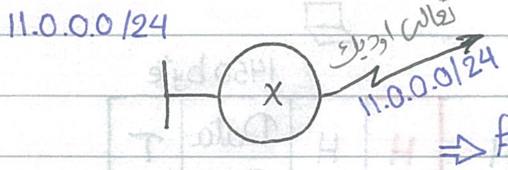
Session 1 Part 1
Routing Overview

Routing Protocol: — Control Plane

It is exchange of information between routers, so as each router tell others about network it can reach.

RIPv1, RIPv2
IGRP, EIGRP
ISIS, OSPF
EGP, BGP
LDP, RSVP, MP-BGP



⇒ Form Routing Table

Routed Protocol: — Forwarding Plane (Data Plane)

It is protocal that carry user data traffic from end to end.

ex: TCP, UDP, IPv4, MPLS

FIB, LF-IB

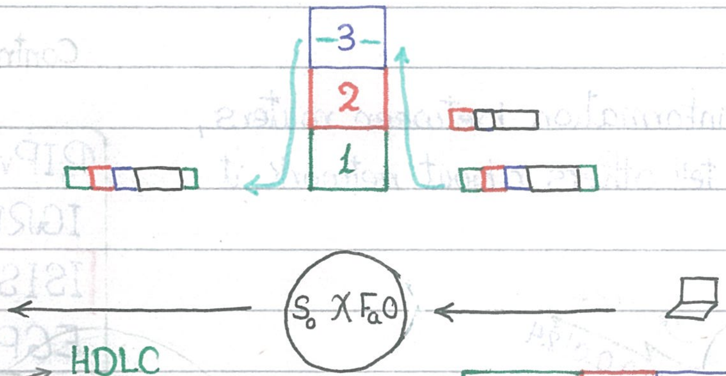
CEF

Application layer	HTTP(80), RIP(520), LDP(646) FTP(20,21), BGP(179), TDP(711) (Cisco) SMTP(25)
Transport layer	TCP, UDP
Internet layer	IPv4
Network Access Layer	Ethernet

TCP/IP Model

PAGE
DATE

Session 1 Part 2
Routing Process



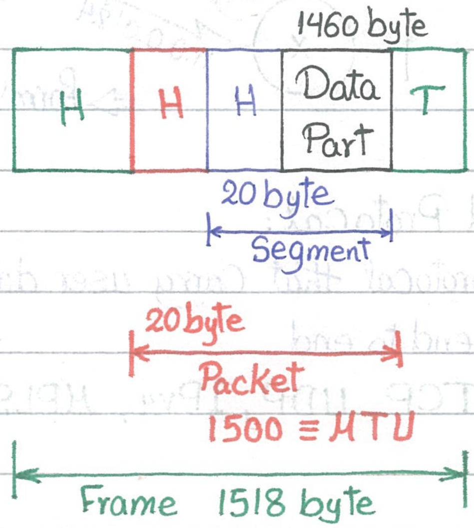
Circuit Switching → HDLC, PPP

Packet Switching → FR, ATM, X.25

Broad Band → PPPOA, PPPOE

Label Switching → MPLS

Ethernet Switching → Ethernet



Routing Table → FIB Table → LF-IB Table

Session 1 Part 3
Routing Classification

Static Routing:

- If network is simple.

  If single path exists to DST.

- Built routing table manually.

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

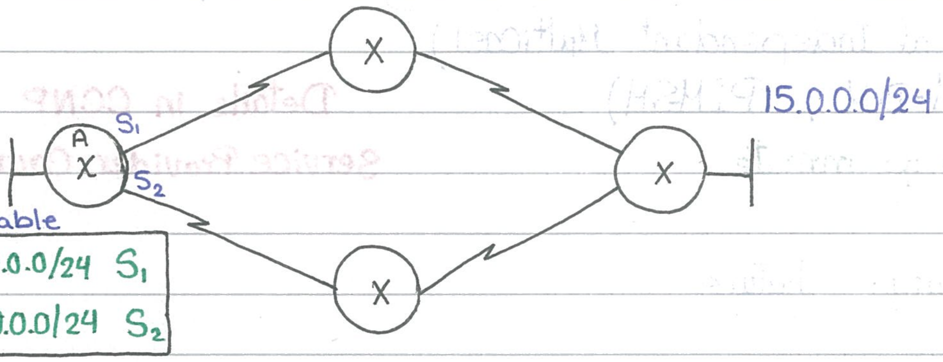
destination البعيدة — network

1-255 — distance

exit interface / ip of next router — vector

Community refer to vrf — name

ex:



routing table

S	15.0.0.0/24	S_1
S	15.0.0.0/24	S_2

A(Config) # ip route 15.0.0.0 255.255.255.0 S_1 } load sharing
A(Config) # ip route 15.0.0.0 255.255.255.0 S_2 } (load Blancing)

OR

A(Config) # ip route 15.0.0.0 255.255.255.0 S_1 10 → Primary Path
A(Config) # ip route 15.0.0.0 255.255.255.0 S_2 20 → Backup Path

Dynamic Routing:

- IP network is Complex. many paths exist to dst.
- Building routing table automatic. (S/W Protocal)

IGP/EGP

Interior / Exterior Gateway / Gateway Protocal / Protocal

Inside AS / between AS

ex: RIPv1, RIPv2, ISIS, OSPF, IGRP, EIGRP — ex: EGP, BGP

Classless/Classful Protocals

Understand Subnetting — Doesn't send mask in updates

ex: RIPv2, ISIS, OSPF, EIGRP, BGP — ex: RIPv1, IGRP, EGP

تعالى اوديك

Distance Vector: exchange routing table without mask ex: RIP, IGRP

Advanced Distance Vector: exchange routing table with mask using multicast ex: RIP2, EIGRP

Link state: exchange LSA with mask using multicast ex: isis, OSPF خد اوريك

Path vector: exchange routing table with rich attributes ex: EGP, BGP

Multicast Routing:

Class D 224.x.x.x → 239.x.x.x

MOSPF (Multicast OSPF).

DVMRP (Distance Vector Multicast Routing Protocal).

PIM (Protocol Independant Multicast).

PIM_2 (PIM-DM, PIMSM). Details in CCNP Service Provider Course

#show ip mroute

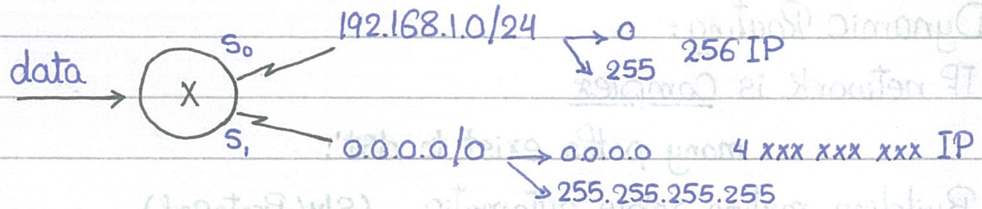
Segment Routing: Future

Session 1 Part 4
Routing Table Search

Best Path is:

1. Longest bit match:

longer mask ≡ more accurate



2. Least admin. distance:

Protocal	Admin. Distance 0-255	
Connect	0	
Static	0, 1	vector is Interface name, IP of next hop
RIP	120	
OSPF	110	
EIGRP	90, 170, 5	Internal, External, Summary
ISIS	115	
BGP	20, 200	External, Internal

It's for cisco only default & can be changed

بعض الشركات الاخرى تستخدم ارقام مختلفه ولكن بنفس الترتيب

3. Least Metric :

Hop (RIP) , Cost (OSPF) , BDRLH (EIGRP)
Expense , Error (ISIS) .

