source Algorithm
open stander

1. Link State Protocal.
   - exchang of LSA.
   - Form LSDB (all LSAs).
   - draw LSDB (link state Data Base).
   - run Dijrstra algorithm (SPF algorithm) to calculate shortest Path.
   - Bulid routing table.

2. use multicast (224.0.0.5, 224.0.0.6).

3. Classless Protocal (NIA auto-summary).

4. Optional Authentication.

5. Use Dijstra algorithm.

6. Symbol in routing table "O, OIA, OE_1, OE_2, ON_1, ON_2, O*".

7. Admin Distance = 110.

8. Metric is cost = 10^8/BW least is 1
Metric Configuration:

(Config)# interface S_0
(Config-if)# ip OSPF Cost # [1]

(Config-if)# Bandwidth $\frac{}{\text{Speed (Kbps)}}$ [3]

(Config) ※ router OSPF 1 [2]

(Config-router) ※ auto-Cost reference-Bandwidth ___ (by default 100 / unit is millions / $\times 10^6$)

9. Support equal load sharing.

(Config) ※ router OSPF 1

(Config-router) ※ maximum-Paths ___

10. Support Hierarchical desgin. (Support multiple area).

Session 5 Part 1

OSPF Tables

1- OSPF neighbor table:
It contains directly connected neighbors.
※Show ip ospf neighbors

Router ID neighbor	IP of neighbor	Interface

2- Link State Data Base (LSDB):
It contains all details about routers in the network.
※Show ip ospf data base.

3- Routing Table (S/W) = FIB Table (H/W) ≡ Forwarding Info Base
It contains best paths to find end network.
※Show ip route ospf
Show ip cef ospf "Cisco expres forward"

OSPF packet types

1- Hello packet:
Used for build/maintain neighbor table.

2- DBD (Data Base Description Packet DDP):
Used to advertise summary about LSDB.

3- LSR (Link State Request):
Used to request details about missing LSAs.

4- LSU (Link State Update):
Details about LSDB (Group of LSAs).

5- LSAck (Link State Acknowledgement):
Confirmation message.

Session 5 Part 2

OSPF Topologies / modes

1- Point to Point mode:
A network that joins a single pair of routers. Interfaces running PPP or HDLC or Point to Point sub interfaces ATM & Frame Relay.

(Config-if)# encapsulation ? PPP/ HDLC (default)?

(Config-if)# ip ospf network point-to-point

1.1- Neighbor discovery: Auto neighbor discovery using hello.

1.2- Elect DR & BDR: No elections (no DR/no BDR).

1.3- Hello/dead interval: 10/40 second.

2- BMA (Broadcast Multiple Access):
technology Provide Broadcast address → star topology
Default on ethernet.

(Config-if)# ip ospf network broadcast

1.1- Neighbor discovery: Auto using hello.

1.2- Elect DR & BDR: Auto election.

1.3- Hello/dead interval: 10 / 40 second.

3- NBMA (Non Broadcast Multiple Access):
Technology doesn't provide broadcast address
Default on packet switching interface (FR, X2.5, ATM).

(Config-if)# encapsulation {x25 | FrameRelay | atm }

(Config-if)# ip OSPF network non-Broadcast

3.1- Neighbor discovery: Manual neighbor discovery.

(Config)# router OSPF 1

(Config-router)# neighbor ___IP___

3.2- Elect DR & BDR:
Router that configure neighbor commend 1st is DR the 2nd BDR.

3.3- Hello/dead interval: 30/120 second.

Session 5 Part 3

OSPF Operation

@ Startup: (Config)# router OSPF ___Process id___

0- Create Router ID (32 bits):
0.1 Manual
(Config-router)# router-id _____ Prefered write it like IP

this is only method on IPv6.

0.2 _ Highest Loopback interface IP:

(Config)# interface Loopback0

(Config-if)# ip address _____ 255.255.255.255

⇒ virtual, logical, S/W, internal interface always up. Used for easy management. Can be Telnet or Ping on it if router has physical interface is up.

0.3 _ Highest Physical active interface IP:
ethernet serial up

⇒ when we need change RID:
Restart Router
no router OSPF
(Config-router)# clear ip ospf process

Session 6 Part 1

OSPF Operation

@StarTup: (Config)# router OSPF Process id
- Can never be 0
- 1-65535
- May not match between routers

0- Create Router ID (32 bit):

0.1 - Manual:

(Config-router)# router-id _____

this is only method on IPv6...

0.2 - Highest Loopback interface IP:

(Config)# interface loopback 0

(Config-if)# ip address _____ 255.255.255.255

0.3- Highest Physical active interface IP:
ethernet - Serial - up

** Can't create OSPF without Router ID **

1- Neighbor discovery (hello protocal):

1.1 - Down State:

no exchange yet

1.2 - Initial State:

the 1st discovery hello is sent but waiting reply.

IP header 20byte

SRC IP _____ DST IP 224.0.0.5 Protocal 89, TTL 1	Type 1=Hello length 64 byte	R ID	Auth. method & key	Area id & type	Priority hello/dead interval	DR BDR IDs	

Neighbor ID list	length of hello depend on it (no. of it depend on no. of neighbors)	Hello Packet

⇒ Conditions of OSPF routers to be neighbors:

① Same subnet.

② Same Authentication method:

null —

clear text (Config-if) ※ ip OSPF authentication.

Hashed MD5 (Config-if) ※ ip OSPF authentication message-digest.

③ Same Authentication key:

null —

clear text (Config-if) ※ ip OSPF authentication-key Password

Hashed (Config-if) ※ ip OSPF authentication message-digest key Password md5 number

④ Same Area ID.

⑤ Same Area type

⑥ Same hello interval (Config-if) ※ ip OSPF hello interval 10 sec (by default)

⑦ Same dead interval (Config-if) ※ ip OSPF dead-interval 40 sec

1.3- Two way State:

Hello is received back & Contains me in their neighbor list.

※ Show ip OSPF neighbor

※ debug ip OSPF adj

Session 6 Part 2

2- DR & BDR Election (Designated Router, Backup):
welcome new comers and focal point of comm @ change.
DR & BDR multicast 224.0.0.6

ⓐ Router that first boots OSPF with enough time (dead time).

ⓑ Router having highest priority per interface (by default=1).
Can never be DR or BDR ...

(Config-if)# ip OSPF priority 0:255

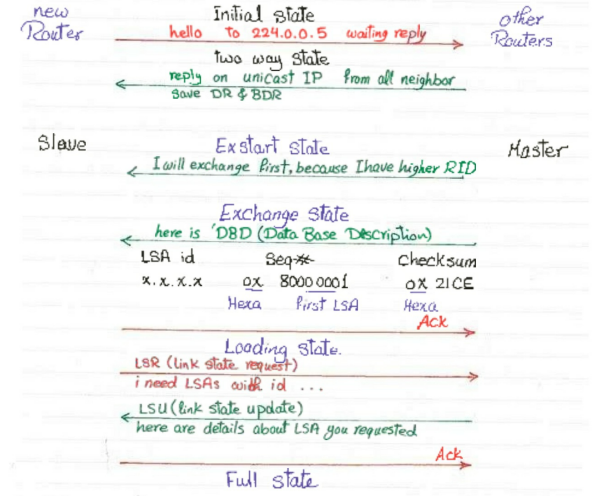
ⓒ Router has highest RID.

3-Routers discovery:
3.1 - ExStart state:
- Choosing master / slave.
- master is the highest RID.
- Router that will start exchange first.

3.2 - Exchange state:
- Send the Data Base Description: (LSA id, Seq#, Checksum)

3.3 - Loading state:
- Requesting details from specific LSDB entries (LSR).
- Here are all details about LSA you requested (LSU).

3.4 - Full state:
- All routers has a common LSDB.



Details IP/mask , cost , Link Type , router type , LSA type

ex:

192.168.1.1/27 , cost=10 , Stub → Router connect to PCs

Point to Point → PPP / HDLC

Transit → NBMA , BMA

Session 7 Part 1

OSPF Operation

@startup :

0. Create RID (32-bit).
1. Neighbor discovery (hello protocal):

Neighbor ID	Neighbor IP	Interface	state

※show ip ospf neighbor ※debug ip ospf adj

Stop in initial state ——— ——— → neighbor conditions.

Stop in exchange state, due to mismatch in MTU. If you want to ignore mismatch in MTU...

(Config-if) ※ ip ospf mtu-ignore or edit mtu

(Config-if) ※ ip mtu ___

2. DR & BDR : first to boot OSPF.
Highest priority.
Highest RID.

3. Routes discovery (exchange of LSDB).
4. Drow LSDB Tree.
5. Use Dijkstra algorithm (SPF) : to calculate best path.
Build Routing Table.

@Convergence : Steady state
only priodic hello

PPP / HDLC / MPLS / ethernet
Sub interface (Point to Point)
every 10 sec

X.25 / FR / ATM
every 30 sec

@ Change :

- Router that feels the change will form new LSA & send it on 224.0.0.6 (DR & BDR).
- Only DR send new LSA to all other routers.
- All routers run SPF algorithm. SPF delay = 5 sec ... Time between receiving last change & calculating SPF algorithm ... to avoid flapping & hanging.

※ Show ip OSPF ⇒ SPF calculate SPF delay

(Config-router) ※ timer SPF ____ / sec

Session 7 Part 2
OSPF Configuration

New Method :

(Config) ※ router OSPF Process Id

(Config) ※ interface ___

(Config-if) ※ ip OSPF Process Id area area id

Old Method :

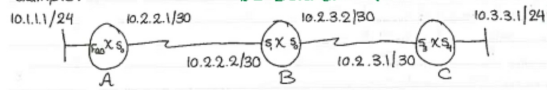
(Config) ※ router OSPF Process Id

(Config-router) ※ network ip of network wild card mask / inverted mask area area id

0 = exact match

1 = Don't care

Example :



A(Config) ※ router OSPF 1

A(Config) ※ interface Fa0

A(Config-if) ※ ip ospf 1 area 0

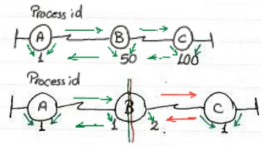
A(Config) ※ interface S0

A(Config-if) ※ ip OSPF 1 area 0

B(Config)# router OSPF 1
B(Config-router)# network 10.2.2.2 0.0.3.0 area 0

Process Id : no. = 1-65535 used to divide OSPF router in sub routers. Process id locally significant.

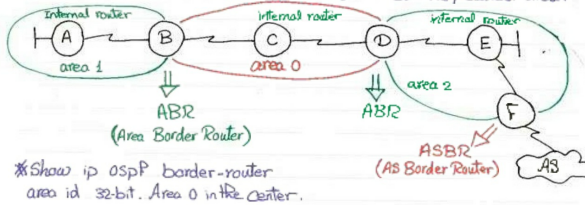
example :



Session 7 Part 3
Multiple Area OSPF

Single Area disadvantage :
1. Need very big memory.
2. Need very high CPU.
3. Instability affect the entire AS.

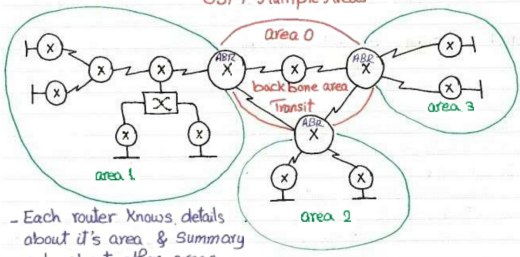
Recommended :
each 50 router in one area. divide AS into sub AS, called area.



#Show ip ospf border-router
area id 32-bit. Area 0 in the center.

Session 8 Part 1

OSPF Multiple Areas



- Each router knows details about it's area & summary only about other areas.

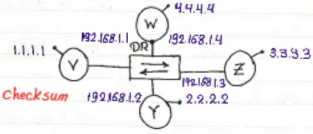
Types of LSAs

1. Type 1 LSA (Router LSA):
   It is generated by each router describing details about itself.
   It is flooded inside area only (intra-area). area الى نفس
   It contains :
   * 1. Router Type (internal, ABR, ASBR).
   2. Router ID. → LSA id | Seq# | LinkCount | Checksum
      3. Interface IP. router id | 0X80000001 | 5 | 0X21BC
   * 4. Interface Mask.
   * 5. Interface Cost.
   6. Interface Type (loopback, stub, P2P, Transit).

   # show ip ospf database [LSA Name]

2. Type 2 LSA (Network Link LSA):
   It is generated by DR only. It is flooded inside area only (intra-area).

It Contains :
1. DR ID .
2. List of losers ID .

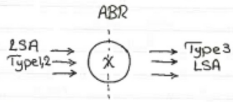


LSA Id | Seq# | LinkCount | Checksum

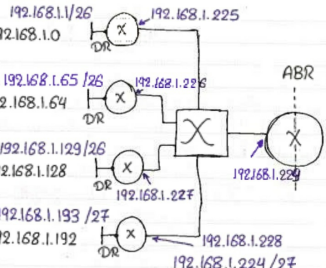
IP of winning of interface

1

[3] Type 3 LSA (Summary Network LSA) :
It is generated by ABR, Flooded in AS (all areas)...(inter-area).
It Contains :
1. Network Address (4 byte).
2. Network Mask (4 byte).
3. Network Cost (2 byte).



5 Type 1 LSA
5 Type 2 LSA
5 Type 3 LSA



192.168.1.0/26, 110
192.168.1.64/26, 110
192.168.1.128/26, 110
192.168.1.192/27, 110
192.168.1.224/27, 110

⇩

no auto-summary

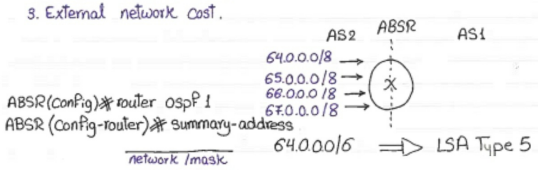
ABR (Config)# router ospf 1
ABR (Config-router)# area 1 192.168.1.0 /24
network /mask

⇩

least cost

192.168.1.0/24, 110

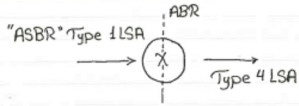
5 Type 5 LSA (External Network LSA):
It is generated by ASBR & Floodeed in AS "all areas" (inter-AS).
It Contains:
1. External network address.
2. External network mask.
3. External network cost.



7 Type 7 LSA (External NSSA Network LSA):
NSSA (Not so Stub Area.) drop each Type 5 LSA, so it is the same Type 5 LSA but if ASBR was NSSA.

6 Type6 LSA: Not used now...

4 Type 4 LSA (ASBR summary LSA):
It is generated by ABR and tells about ASBR exist once.



Session 9 Part 1

Types of LSAs

Link State Data Base (LSDB):

- Router LSA (Type 1 LSA) generated by any router.
- Network LSA (Type 2 LSA) generated by DR.
- Summary LSA (Type 3 LSA) generated by ABR.
- ASBR Summary LSA (Type 4 LSA) generated by ABR "there is ASBR".
- External LSA (Type 5 LSA) generated by ASBR.
- External NSSA LSA (Type 7 LSA) generated by ASBR.

Routing Table:

O → intra-area
O IA → inter-area
O E_2 → inter-AS external
O N_2 → inter-AS NSSA

Internal Metric:

Cost = 10^8 / BW

External Metric:

Type 2: default — ASBR doesn't add internal metric to external metric.

Type 1: ASBR include internal metric to external metric.

Types of Areas

- Backbone Area (Transit Area):
  LSAs = Type 1,2 (for Area Zero), Type 3,4 (for other Areas), Type 5 ... not recommended include ASBR.

1. Normal Area (Ordinary Area):
   LSAs = Type 1,2 , Type 3,4 , Type 5
   area x other areas

2. Stub Area:
   Area that doesn't have ASBR. Filter (Type 5 LSA) and used default route "O" 0.0.0.0/0 on ABR only (Automatic).
   LSAs = Type 1,2 "O", Type 3,4 "O IA"

3. Totally Stub Area:
   Area with no ASBR. Filter (Type 3,4,5 LSAs) and used default route "O" 0.0.0.0/0 on ABR only (Automatic).
   LSAs = Type 1,2 "O"

   (Config-router)# area 3 stub no-Summary on ABR only
   (Config-router)# area 3 stub on other routers

4. Not So Stub Area (NSSA):
   Stub + ASBR. LSAs = Type 1,2 "O", Type 3,4 "O IA", Type 7

   (Config-router)# area x nssa.

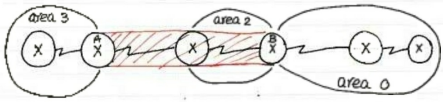
5. Totally NSSA:
   LSAs = Type 1,2 "O", Type 7

Session 9 Part 2

Area Type	LSDB	Routing Table
Area 0 & normal area	Type 1,2,3,4,5	O, O IA, OE_2
Stub	Type 1,2,3,4	O, O IA, O*
NSSA	Type 1,2,3,4,7	O, O IA, O*, ON_2
Totally Stub	Type 1,2	O, O*
Totally NSSA	Type 1,2,7	O, O*, ON_2

Virtual Link in OSPF :

A(Config)# router OSPF 1
A(Config-router)# area 2 virtual-link RID|$_B$
Should be normal area
B(Config)# router OSPF 1
B(Config-router)# area 2 virtual-link RID|$_A$



OSPF ver.3

Session 9 Part 3

OSPF for IPv6 networks :
- Same Router type (internal/ABR/ASBR).
- Same types of areas.
- Same operation (down/initial/2way)
  ⇒ extra neighbor condition :
  - Same instance id (global Process : default = 0).
  - operation (exstart, exchange, loading and Full state)
- Same LSA Types but no Type 1,2 LSA same as Type 8,9.