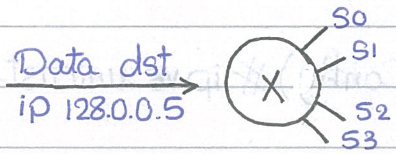
4. Equal loadsharing:

Up to 4 paths by default, maximum by configuration 16 or more

(Config)# router Protocal
(Config-router)# maximum-paths $\frac{\text{1-16 or 256}}{\text{default 4}}$

ex:

O	128.0.0.0/26	S0	→ 0 → 63
D	128.0.0.0/8	S1	→ 128.0.0.0 → 128.255.255.255
R	128.0.0.0/24	S2	→ 0 → 255
S*	0.0.0.0/0	S3	→ 0.0.0.0 → 255.255.255.255



worst bit match

اخر ملاز علشان توصل
data لكل البلاز

Session 2 Part 1

Routing Procedure

1. Check IOS Capability for routing & routed protocal.

IOS XE } Cisco — ISIS — IPv4

IOS XR — BGP — IPv6

JunOS } Juniper

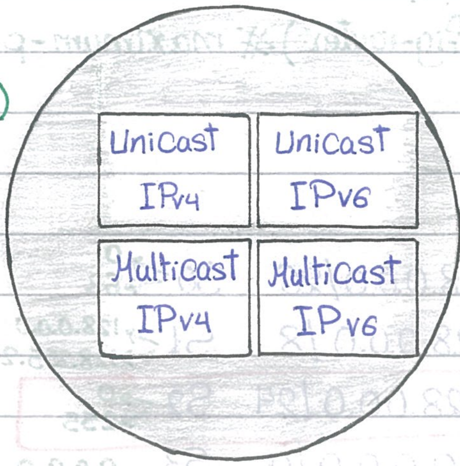
2. Enable router processor.

(Config)# ip routing (enable by default)

(Config)#ip multicast-routing

(Config)# ipv6 unicast-routing

(Config)# ipv6 multicast-routing



3. Create routing process (routing instance).

(Config)# router Protocal

4. Activate routing process on interface.

(Config-router)# network ip of interface

OR...

(Config)# interface name

(Config-if)# ip Protocal

5. Exchange of updates.

Send / Receive

6. Building routing table.

Routing Table:

Protocal	Network / mask Prefix / Prefix length	Distance	Vector	Time
		[admin. distance / metric]	exit interface & IP of next hop	Period from add route to routing Table

ARP Table

IP	MAC

IARP Table

IP	DLCI

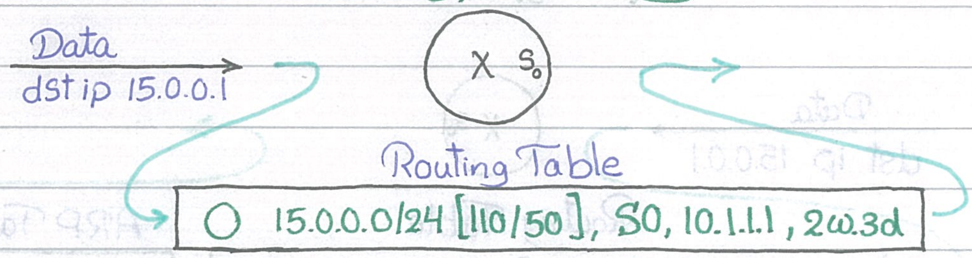
Session 2 Part 2
Routing Generations

1st generation:

Always routing (normal routing) ≡ Sequencial search

Route thousonds of pps.

(Config)# ip routing



2nd generation:

Route once, Switch many.

Route tens of thousonds of pps.

(Config)# ip routing

(Config)# ip route-cache

Data 2
dst ip 15.0.0.1

Data 1
dst ip 15.0.0.1

X S_0

Routing Table

O 15.0.0.0/24 [110/50], S0, 10.1.1.1, 2w.3d

Route cache

O 15.0.0.0/24 [110/50], S0, 10.1.1.1, 2w.3d

#Show route-cache
#Show ip cache

3rd generation:

Always switching (Pointer Search).
Route millions of pps.

(Config)#ip routing
(Config)# ip cef

Data
dst ip 15.0.0.1

X S_0

Routing Table

O 15.0.0.0/24 [110/50], S0, 10.1.1.1, 2w.3d

ARP Table

10.1.1.1	A

بتستف ال routing table
تستيفه عشان H/W search

0x2183 CEF Cisco Express Forward

FIB Table (Forwarding Info Base)

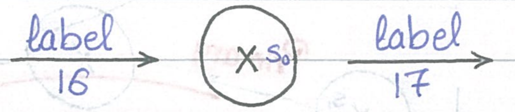
0X2183	15.0.0.0/24	S0	A

#Show ip cef

4th generation :

Route ten of millions of pps.

"MPLS"



LF-IB (label forwarding info base) | 16 S0 17 |

5th generation :

Route hundred of millions of pps.

"Segment Routing"

Session 2 Part 3
static & default static routes

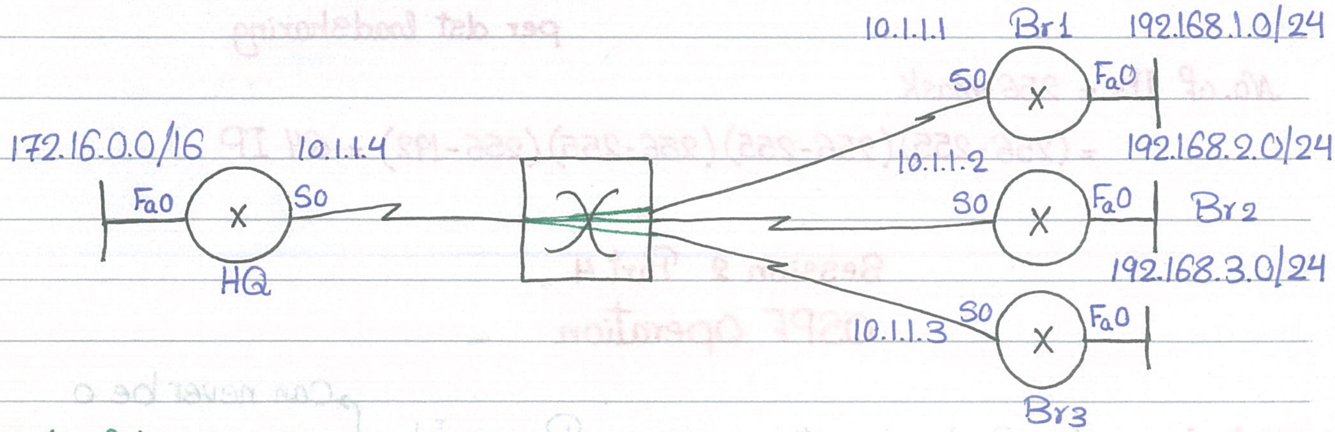
(Config)# ip route network mask vector [Distance] [tag name]

exit Interface → circuit switching only

IP of next hop → every time

بيعمل Search مرتين في routing table لو كتبت ده في P-M مش هيعرف

مرة علشان network ومرة علشان exit interface يروح فين ف drop



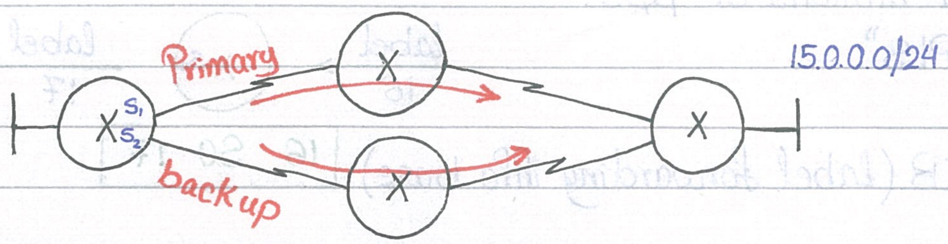
HQ (Config)# ip route 192.168.1.0 255.255.255.0 10.1.1.1

HQ (Config)# ip route 192.168.2.0 255.255.255.0 10.1.1.2

HQ (Config)# ip route 192.168.3.0 255.255.255.0 10.1.1.3

Brx (Config)# ip route 0.0.0.0 0.0.0.0 10.1.1.4

Active / Backup scenario (floating static):



(Config) # ip route 15.0.0.0 255.255.255.0 S_1 Primary Path
(Config) # ip route 15.0.0.0 255.255.255.0 S_2 10 backup Path

Equal loadsharing / Loadbalance:

(Config) # ip route 15.0.0.0 255.255.255.0 S_1
(Config) # ip route 15.0.0.0 255.255.255.0 S_2

Unequal loadsharing / load balance:

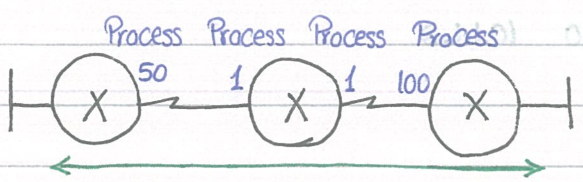
(Config) # ip route 15.0.0.0 255.255.255.0 S_1 (0-255)
(Config) # ip route 15.0.0.0 255.255.255.192 S_2 (0-63) longest bit match
per dst loadsharing

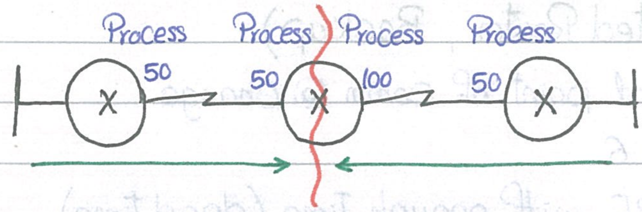
No. of IPs = 256-mask
= (256-255)(256-255)(256-255)(256-192) = 64 IP

Session 2 Part 4
OSPF Operation

@startup : (Config) # router OSPF Process Id
locally significant

- 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.

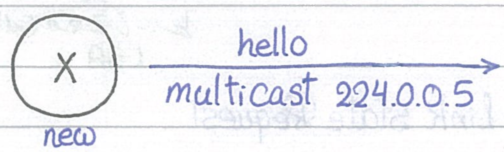
0.3 - Highest physical active interface IP.

ethernet serial Up

** Can't create OSPF without router id **

** Each process id has router id **

1- Neighbor Discovery (hello protocol):



Neighborship Conditions:

- Same subnet.
- Same area id / area type.
- Same Authentication method & key.
- Same hello & dead time.

Two way state

Build OSPF neighbor table:

Neighbor ID	state	Interface	IP of neighbor

Show ip OSPF neighbor

2. DR & BDR Election (Designated Router, Backup):

welcome new comers and facal point of comm @ change.

DR & BDR multicast 224.0.0.6

@ Router that 1^{st} boots OSPF with enough Time (dead time).

ⓑ Router having highest priority per interface (by default = 1).

priority 0 can never be DR or BDR ...

(Config-if) # ip ospf priority 0-255

ⓒ Router has highest RID.

3. Router Discovery:

exchange of LSDB (all LSAs).

← Here is DBD — Data Base Description

LSAid	Adv Router	Seq #	Check Sum	Link count
x.x.x.x	x.x.x.x	0X 80000001	0x	
		عدد التغيرات اللي حصلت على LSA		عدد Interfaces اللي بتحكي عنها LSA

Ack →

LSR → Link State Request

i need LSAs with id ...

← LSU — Link State Update

here are details about LSAs you requested it

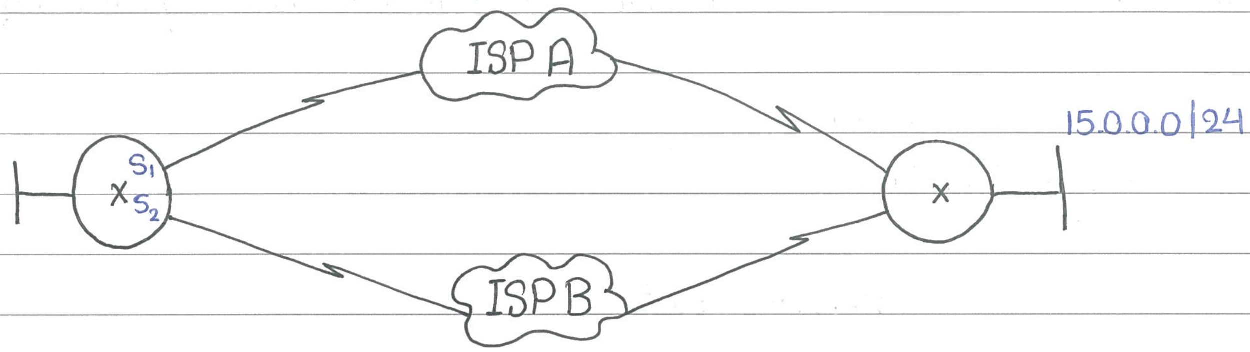
Ack → Full state

Session 3 Part 1

Case Study

Using static route only satisfy the following:

- Data destined to 15.0.0.0 → 15.0.0.15 should go through ISP A.
- Data destined to 15.0.0.16 → 15.0.0.255 should go through ISP B.
- Data destined to 15.0.0.50 & 15.0.0.100 should be dropped.



(Config) # ip route 15.0.0.0 255.255.255.240 S_1 0 15
(Config) # ip route 15.0.0.0 255.255.255.0 S_2 0 255
(Config) # ip route 15.0.0.50 255.255.255.255 null0
(Config) # ip route 15.0.0.100 255.255.255.255 null0

OSPF in Single Area

@ start up:

Operation:

1. Create RID. manual, highest loopback, highest active physical interface
2. Neighbor discovery. exchange of hello
3. Electing DR/BDR. first to run OSPF, highest priority, highest RID.
4. Routes discovery. exchange of LSDB
5. Choosing best path using Dijkstra (SPF algorithm).
6. Building forwarding table.

@Convergence: —: Periodic hello:-

Point to point: HDLC, PPP

Broadcast Multiple Area (BMA): Ethernet > every 10sec/40sec

Non Broadcast Multiple Area (NBMA): x.25, FR, ATM every 30 sec/120 sec

Periodic LSA every 30 min for LSDB refreshment.

@Change:

Router that feels the change will generate new LSA with new sequence no.

→ update LSDB.

→ New Dijkstra calculation.

→ Update routing table.

Session 3 Part 2

OSPF Multiple Area

Divide main AS into sub ASs called Areas.

* Types of Routers:

1. ABR (Area Border Router).
2. ASBR (AS Boundery Router).
3. Internal Router.
4. Backbone Router "Can be internal, ABR or ASBR"

   router has one interface at least in area zero.