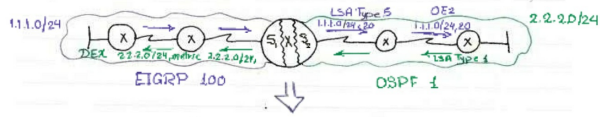
(Config)# ipv6 unicast-routing
(Config)# ipv6 router ospf 1
(Config-rtr)# router-id _____

(Config)# interface S0
(Config-if)# ipv6 OSPF 1 area 0 [instance ___]

Session 10 Part 1
Manipulating multiple routing protocols

- Service provider (Transit AS) & serves many customers.
- Boundary between ASs.
- Mixed vendor devices.

Redistribution:




```
(Config)# router OSPF 1
(Config-router)# redistribute eigrp 100

(Config)# router eigrp 100
(Config-router)# redistribute OSPF 1
```

Redistribution Conditions:

- Redistribution can be done between any two routing methods.

EIGRP ⟷ OSPF
RIP ⟷ BGP
IGRP ⟷ EIGRP
automatic in the same AS

Static → BGP, RIP, EIGRP, ISIS, OSPF

Connected → any protocol by network command.

- Redistribution can not work between two different routed protocols.

IPv4 RIP ⟷ IPx OSPF
Apple talk EIGRP ⟷ IPv6 BGP

Session 10 Part 2

Admin. Distance:

While redistribution the admin distance rules is the same as the new protocol rules.

RIP Admin distance 120 → OSPF Admin distance 110

RIP Admin distance 120 → EIGRP Admin distance 170

Metric:

OSPF Cost: x
Any routing Protocal except BGP → Another OSPF Process Cost=x
BGP → OSPF Cost = 20
OSPF Cost = 1

Any routing Protocal → ISIS Cost = 0

Any routing Protocal → RIP, EIGRP, IGRP
Distance vector, Advanced Distance vector

we have to configure seed metric. initial manual metric
metric = ∞

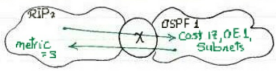
Session 10 Part 3

Redistribution Configuration:

(Config)# router Protocal 1
(Config-router)# redistribute Protocal 2 [metric seed metric] [metric-type ? type-1 | type-2] [subnets] [route-map filter name]

OSPF Only
OE2 OE1
(default neglact internal metric)
For OSPF only to allow subnets

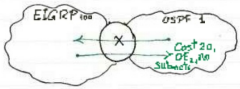
example 1 :



(Config) ※ router RIP
(Config-router) ※ version 2
(Config-router) ※ redistribute OSPF 1 metric 3

(Config) ※ router OSPF 1
(Config-router) ※ redistribute rip metric 17 metric-type type-1 subnets.

example 2 :



BDRLH
BW
Delay
Reliability ≡ stability (0-255) bad Good
Load ≡ UTL (1-255)
MTU = 1500 Good bad
※ Show interface name

(Config) ※ router OSPF 1
(Config-router) ※ redistribute eigrp 100

(Config) ※ router eigrp 100
(Config-router) ※ redistribute OSPF 1 metric 10000 100 255 1 1500

Session 10 Part 4
Route-Filter

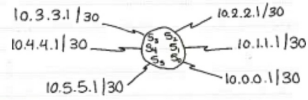
ACL (Access Control List) for network in routing table :
1. Distribute-List using Access-list :

(Config) ※ router OSPF 1
(Config-router) ※ redistribute rip
(Config-router) ※ distribute-list 64 out RIP — Activate
(Config) ※ access-list 64 {Permit | deny} network — Create
Note : deny any at the end

Session 11 Part 1
Controlling Routing Updates

Passive-Interface :

. Interface that will stop sending updates. It can receive updates.




```
(Config)# router rip
(Config-router)# version 2
(Config-router)# network 10.0.0.1
```

```
(Config-router)# Passive-interface default   Required only S0 should
(Config-router)# no passive-interface S0      run RIPv2
```

OR

```
(Config-router)# passive-interface S1
(Config-router)# passive-interface S2
(Config-router)# passive-interface S3
(Config-router)# passive-interface S4
(Config-router)# passive-interface S5
```

RIP → Classfull Command with default wildcard mask "Can never be changed" ... Class A : 0.255.255.255 ...

EIGRP → classfull / classless command.

OSPF → Classless Command "must choose wildcard mask".

⇒ Passive interface on RIP : router stop sending update but can receive updates.

⇒ Passive interface on all other protocals : stop protocal (Stop neighbor ship).

Required all interfaces OSPF except S0

```
(Config)# router OSPF 1
(Config-router)# network 10.0.0.1 0.255.255.255 area 0
```

(Config-router)# passive-interface 50

Session 11 Part 2

- Changing Admin Distance: (Config-if)# ip summary-address eigrp _ _ _ [_] (network, mask, global Process, distance)

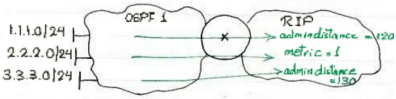
BGP:
(Config)# router bgp AS#
(Config-router)# distance bgp
internal external

EIGRP:
(Config)# router eigrp global Process
(Config-router)# distance eigrp
internal external

OSPF:
(Config)# router OSPF local Process
(Config-router)# distance ospf external ___ inter-area ___ intra-area ___

Protocal	Admin Distance ≡ Preference (default)
RIP	120
ISIS	115
OSPF	110
EIGRP	90 internal, 170 external 5 summary
BGP	200 internal, 20 external

Any Protocal:
(Config)# router ___
(Config-router)# distance ___ [acl#]
example:



(Config)# router rip
(Config-router)# version 2
(Config-router)# redistribute OSPF 1 metric 1
(Config-router)# distance 130 64
(Config)# access-list 64 permit 3.3.3.0

Session 11 Part 3

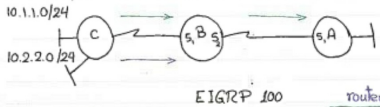
Route Filter :

1. Distribute list using Access list :

Active for updates create

(Config)# router Protocal
(Config-router)# distribute-list ACL# { out Protocal (while redistribution) / out interface (after routing table) / in interface (before routing table) } same Protocal

example 1 :



EIGRP 100

B(Config)# access-list 64 permit 10.1.1.0
B(Config)# router eigrp 100
B(Config-router)# distribute-list 64 out S_2

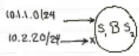
router B

D	10.1.1.0 /24	S_1
D	10.2.2.0 /24	S_2

router A

D	10.1.1.0 /24	S_1

example 2 :



B(Config-router)# distribute-list 64 in S_1

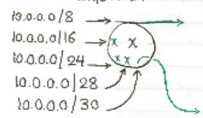
2. Distribute list using Prefix list :

(Config)# ip prefix-list name [seq#] {Permit | deny} network/mask
(by default 1st line = 5 then +5)

(Config)# router Protocal
(Config-router)# distribute-list prefix-list name { out Protocal / out interface / in interface }

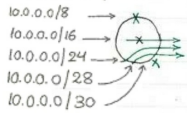
prefix-list need processing more than access-list.

example 1:



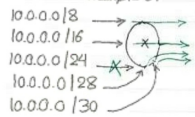
(Config)# ip prefix-list STS permit
10.0.0.0 /30
(Config) # ip prefix-list STS permit
10.0.0.0 /8
(Config) # router Protocol
(Config-router) # distribute-list prefix-list STS in interface

example 2:



(Config)# ip prefix-list 64 Permit
10.0.0.0 / 16 Le 28 less than
or 28 ge 16 greater than or equal

example 3:



(Config)# ip prefix-list 64 deny
10.0.0.0/24
(Config)# ip prefix-list 64 permit
0.0.0.0/0 Le 32 ≡ permit any

3. Route-map: Permit, deny and modify
. Activate route-map:
(Config-router) # redistribute Protocol [metric ____]

[metric-type {1,2}] [subnets] [route-map tag]
⇓ OSPF only ⇓ OSPF only

- Create route-map :

(Config) # route-map tag {Permit/deny}

(Config-route-map) # match ip address ACL#

OR

(Config-route-map) # match ip address prefix-list name

(Config-route-map) # set metric ____

(Config-route-map) # set metric-type {type-1 | type-2}

Session 12 Part 1

Route map ...

It is a sophisticated Access Control list, used to permit, deny and modify.