* Types of LSAs:

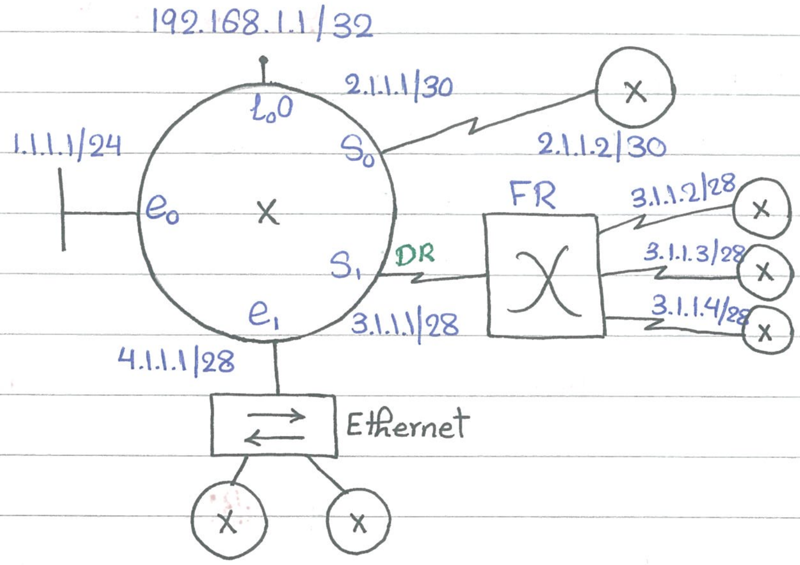
1. LSA Type 1 (Router LSA):

It is generated by each router, describing:

1. Interface IP.
2. Neighbor IP (optional).
3. Link mask.
4. Link Cost. $10^8/BW$
5. Link Type. P2P, Transit, stub, virtual link

6. Router Type.

LSA Id = RID



※ Show ip ospf database — DBD

LSA Id	Adv. RID	Seq ※	Link Count	Checksum
192.168.1.1	192.168.1.1	0X8 000 000 1	6	0X21BF

※ Show ip ospf database router — LSU

Interface IP / link mask	Cost	Link Type	Neighbor IP
1.1.1.1 / 24	10	Stub	
2.1.1.1 / 30	64	P2P	2.1.1.2
3.1.1.1 / 28	64	Transit	Type 2 LSA
4.1.1.1 / 28	64	Transit	Type 2 LSA
192.168.1.1 / 32	1	Stub	

Router Type : Internal Router

2. LSA Type 2 (Network link LSA) :

It is generated by DR, describing:

1. DR ID .. 192.168.1.1
2. List of losers. 3.1.1.2 , 3.1.1.3 , 3.1.1.4

LSA Id = IP of winning Interface

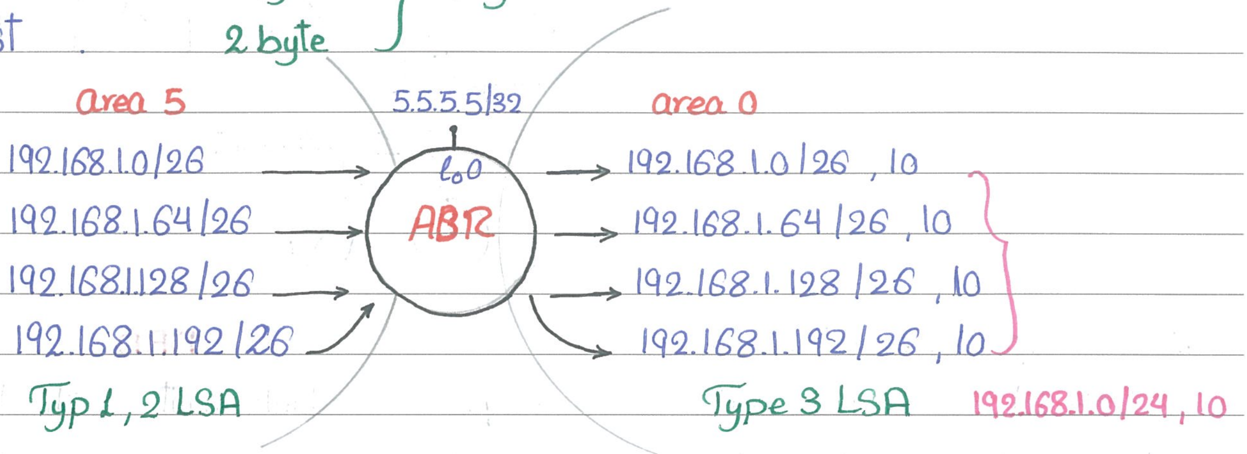
3. LSA Type 3 (Summary LSA):

It is generated by ABR, describing:

1. Network Id . 4 byte
2. Mask . 4 byte
3. Cost . 2 byte

$\left.\right\}$ 10 byte

LSA Id = Network Id



ABR (Config)# router ospf 1

ABR (Config-router)# area 5 range 192.168.1.0 255.255.255.0

#Show ip ospf database — DBD

LSA Id	Adv. RID	Seq #	Check sum
192.168.1.0	5.5.5.5	0X 8000 0001	0X1401

Show ip ospf database Summary — LSU

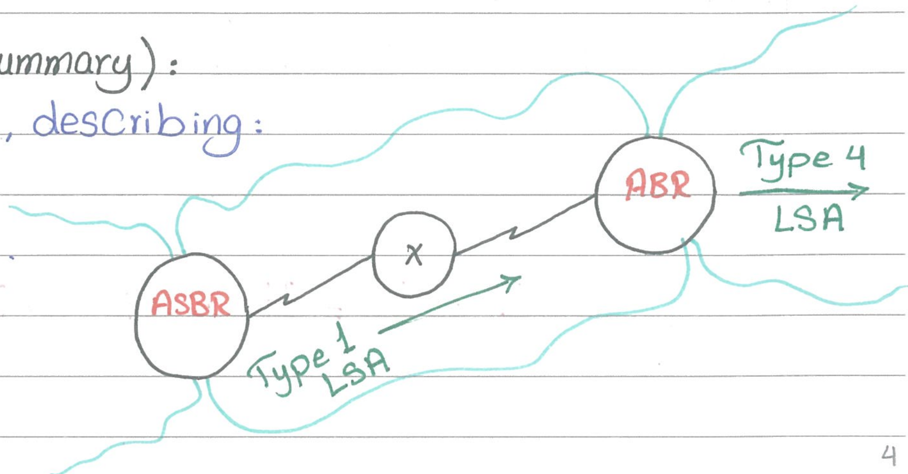
Network Id	/mask	Cost
192.168.1.0	/ 24	10

4. LSA Type 4 (ASBR Summary):

It is generated by ABR, describing:

1. RID of ASBR
2. Cost to reach ASBR.

LSA Id = ASBR ID



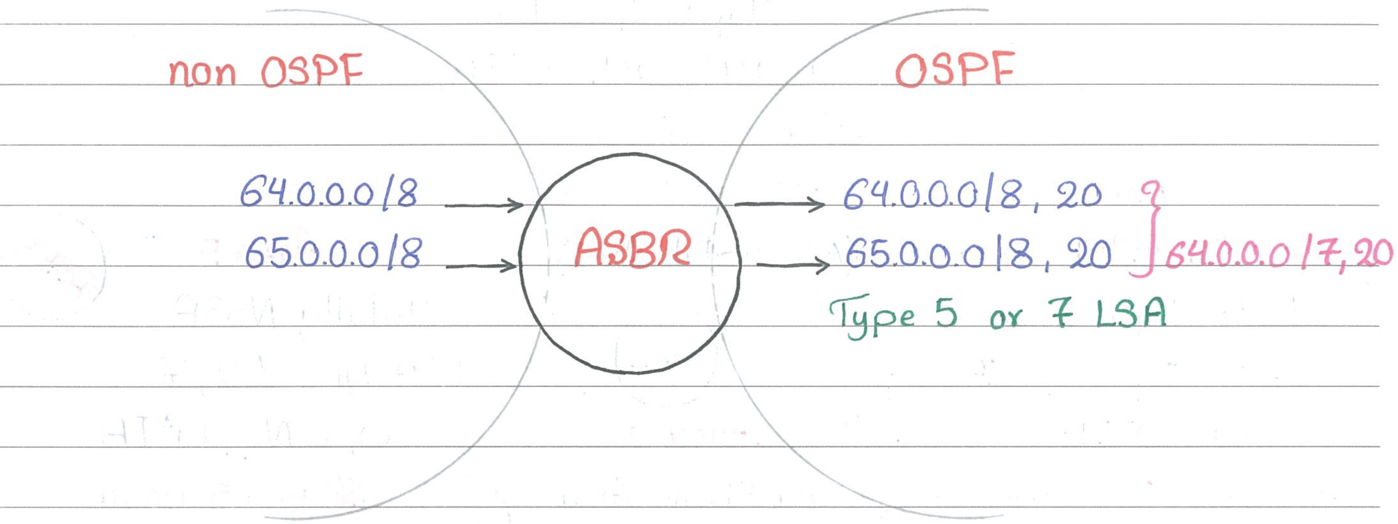
5. LSA Type 5 / Type 7 (External / External NSSA):