Benefits of route-map:

1. Routing updates filter (routing).
2. Modify data traffic path (routed).
3. Use to Configure BGP Policies & attribute.

1. Route-map as routing updates filter:

1.1 Create route-map: ✳ Show route-map

(Config) ✳ route-map name {Permit | deny} [seq #]

- Permit: Allow update
- deny: discard update
- seq #: ↳ start from 10 by default and didn't count automatic

(Config-route-map) ✳ match ip address ACL #

OR

(Config-route-map) ✳ match ip address prefix-list name

(Config-route-map) ✳ set metric ——

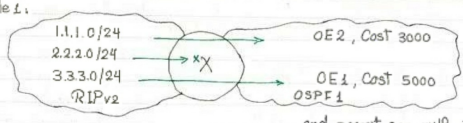
(Config-route-map) ✳ set metric-type {type-1 | type-2}

If no match statment exist ≡ match any.

1.2 Activate route-map:

(Config-router) ✳ redistribute Protocal [route-map name]

example 1:



and permit any without modification ...

(Config)# access-list 1 permit 1.1.1.0
(Config)# access-list 2 permit 2.2.2.0
(Config)# access-list 3 permit 3.3.3.0

(Config)# ip prefix-list 3 permit 3.3.3.0/24

(Config)# route-map Tifa permit
(Config-route-map)# match ip address 1
(Config-route-map)# set metric 3000

(Config)# route-map Tifa deny 20
(Config-route-map)# match ip address 2

(Config)# route-map Tifa permit 30
(Config-route-map)# match ip address 3
(Config-route-map)# set metric 5000
(Config-route-map)# set metric-type type-1

(Config-route-map)# match ip address prefix-list 3

(Config)# route-map Tifa permit 40

(Config)# router OSPF 1
(Config-router)# redistribute rip route-map Tifa subnets

2. Route-map as policy based routing:
   2.1 Create route-map:

(Config)# route-map name {Permit | deny} [Seq#]

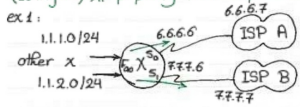
- Permit: Policy
- deny: Policy (use normal routing table)

(Config-route-map) # match ip address ACL # — source IP
OR (Config-route-map) # match tos Priority
OR (Config-route-map) # match length min max — Package length
(Config-route-map) # set interface ____ DST network exists exactly in routing table.
(Config-route-map) # set default interface ____ DST network doesn't exactly in routing table but there is a default route.
(Config-route-map) # set ip next-hop ____ DST network exists exactly in routing table.
(Config-route-map) # set ip default next-hop ____ not exact match for DST network

Show ip policy

2.2 Activate route-map:
(Config-if) # ip policy route-map name

ex1:



* Data sourced from 1.1.1.0/24 should goto internet through ISP A and ISP B is backup.
* Data sourced from 1.1.2.0/24 should goto internet through ISP B and ISP A is backup
* Data sourced from any other subnets should be dropped.

(Config) # access-list 1 Permit 1.1.1.0 0.0.0.255
(Config) # access-list 2 Permit 1.1.2.0 0.0.0.255
(Config) # route-map Hassen permit
(Config-route-map) # match ip address 1
(Config-route-map) # set default interface S_0 S_1
(Config) # route-map Hassen permit 20
(Config-route-map) # match ip address 2

```
(Config-route-map)# set default next-hop 7.7.7.7  6.6.6.7
(Config)# route-map Hassen permit 30
(Config-route-map)# set default interface null0

(Config)# interface Fa0
(Config-if)# ip policy route-map Hassen

#show route-map
#show ip policy
```

Session 13

BGP (Border Gateway Protocol)

It is EGP (exterior gateway Protocol) that run between routers in different Autonomous System.

Group of devices that is under single technical administration...

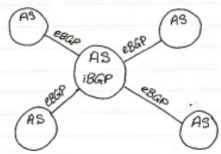
Old AS no. (16 bit) = 1 - 65 535
Private AS no. = 64512 - 65 535
New AS no. (32 bit) = 1 - 4 294 967 295

When BGP is not appropriate ? Use Static

1. If Single path exists between 2 AS.
2. If there are lack of resources.
   CPU, Memory, BW
   (min. 1800 series) > T1 = 1054 Mbps
3. If there are no good understanding for BGP Policies.

When BGP is appropriate ?

1. Multiple paths between ASs.
2. If your AS is a transit AS.
   Service Provider



3. If dynamic policies are requires.

Session 13 Part 2

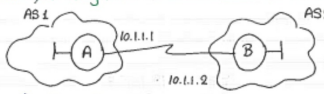
BGP Table

1. BGP Neighbor table :

It is formed manually

(Config) # router bgp AS#

(Config-router) # neighbor ip of neighbor remote-as neighbor AS#



A(Config) # router bgp 1 ← ebgp →

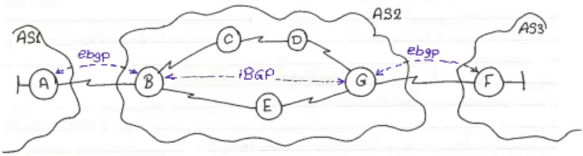
A(Config-router) # neighbor 10.1.1.2 remote-as 2

B(Config) # router bgp 2 ← ebgp →

B(Config-router) # neighbor 10.1.1.1 remote-as 1

#Show ip bgp summary

IP of neighbor	AS#	State



B (Config) # router bgp 2 ← ibgp →

B (Config-router) # neighbor G remote-as 2

G(Config) # router bgp 2 ← ibgp →

G(Config-router) # neighbor B remote-as 2

- ebgp : neighbors should be directly connected by default.
- ibgp : neighbors may not be directly connected.

2. BGP Table (BGP data base, BGP topology table):
All learnt routes * Show ip bgp

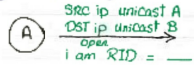
Network /mask	Attributes

3. Routing Table:
Best routes, best attributes
routing table —CEF→ FIB (Forwarding info Base ≡ FIB table)

Session 13 Part 3
BGP Packets

1. Open msg: (startup @hello).

(Config) * router bgp AS#
(Config-router) * neighbor _____ remote-as AS#

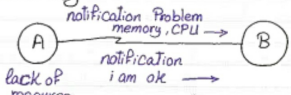


RID BGP:
- Manually
- Highest loopback ip.
- Highest Active physical interface ip.

2. Update msg:
It contains network /mask, attributes

3. Keep alive msg (periodic hello):
Every 60 sec periodic hello.
Dead time = invalid time = 180 sec.

4. Notification msg:



BGP Characteristic :

1. It is egp path vector (≅ advanced D.V).
   with details (all attributes).

2. Neighborship is manually configured & all BGP msg are sent unicast to neighbors.

3. @change send batched updates every 30 sec.

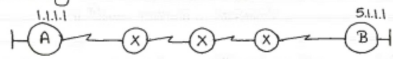
4. Use rich metric called attributes.
5. Classless protocols (FLSM, VLSM, Summarization, CIDR).
6. Optional Authentication.
7. Symbol in routing table "B".
8. Admin. distance = 20 ebgp, 200 ibgp.
9. It is considered as application using port 179 /TCP ...

Session 14 Part 1
BGP Operation

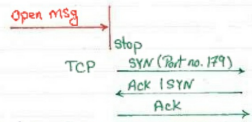
@ Start up :

⚙ Create router id :
- Manual .
- Highest loopback ip .
- Highest Active physical interface ip .

1 Neighbor Discovery :



1.1 Idle State : no exchange yet
A is still searching for a route to reach neighbor .
A (config) # router bgp AS#
A (config-router) # neighbor 5.1.1.1 remote-as neighbor AS#



1.2 Connect state : BGP 3 way handshake is done ...
1.3 Open Sent State :
open msg "my AS#, my RID"
1.4 Open Confirm state :
Open msg
1.5 Established state : router received open msg
... appear empty in neighbor table ...

Active Router State sent msg & waiting reply

IP of neighbor	AS of neighbor	State	PFX rcd

Prefixes Received no. of networks

Neighbor Table # Show ip bgp summary

② Routes Discovery:

Exchange of updates.

update →
network/mask, Attributes
← update

Form BGP Table ... All learnt routes #show ip bgp

⇒ to build routing table, Choose best path

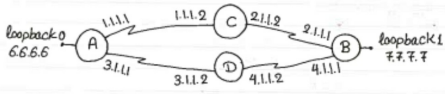
Session 14 Part 2
Neighbor Discovery Condition

1. Configure for neighbor command.

(Config) # router bgp AS#

(Config-router) # neighbor _____ remote-as ____

2. Neighbor should be reachable in routing table.



3. Update source loopback:

A (Config) # router bgp AS# ← ibgp → AS#

A (Config-router) # neighbor 7.7.7.7 remote-as AS#

A (Config-router) # neighbor 7.7.7.7 update-source loopback0

if you have more than one path to neighbor, make neighbor ship between loopbacks ...

All routing protocals msgs are with TTL = 1 "non routable" except ibgp TTL = 225 ...

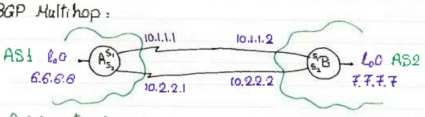
ebgp neighbor should be directly connected by default, TTL = 1 ...

ibgp neighbor may not be directly connect, TTL = 255 ...

B(Config) # router bgp 1
B(Config-router) # neighbor 6.6.6.6 remote-as AS-#
B(Config-router) # neighbor 6.6.6.6 update-source loopback0

Session 14 Part 9

4. eBGP Multihop :



A(Config) # router bgp 1
A(Config-router) # neighbor 7.7.7.7 remote-as 2
A(Config-router) # neighbor 7.7.7.7 update-source loopback 0

the only acceptable dynamic routing protocal between AS is BGP...

A(Config) # ip route 7.7.7.7 255.255.255.255 S1
A(Config) # ip route 7.7.7.7 255.255.255.255 S2
A(Config-route) # neighbor 7.7.7.7 ebgp-multihop [2]
recommended to more security

Session 14 Part 1
BGP Operation

① Create Router ID:
- Manual.
- Highest loopback ip.
- Highest Active physical Interface ip.

② Neighbor Discovery:
- neighbor command. Idle State
  (Config-router) # neighbor _____ remote-as _____

- neighbor ip should exist in routing table using any protocal.
  Active State
  ...stop here if Authentication not matched...

- Update source loopback.
  (Config-router) # neighbor _____ update-source _____
  Established State

  # Show ip bgp summary

- eBGP TTL Consideration (Stack in idle):
  (config-router) # neighbor _____ ebgp-multihop [2-255]

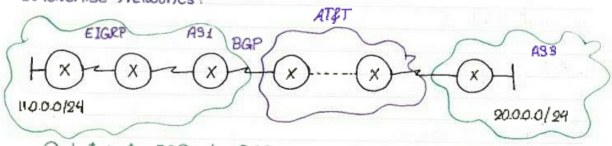
- Optional Authentication.
  A(config) # router bgp AS#
  A(Config-router) # neighbor ip of B password cisco

  B(Config) # router bgp AS#
  B(Config-router) # neighbor ip of A password cisco

② Routes Discovery:

Considerations :-

- Advertise Networks :



* Redistribute IGP into BGP: not recommanded

(Config) # router bgp 1

(Config-router) # redistribute eigrp 1 route-map tag

* Use Network Command :

(Config) # router bgp 1

(Config-router) # network 11.0.0.0 mask 255.255.255.0

Synchronization Rule :

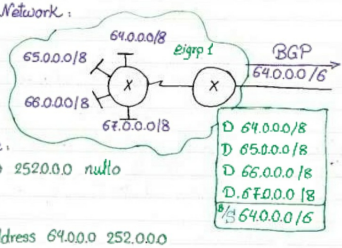
Network should exist exactly (network/mask) in routing table ...

- Advertise Summarized Network :

(Config) # router bgp 1

(Config-router) # network

64.0.0.0 mask 255.0.0.0



+ inject bogus static route :

(Config) # ip route 64.0.0.0 252.0.0.0 null0

+ aggregate address :

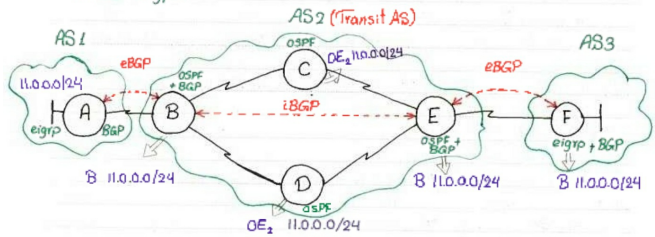
(Config-router) # aggregate-address 64.0.0.0 252.0.0.0

2.1) Inside Stub AS :

we need network command or aggregate address command to advertise routes into BGP world.

2.2) Inside Transit AS (Service Provider) :

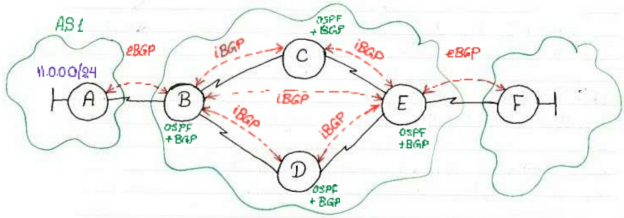
- Run iBGP inside all transit AS routers (To avoid black holes).
- BGP split horizon rule: (To avoid internal loops)
  Route learnt from ibgp should never be advertised back to another ibgp ...



Conclusion: in Transit AS

Run iBGP → Full mesh neighbor $n(n-1)/2$.

→ Route Reflector (disobeg split horizon rule).



→ MP-BGP (MPLSVPN) ≡ Tunnels.

Session 15 Part 1

BGP Operation

- Neighbor Discovery Consideration :

1. (Config) # router bgp my AS #
   (Config-router) # neighbor ip of neighbor lo remote-as AS # (neighbor)

2. (Config) # router ospf #
   (Config-router) # neighbor ip of my interface w.c.m area #

3. (Config) # router bgp AS #
   (Config-router) # neighbor ip of neighbor lo update-source my loopback name

4. (Config-router) # neighbor ip of neighbor lo ebgp-multihop TTL

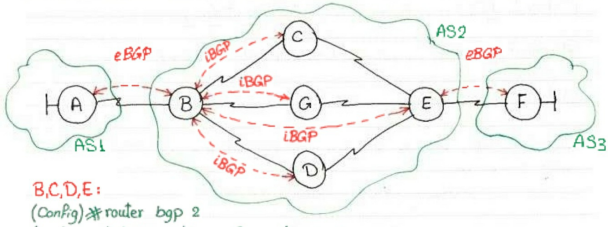
show ip bgp summary

- Routes Discovery : "exchange of updates → network/mask, attributes"

1. Advertise Routes : Stub AS
   (Config) # router bgp AS #
   (Config-router) # network _____ [mask _____]

2. Synchronization Rule :
   Routes advertised by BGP should be learnt by IGP → static, connected, OSPF, RIP, ...
   (Config) # router bgp AS #
   (Config-router) # no synchronization

3. For Transit AS :
   Run iBGP on all Transit AS router
   * Full mesh neighbor ship n(n-1)/2 .
   * route-reflector (n-1) ... RR disobey BGP split horizon rule ...
   * MP-BGP (MultiProtocal-BGP) ... (HPIS VPNs) .



B,C,D,E:
(Config)# router bgp 2
(Config-router)# neighbor G remote-as 2

G (RR):
(Config)# router bgp 2
(Config-router)# neighbor B,C,D,E remote-as 2
(Config-router)# neighbor B,C,D,E route-reflector-client

[4] Next hop self for updates:
(Config-router)# neighbor ip of neighbor next-hop-self

#Show ip bgp ⇒ BGP Table.

Session 15 Part 2
Choosing best Path
"WLOA OHNI"

[1] Highest weight. default 0 ... Cisco attribute

[2] Highest local preference. default 100

[3] Originate route prefered over received route.

[4] Shortest AS path list (less ASs is best).

[5] Least Origin (network command or redistribution).

⑥ Least MED.

Till here at least

⑦ eBGP neighbor is prefered over iBGP neighbor.

⑧ Least RID.

BGP by default choose only path for loadsharing used
Configration...
(Config-router)# maximum-paths ____

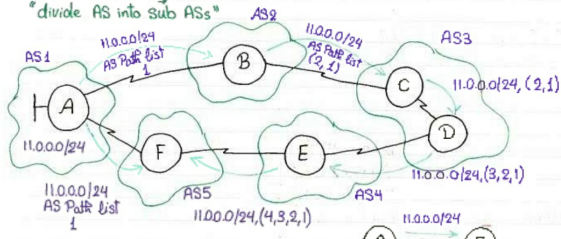
Session 15 Part 3
BGP Attributes

1. AS Path list:

well Known mandatary
Know by iBGP, eBGP
or Confederation
"divide AS into sub ASs"

→ inevery update

Force incoming Traffic



AS no. is prepended in eBGP sessions...