It is generated by ASBR, describing:

1. Network . 4 byte
2. Mask . 4 byte
3. Cost . 2 byte

} 10 byte

LSA Id = Network Id



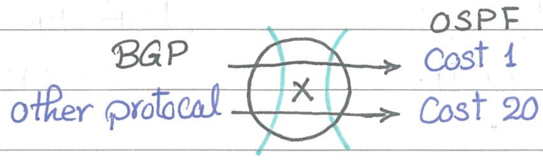
ASBR(Config)# router ospf 1
ASBR(Config-router)# Summary-address 64.0.0.0 254.0.0.0

⇒ Redistribution to OSPF:

Metric Type:

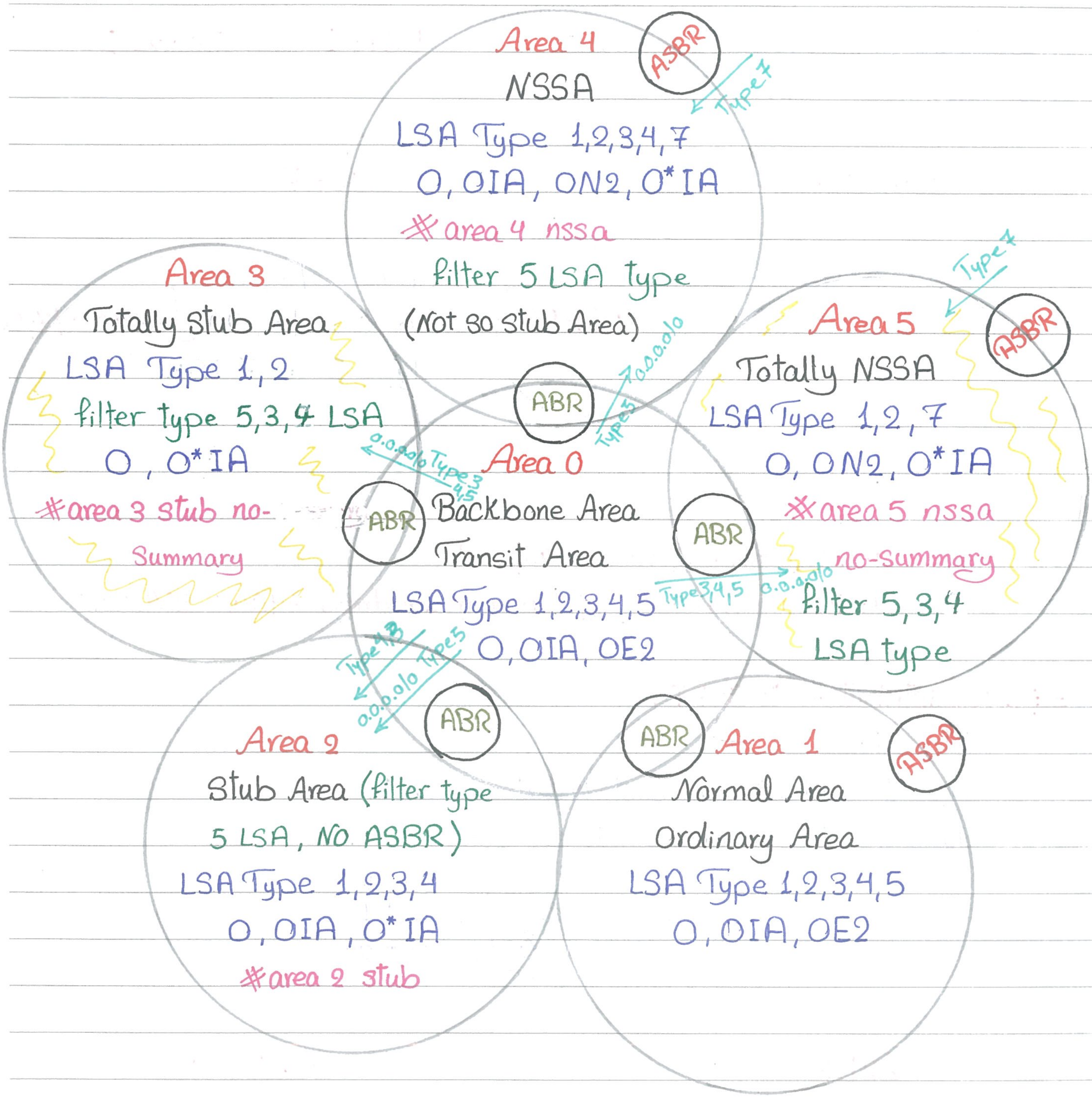
Type 1 add internal cost to external cost.

Type 2 (default) ignore internal cost.



LSDB			Routing Table
Type 1 LSA	Type 2 LSA	Intra area	O
Type 3 LSA	Type 4 LSA	Inter area	OIA
Type 5 LSA	Type 7 LSA	External	OE_2, ON_2, OE_1, ON_1

Session 3 Part 4
Types of Areas



Session 4 Part 1

ISIS Over View

why we use ISIS ?

open standard → developed before OSPF

1. It is the most robust (متين) routing protocal in ISP industry.

   AT&T, Flag, TATA, OBS, VIS, Noor ...

2. It is Simpler, more stable and more scalable then OSPF.

3. It is well oriented for any new routed protocals (routed protocal independent) because it is layer 2.5 protocal (under layer 3).

H	ISIS msg	T

why ISIS is not widely spread ?

1. Modern bussiness prefer OSPF because OSPF has more feature (easier troubleshooting)..
2. Lack of expertise knowing about ISIS (lack of educational resource).

ISIS is OSI model routing protocal:

TCP/IP	OSI	
Host	ES	end system
Router	IS	intermediate system
AS	Domain	
ARP	ES-IS	
IP protocal	CLNS	Connection-less network service
IP header	CLNP	Connection-less network protocal
IP address	NSAP	network service access point
layer 2 address	SNPA	sub network point of attachement
DLCI, VPI/VCI ≡ MAC		

Session 4 Part 2
OSI Addressing

identifies any system in the OSI model

NSAP address Contains :

1. Domain ID . (Private Domain 49) ...
2. Area ID .
3. System ID .
4. NSEL (network selector). Function of device

   00 for Routers

In Hexadecimal .

Domain ID	Area ID	System ID	NSEL
1 byte	1-12 byte	6 byte	1 byte

NSAP address for router ≡ NET address (network entity title) ...

(Config) # router isis
(Config-router) #net ____RID____

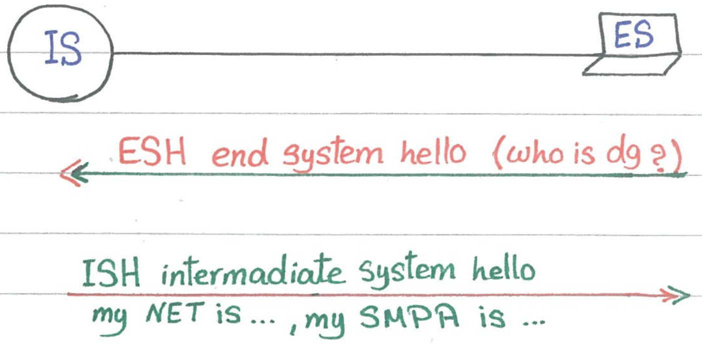
Rules of IOS addressing:

1. Router should have only one NSAP = NET .
   IOS address is assigned to the system, not to the interface ...
2. System id should be unique in side Area (It can be used again in another area). It must have the same length for all ISs & ESs within the domain ...
3. All routers in same area should have same area id .