F router BGP Table

network /mask	AS
>11.0.0.0 /24	1
11.0.0.0/24	4,3,2,1

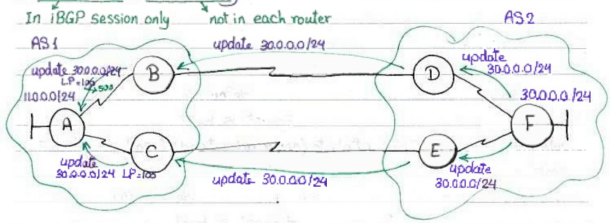
A(Config)# route-map A permit
A(Config-route-map)# match ip address 11
A(Config-route-map)# set as-path prepend 1 1 1 1
A(Config)# router bgp 1
A(Config-router)# neighbor F remote-as 5
A(Config-router)# neighbor F route-map A

2. Local Preference :

Force outgoing traffic

well known — discretionary

In iBGP session only — not in each router



B(config)# route-map B permit

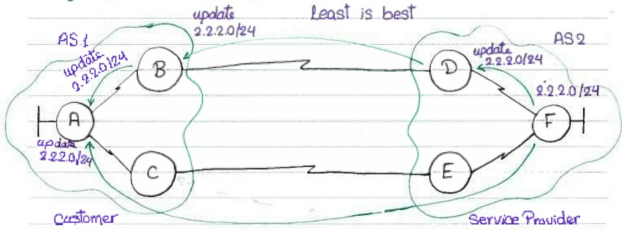
B(config-route-map)# match ip address 30

B(config-router-map)# set local preferance 500 Highest is best

Session 16 Part 1
BGP Attributes

(Config) # route-map tag permit
(Config-route-map) # match ip address #
(Config-route-map) # set weight _____ default 0
↖ Force — Highest is best
outgoing traffic — Cisco attribute (never advertised) locally significant
(Config-route-map) # set local preference _____ default 100
Highest is best
Standard attributes (advertised inside AS only)

(Config-route-map) # set metric _____ default 0
↖ Force — Least is best
incoming traffic — advertised to all ASs (eBGP, iBGP)
MED (Multi Exit Discriminator)
(Config-route-map) # set as-path prepend _ _____ ... default no extras
Least is best



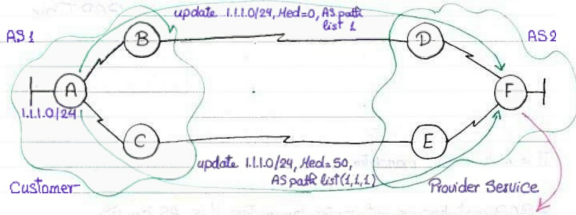
(A) BGP Table

network /mask	N.H	W
> 2.2.2.0 /24	B	50 → 0
2.2.2.0 /24	C	0

(A) BGP Table

network /mask	N.H	ω	L.P
> 2.2.2.0 /24	B	0	200 → 100
2.2.2.0 /24	C	0	100

Set weight 50 (on A) (on B) Set local preference 200



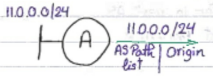
BGP Table :

network /mask	N.H	ω	L.P	Med	AS
> 1.1.1.0 /24	D	0	100	0	1
1.1.1.0 /24	E	0	100	50	1,1,1

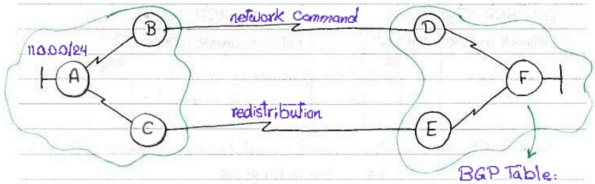
on E or C :
Set metric 50

Session 16 Part 2

5. Origin Attribute :
It is well known mandatory.
in each update



0 → network Command (is prefered).
1 → redistribute into BGP



>	11.0.0.0 /24	D	0
	11.0.0.0/24	E	1

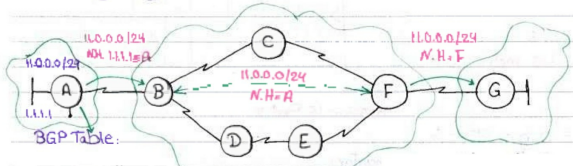
7. Next Hop Attribute:

It is well known mandatory.

in each update

in BGP next hop is not router by router, it is AS by AS.

it is change only in eBGP sessions.



11.0.0.0/24	0.0.0.0 self

in BGP N.H is router in next AS.

least N.H → least loopback

B(config)# router bgp 2

B(config-router)# neighbor internal ip next-hop-self

8. Community Attribute:
VRF (Virtual Routing & Forwarding)...

... * (After changing any BGP Attribute you should clear BGP so attribute can take effect...
#clear ip bgp { ip of neighbor | * { All neighbours } * ...

Session 16 Part 3
EIGRP (Enhanced IGRP)

1. Advanced Distance Vector:
Cisco protocal (Soon will be standard) → IEIF
- mask (classless Protocal).
- multicast (use 224.0.0.10).
- authentication (optional).

2. It is a Simple protocal.
Configuration → Operation

3. Configuration. (Config) # router eigrp AS # (Global Process)
(Config-router) # network ip of interface [w.c.m]

4. Seamless (Same) operation a many different topology.

5. DUAL algorithm.
Choose best path (Successor) and backup path (Feasible successor)

6. Symbol in Routing Table. "D" , "DEX"
internal external

7. Admin. distance = 90 , 170 , 5

8. Metric = $256\left\{\left(K_1\frac{10^7}{BW}\right)+\left(\frac{K_2(10^7/BW)}{256-load}\right)+K_3+(10.delay)+\left(\frac{K_5}{K_4+Reliability}\right)\right\}$

Default K-values $\begin{cases} K_1 = K_3 = 1 \\ K_2 = K_4 = K_5 = 0 \end{cases}$

Default Metric $= 256\left\{\frac{10^7}{BW}+(10.delay)\right\}$

(Config-router) # metric weight 0 1 0 1 0 0 — TOS = Periority

prefered 6 ← 0:7

K = 0:255

K_1 K_2 K_3 K_4 K_5

Session 17 Part 1

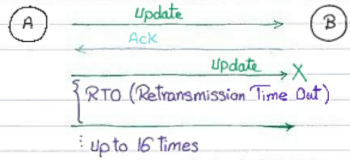
EIGRP Components

EIGRP is a layer 3 protocol no. 88 that needs some other SIWs to operate properly.

- DUAL (Diffusion Update ALgorithm):
  Choose successor (best Path) & feasible successor (backup Path)...

- PDM (Protocol Dependent Module):
  It is SIW adaptible, makes eigrp work with any routed protocol ... IPx, Apple talk, IPv4, IPv6

- RTP (Retransmission Transport Protocol).
  like TCP for eigrp on l3..



Session reset = reset neighbor ship

SRTT (Smooth Round Trip Time)

RTO = n * SRTT

integer number based on interface type

neighbor Failure
16 RTO or 3 hello

EIGRP Tables

1. EIGRP neighbor table :

Directly connected neighbor

#Show ip eigrp neighbor

IPoP neighbor	Interface	SRTT	RTO

2. EIGRP Topology table :

All learnt routes (me & my neighbors routing table) ...

#Show ip eigrp topology

S, FS

#Show ip eigrp topology all-links

S, FS, Non.

3. Routing Table :

All best paths . CEF Search by H/w very speed

#Show ip route .

#Show ip route eigrp.

EIGRP Packets

- Hello
- Update
- Ack .
- Query
- Reply } @change.

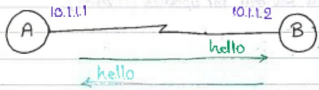
Session 17 Part 2
EIGRP Operation

@Startup:

(Config)# router eigrp AS#
global Process

(Config-router)# network ip of interface [w.c.m]

1. Neighbor Discovery:



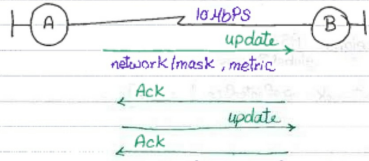
- Neighbor ship Conditions :-
  1. The same subnet.
  2. Same AS # "Global Process".
  3. Same K-values. "MTU is tiebreaker"
  4. Same Authentication (mode, Key).
     null / Hashed (MD5)

(Config)# interface S0
(Config-if)# ip authentication mode eigrp 222 {null | Hashed}
(Config-if)# ip authentication Key-chain medo

(Config)# Key Chain medo
(Config-Key-chain)# Key 1
(Config-Key-chain)# Key-String Cisco 1
(Config-Key-chain)# accept-life time 0:00:00 1-1-2019 (start) 23:59:59 31-1-2019 (end)
(Config-Key-chain)# Key 2
(Config-Key-chain)# Key-string Cisco 2
(Config-Key-chain)# accept-life time 0:00:00 1-2-2019 23:59:59 28-2-2019

Session 17 Part 3

2. Routes Discovery:



EIGRP reserve 50% of BW max. for updates (if exist)...

(Config) # interface S0
(Config-if) # ip bandwidth-percentage eigrp 222 ____
% "default 50"

⇒ Building Topology Table:

Choose Successor & Feasible Successor
- Best Path — least metric
- Backup Path — achieve feasibility conditions

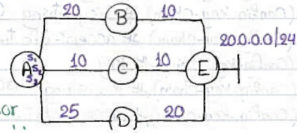
$FD(S) > AD(FS)$

FD: Feasible distance (Full distance)
metric from my router till dst network.

AD: advertised distance (reported distance)
metric between my neighbor & dst network.

Topology Table| A

20.0.0.0/24	FD	AD	
Via B	30	10	FS
Via C	20	10	Successor



A(Config) # access-list 64 permit 20.0.0.0
A(Config) # router eigrp 222
A(Config-router) # offset-list 64 S_2 4
↳ offset adder

20.0.0.0/24	FD	AD	
via B S_1	30	10	FS
via C S_2	24	14	S
via D S_3	45	20	FS

Unequal loadsharing :
(Config) # router eigrp 222
(Config-router) # variance integer 1-255 "default 1"

In routing table ⇒ metric least ⇒ metric * variance

Feasible condition achieved
#Show ip protocals

Session 18 Part 1
EIGRP Operations

@start up

1. Neighbor Discovery.

2. Routes Discovery.

- Summarization:

EIGRP by default support auto-summary

(Config) # router ____
(Config-router) # no auto-summary

Manual Summary:

(Config) # interface S0
(Config-if) # ip summary-address eigrp 1 Summary mask [distance]
by default 5

- RIPv2:

(Config-if) # ip summary-address rip network mask

- OSPF:

ASBR (Config-router) # summary-address network mask
manual summary for networks known by Type 5 LSA

ABR (Config-router) # area __ range network mask
manual summary for networks known by Type 3 LSA

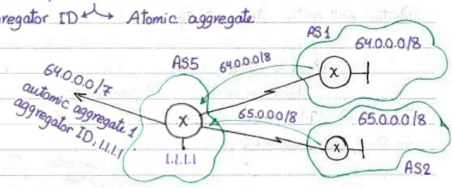
_BGP:

(Config-router) # aggregate-address network mask [summary-only]

default BGP will advertise details + summary

2 extra optional attributes

aggregator ID ↔ Atomic aggregate



Session 18 Part 2

@Convergence:

- no periodic update.
- Periodic hello.

every 5 sec
- Ethernet / HPLS
- PPP / HDLC
- FR / ATM / X.25 if speed > T1

every 60 sec
- FR / ATM / X.25 if speed ≤ T1

_RIPv2 : Periodic update every 30 sec.

_OSPF : Periodic LSA every 30 min (for LSDB refreshment).
Command to cancel it.

_BGP : No periodic update.

@change:

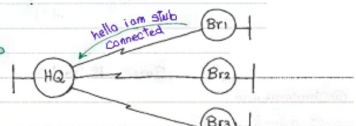
_IP routing disabled eigrp :

(Config) # no router eigrp 222

- If best path failed & there is FS.
  the router will use FS.

- If best path failed & there is no FS.
  Router will go to Active State
  Out of Convergence. Send queries to all neighbors & will never return to Passive State (Converged) Unless all replies back ...
  Stuck in active, To cancel it
  EIGRP Stub: hub & spokes
  on Br1, Br2 and Br3.

(Config) # router eigrp 222
(Config-router) # eigrp stub



(Config-router) # eigrp stub [connected | summary | receive-only | static]
by default

Session 18 Part 3
Private WAN Switching Topology

- Circuit Switching:
  Point-to-Point Topology

  ex: HDLC & PPP
  Cisco 1% | Standard 99%
  Address: no address
  Switch thousands of Frames per second.

- Packet Switching: star Mesh
  Flexible topology (P-P, P-M, M-M)
  ex: X.25, FR, ATM
  45Kbps 45Kbps 40Kbps
  Address:
  X.25 no. (8 bit, 0-255) , DLCI (10 bit, 0-1023) , VPI/VCI (16 bit, 0-65535)
  Switch thousands of PPS (Packet Per second).

- Ethernet Switching :
  - Flexible topology.
  - ex: Metro ethernet
    - using fiber (100Km, 100GBps)
  - Address : MAC (48 bit)
  - low delay (low latency)
  - expensive ...
  - Switch millions of pps.

- Label Switching (Tag Switching) :
  - Flexible topology.
  - ex : MPLS (Multi Protocal label switching)
  - Address : label (20 bit)
  - low delay
  - Switch millions of pps.

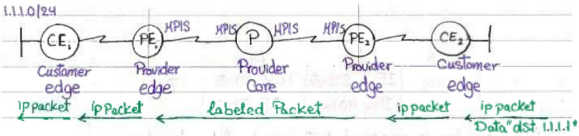
- VPN (Virtual Private Network) :
  - ex : IPsec + GRE → P-P
  - DMVPN → P-M, M-M

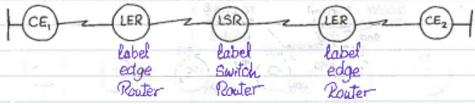
MPLS

It is a new Forwarding Technique based on labels.

Advantage: It is a very low delay technology (use H/W ASIC).

(Config-if) # MPLS ip





Session 19 Part 1

MPLS

It is a new Forwarding technique based on labels.

- hop-to-hop
  - ethernet
  - FR, ATM, X.25
  - PPP, HDLC
  - Switched Protocols
- end-to-end
  - IPx, Appletalk
  - IPv4, IPv6
  - Routed Protocols
- MAC address
- IP address

- MPLS encapsulation (32 bit / 4 byte) : layer 2.5

Label 20 bit	Experimented bit (Traffic class) 3 bits	Bottom of Stack 1 bit	hop limit (T.T.L) 8 bit

0:15 reserved

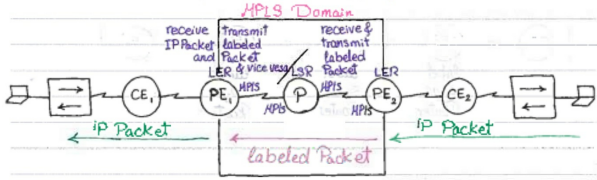
QOS (Quality of Service)
0,1,2,3 data
4 video , 5 voice
6 Routing , 7 switching

1 ≡ 1 label
0 ≡ many labels

avoid loops
hop = any device can understand MPLS(R,S).

L_2	$L_{2.5}$	L_3	L_4		L_2
Ethernet (MAC)	MPLS	IPv4 20byte IPv6 40byte	TCP 20byte UDP 8byte	Data	CRC

MPLS header is imposed between L_2 & L_3 headers...



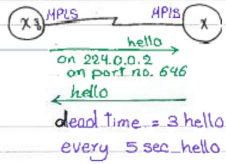
To Build label table : we need signaling protocal (exchange of label information between routers) ...
ex: TDP Tag Distribution Protocal Cisco (Port 711).
LDP Label Distribution Protocal Standard (Port 646).

* ARP : Layer 2.5 Signaling only used MAC & IP *

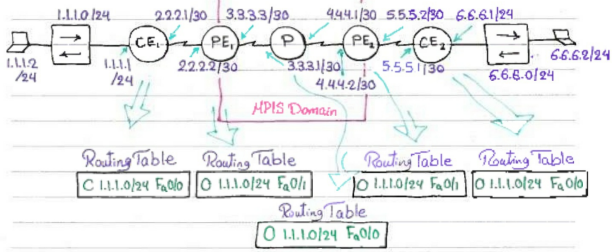
Session 19 Part 2
LDP Operation

1. Neighbor Discovery :-
"exchange of hello"
(config) # ip cef
(config) # interface S0
(config-if) # mpls ip

Show mpls neighbors



2. Labels Discovery : (config-if) # mpls label protocal {LDP|TDP|both}
exchange of labels — by default



LFTB (Label Forward Info Base)

PE$_1$ 1.1.1.0/24

In label	Out label	Interface
16	no label untagged	Fa0/1

PE$_2$ 1.1.1.0/24

In label	Out label	Interface
18	21	Fa0/1

P 1.1.1.0/24

In label	Out label	Interface
21	16	Fa0/0

#show mpls forwarding table
#show ip ospf database

Session 20 Part 1

MPLS Applications

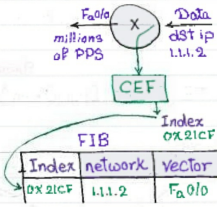
[1] Faster Switching :

Routing Table — LDP — 1.1.1.0/24 label 16 تولي

LF-IB (Label Forward Info Base)

In label	Out label	Interface
16	X	Fa 0/0

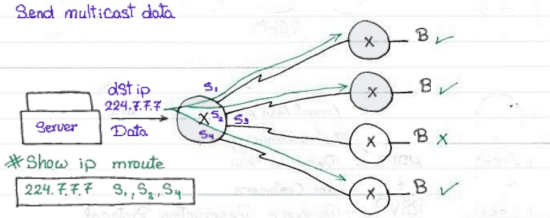
H/W Search CEF



tens of millions of PPS — Fa0/0 — Label 16

[2] Multicast Routing :

Send multicast data

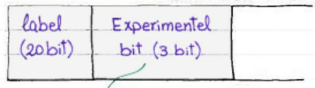


*Show ip mroute

224.7.7.7	S1, S2, S4

MOSPF — Multi OSPF Type 6 LSA ⇒ DVMRP (Distance vector Multicast routing Protocal) ⇒ PIM (Protocal Independent Multicast) ⇒ LDP