Session 4 Part 3
OSI Routing levels

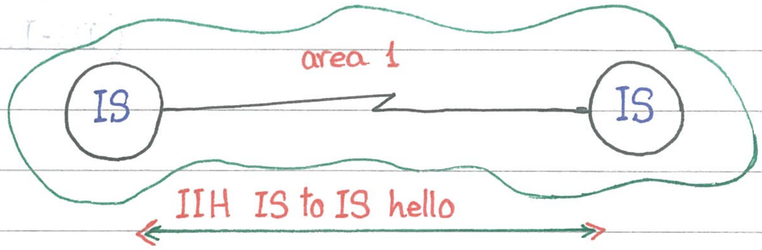
Level 0 Routing :

Between ES & IS . ex: ES-IS protocal .



Level 1 Routing:

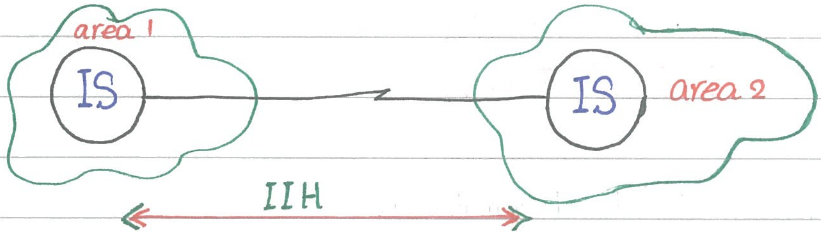
Between IS & IS inside same area.



ISIS Protocal

Level 2 Routing:

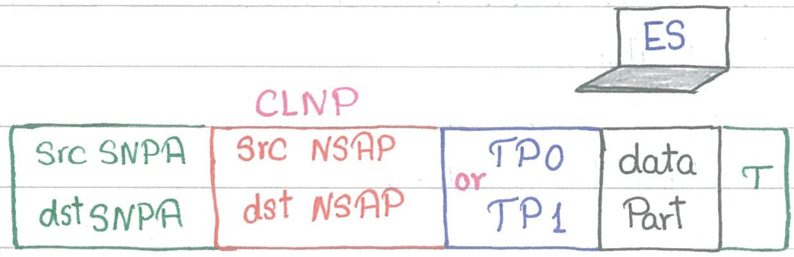
Between IS & IS in different areas.

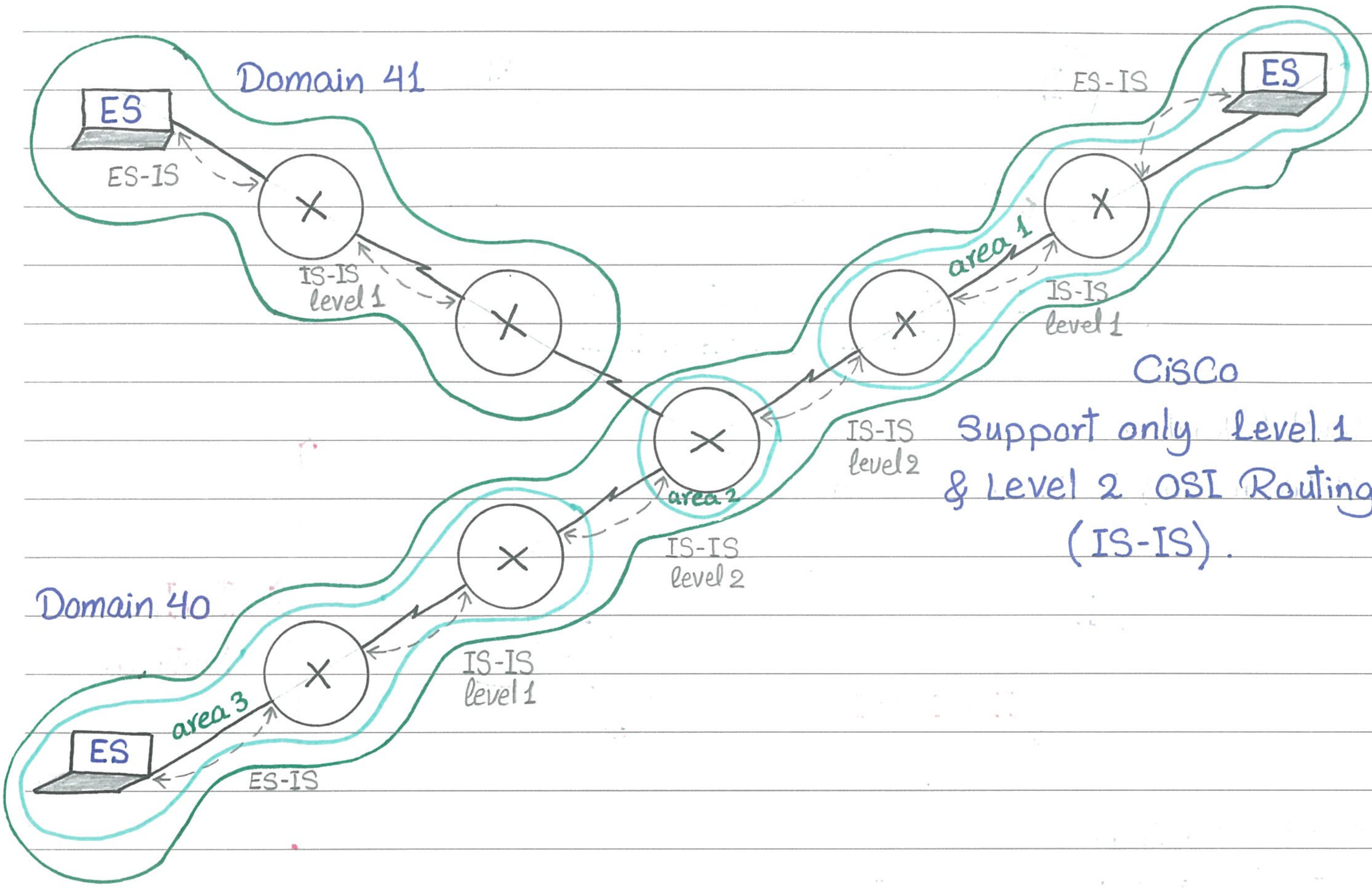


Level 3 Routing:

Between IS & IS in different domains. It's not supported by Cisco.

ex: IDRP (Inter Domain Routing Protocal).

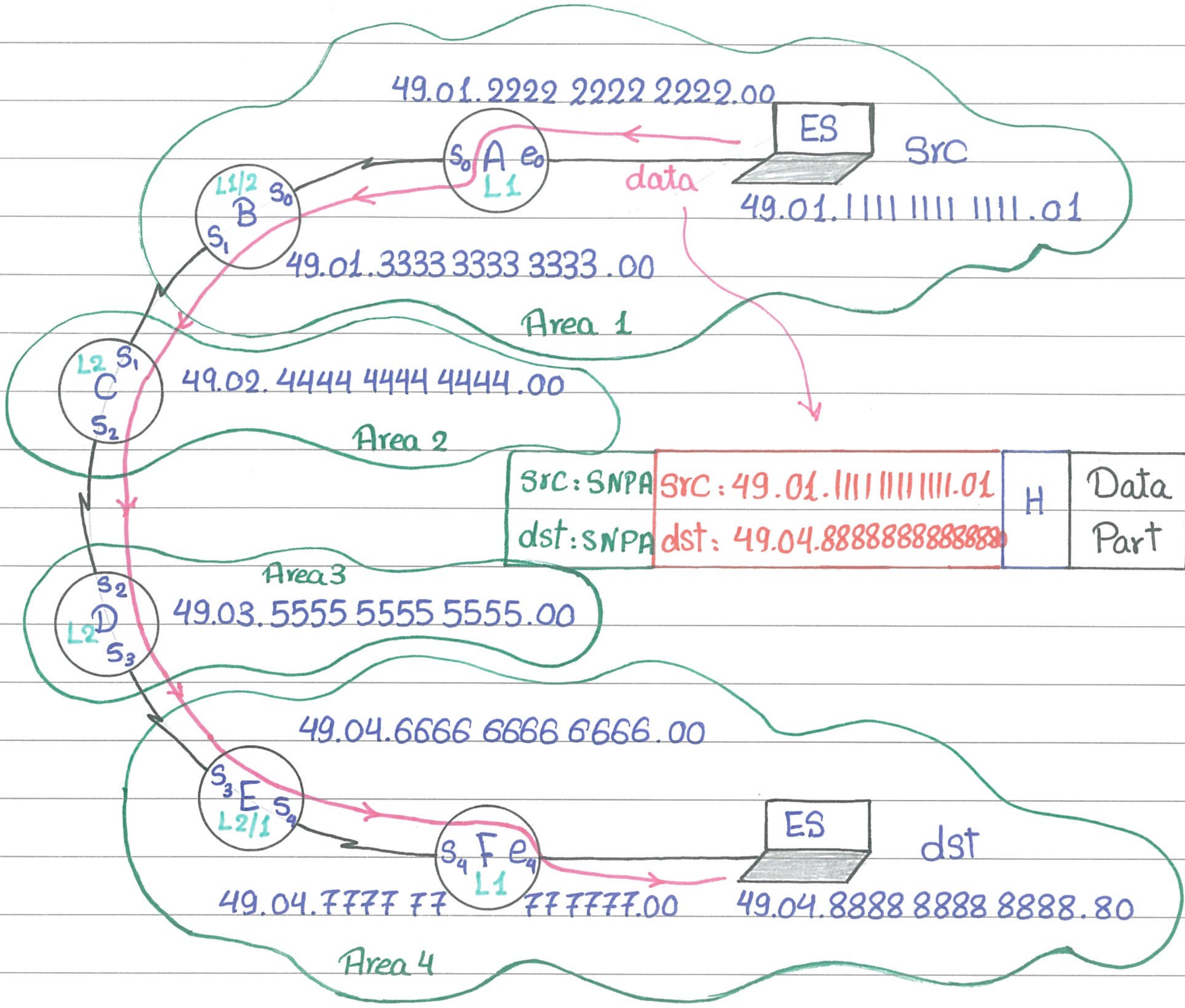




CisCo
Support only Level 1 & Level 2 OSI Routing (IS-IS).

Session 4 Part 4
ISIS Features

1. It is Link State open standard protocal.
2. It uses Dijkstra Algorithm to Calculate best path.
3. It supports Level 1 & Level 2 routing.
   intra area — inter area
4. IS-IS router types:
   * Level 1 Router:
     Form only L1 LSDB that contains only system id.
   * Level 2 Router:
     Form only L2 LSDB that contains only area id.
   * Level 1 / Level 2 Router:
     Form both L1 & L2 LSDB & send default route to internal routers.



_LSDB L1 "A":

1111 1111 1111	e0
2222 2222 2222	S0
3333 3333 3333	—
0.0.0.0	S0

_LSDB L1 "B":

1111 1111 1111	S0
2222 2222 2222	S0
3333 3333 3333	—

_LSDB L2 "B":

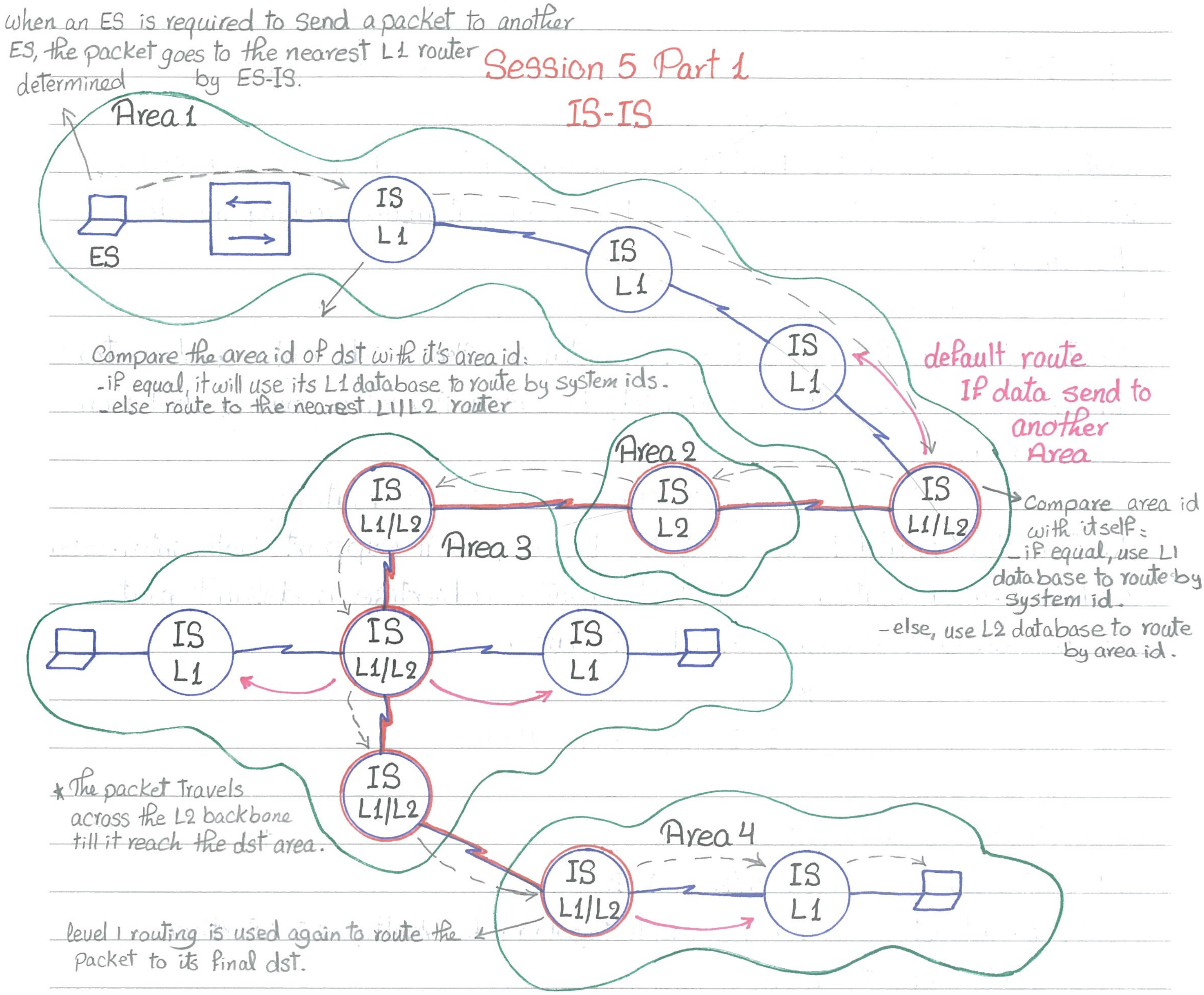
Area 1	—
Area 2	S1
Area 3	S1
Area 4	S1

...

ISIS Routing Process

Session 5 Part 1

IS-IS



- L1 LSDB contain: System id ... Routers make routing inside the area only.
- L2 LSDB contain: Area id ... Routers make routing between areas only.

Notice:

- IS should only exist in one area.
- Each IS need unique NET address.
- IS can have only one NET.
- ISIS backbone is not an area, it is all L2 & L1/2 routers .. Continuous .. Path

⇒ IS-IS Support two routing levels : level 1 & level 2 routing.