3 QoS :



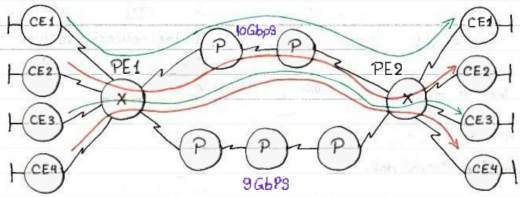
↳ IP Precendence

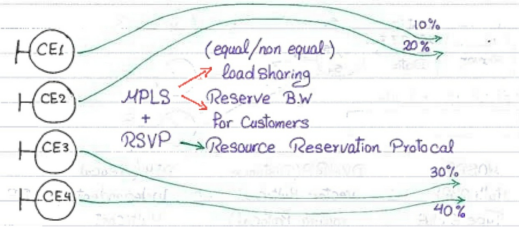
0-7 0,1,2,3 data

4 video 5 voice 6 Routing 7 Switching

Session 20 Part 2

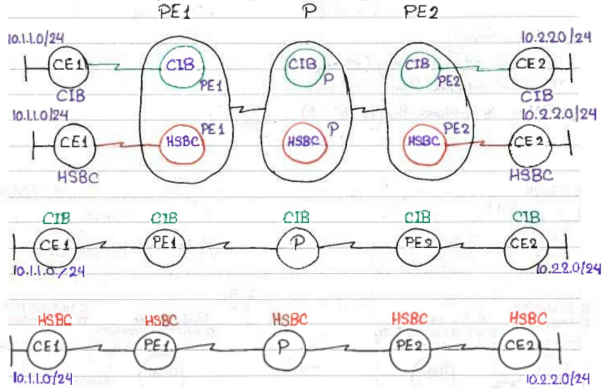
4 TE (Traffic Engineering) :





⑤ MPLS VPN :

Divide SP (Service Provider) network into sub networks called VRF (Virtual Routing & Forwarding).



Control Plane
Routing Protocol
RIP, OSPF, EIGRP, BGP, PIM
Routing Table
LDP
Forward Plane
FIB
LFIB

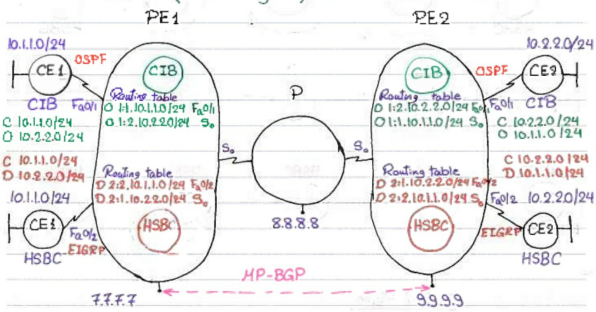
Session 20 Part 3

VRF Virtual Routing & Forwarding

Control Plane	Data Plane (Forwarding Plane)
OSPF + MPBGP	LFIB (using 2 labels)

Address Family:

- IPv4 is address family (32-bit).
- IPv6 is address family (128-bit).
- VPNv4 is address family (96-bit) → RD . IP
  (Route Distinguisher) 64-bit 32-bit



(Config)# ip vrf CIB	(Config)# ip vrf CIB
(Config-vrf)# RD 1:1	(Config-vrf)# RD 1:2
(Config-vrf)# route-target 3:3	(Config-vrf)# route-target 3:3
(Config)# ip vrf HSBC	(Config)# ip vrf HSBC
(Config-vrf)# RD 2:2	(Config-vrf)# RD 2:1
(Config-vrf)# route-target 4:4	(Config-vrf)# route-target 4:4
(Config)# interface Fa 0/1	(Config)# interface Fa 0/1
(Config-if)# ip vrf forwarding CIB	(Config-if)# ip vrf forwarding CIB
(Config)# interface Fa 0/2	(Config)# interface Fa 0/2

MP-BGP (Multi Protocal-BGP)

Understand VPNv4 (96-bit)

RD, RT → Community

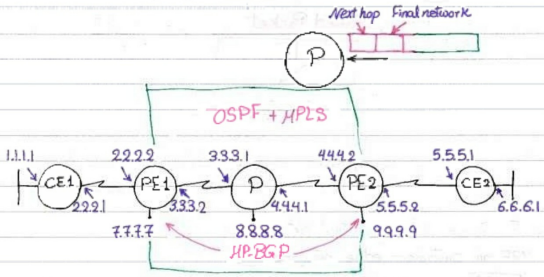
PE1 (Config)# router bgp 1

PE1 (Config-router)# neighbor 9.9.9.9 remote-as 1

PE1 (Config-router)# neighbor 9.9.9.9 update-source lo0

PE1 (Config-router)# address-family VPNv4

PE1 (Config-router)# neighbor 9.9.9.9 activate

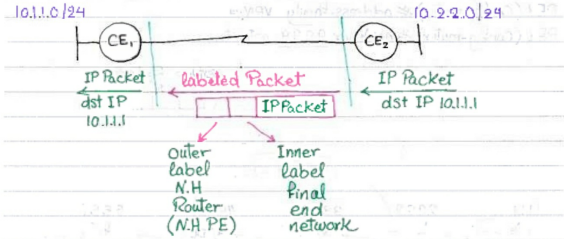


Last

Session 21 Part 1
Virtualization

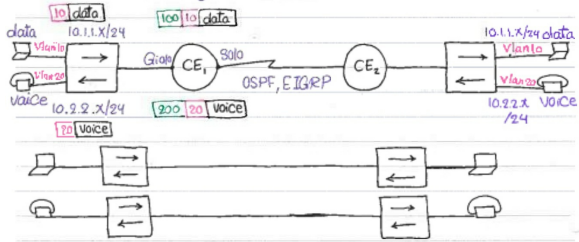
One of the new hot network topics is virtualization (Dividing network into sub networks)..

- It improves network performance.
- It help in network isolation.
- It aids traffic Separation.



VRF lite ≡ EVN (easy virtual Network):

VRF on customer edge network.



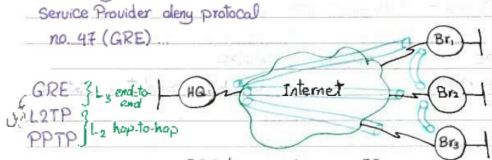
```
CE1(Config)# interface Gi0/0.10
CE1(Config-subif)# ip address 10.1.1.1 255.255.255.0
CE1(Config-subif)# encapsulation dot1q 10
CE1(Config-subif)# vrf forwarding data

CE1(Config)# vrf definition data
CE1(Config-vrf)# vnet tag 100 ← label 1-4094        Vnet = Virtual Network

CE1(Config)# interface Gi0/0.20
CE1(Config-subif)# ip address 10.2.2.1 255.255.255.0
CE1(Config-subif)# encapsulation dot1q 20
CE1(Config-subif)# vrf forwarding voice

CE1(Config)# vrf definition voice
CE1(Config-vrf)# vnet tag 200

CE1(Config)# interface S0/0
CE1(Config-if)# vnet trunk
```

Session 21 Part 2

Public WAN

It is using public network to build private network

Service Provider deny protocol no. 47 (GRE)...



GRE (Tunneling) + IPsec

Generic Routing Encapsulation — Confidentiality — Authentication

ex:

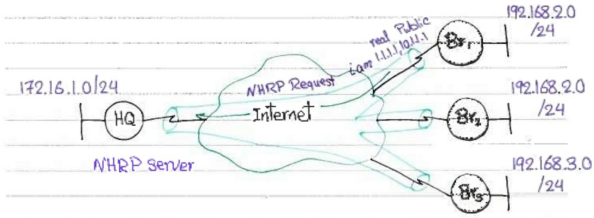
HQ(Config)# interface Tu0
HQ(Config-if)# ip address 10.1.1.4 255.255.255.0
HQ(Config-if)# Tunnel source 4.4.4.4
HQ(Config-if)# tunnel destination 1.1.1.1
HQ(Config-if)# tunnel mode gre default

Br(Config)# interface Tu0
Br(Config-if)# ip address 10.1.1.1 255.255.255.0
Br(Config-if)# Tunnel source 1.1.1.1
Br(Config-if)# tunnel destination 4.4.4.4
Br(Config-if)# tunnel mode gre

Routing Table

C 172.16.1.0/24
C 10.1.1.0/24
D 192.168.1.0/24

- DMVPN (Dynamic Multipoint VPN):
  - NGRE (Multipoint GRE) + IPsec + NHRP (next hop resolution Protocol)



HQ(Config)# interface tuo.
HQ(Config-if)# ip address 10.1.1.4 255.255.255.0
HQ(Config-if)# tunnel source 4.4.4.4
HQ(Config-if)# tunnel protection ipsec
HQ(Config-if)# ip nhrp map multicast

(Config-if)# ip nhrp
nhs 10.1.1.4
next hop server
(Config-if)# ip nhrp
nhs map 10.1.1.4 4.4.4.4