Level 1 router : (like OSPF Internal Routers)

Router that build a L1 LSDB Containing System ids only and router interface to reach these System id, because it make routing inside the area only.

Level 2 router : (like OSPF ABR)

Router that build a L2 LSDB Containing area ids only and router interface to reach these area id, because it make routing between areas only.

Level 1/ Level 2 router : (like OSPF backbone routers)

Router that build both L1 & L2 LSDB, so it support both intra-area and inter-area routing, each L1/2 router advertise a default route to all level 1 routers inside its area.

ISIS Operation Modes

1. Point to Point mode.
2. BMA (Broadcast Multiple Access).
3. NBMA (Non BMA) : N/A in ISIS
   - 3.1 _ Broadcast mode for Full mesh topology for multipoint interfaces (will simulate BMA).
   - 3.2 _ Point-to-point mode for Partial mesh point-to-point sub-interface (will simulate point-to-point).

ISIS Operation

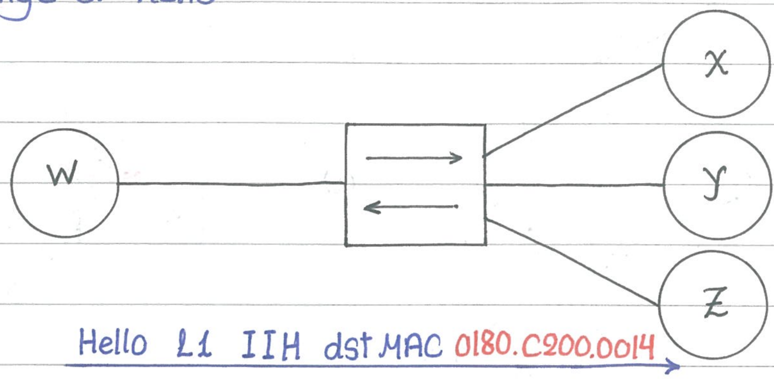
☐ Create ISIS router ID (NET) :

(Config) # router isis

(Config-router) # net <u>domain id</u> . <u>area id</u> . <u>System id</u> . 00

1 Neighbor Discovery:

exchange of hello



Multicast MAC for data
0100.5e xxx xxx
Multicast MAC for signaling
0180.C200.xxxx

Hello L1 IIH dst MAC 0180.C200.0014 →

Hello L2 IIH dst MAC 0180.C200.0015 →

← Hello

2 way state

⇒ Only one neighborship Conditions:

- Same process id.

⇒ Hello interval:

- Hello every 10 sec except DIS (Designated IS) hello every 3.3 sec.

Session 5 Part 2

2 Elect DIS called pseudo node: نقطه وهميه لنقل data

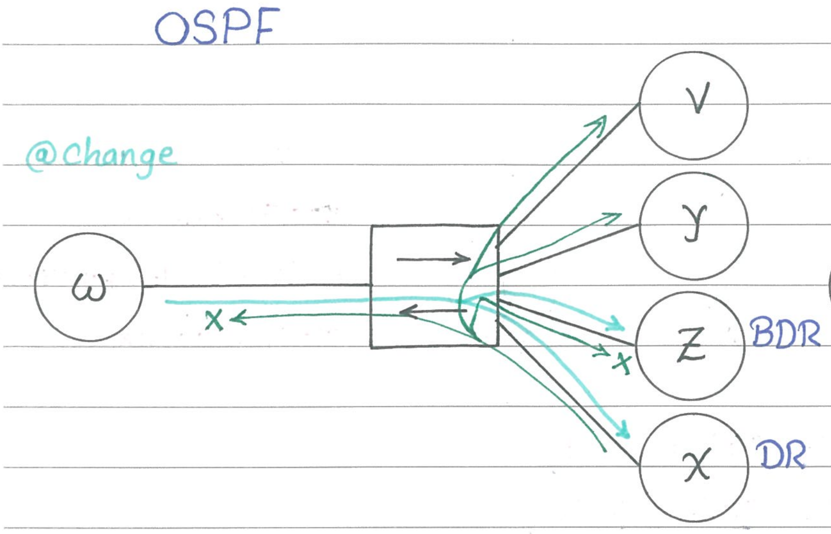
- DIS is IS having highest priority (0-127) default 64.
- Then IS having highest SNPA (MAC) address.

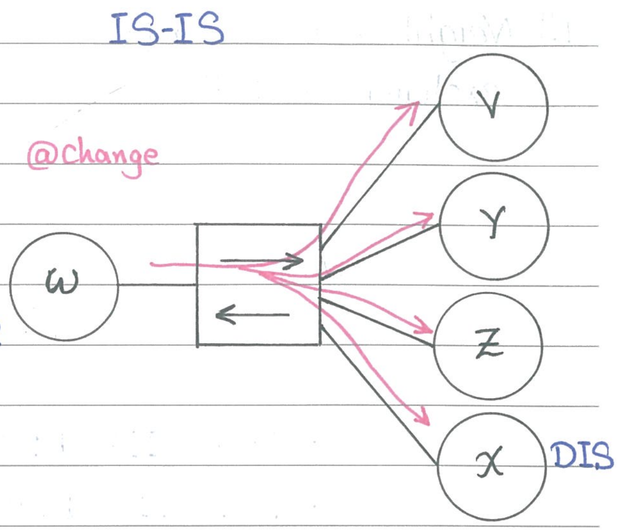
All other routers consider themselves Backup DIS.

valid for OSPF only.

DR welcome newcamer & @change routes send changes to it before others.

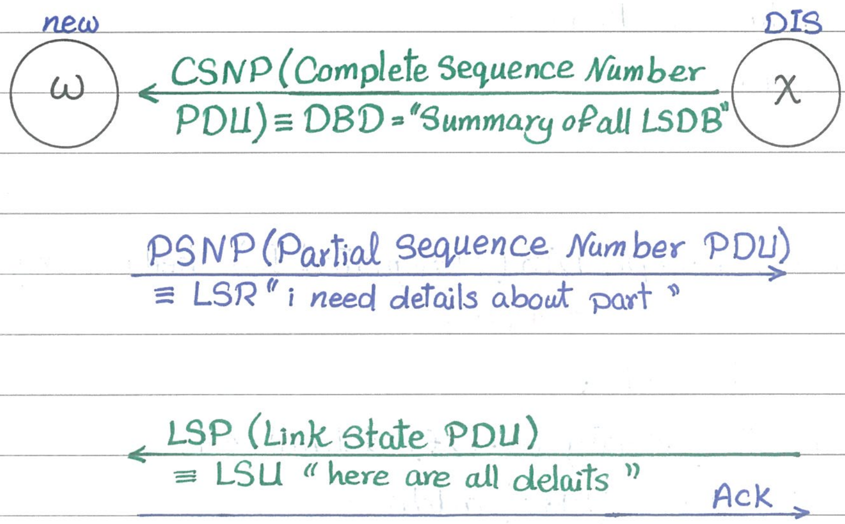
DIS welcome new camer only & @ change, router that feels the change send to all ISs.





③ Routes Discovery:

exchange of LSDB



LSP contain full information for certain parts of LSDB described in TLV (Type / Length / Value)

TLV	Type
Area Id	1
IS System Id	2
ES System Id	3
IPv4 Internal network	128
IPv4 External network	130

• Recommended maximum number of routers per area = 1000.
• LSP refreshment is done every 15 minutes, maximum age time for a LSP entry in database is 20 minutes.

Session 5 Part 4
Configuration

1. Enable TCP/IP & OSI Router Process:
   (Config)# ip routing
   or (Config)# CLNS routing

2. Create ISIS routing process:
   (Config)# router isis [Tag]
   default 0
   (Config-router)# net RID

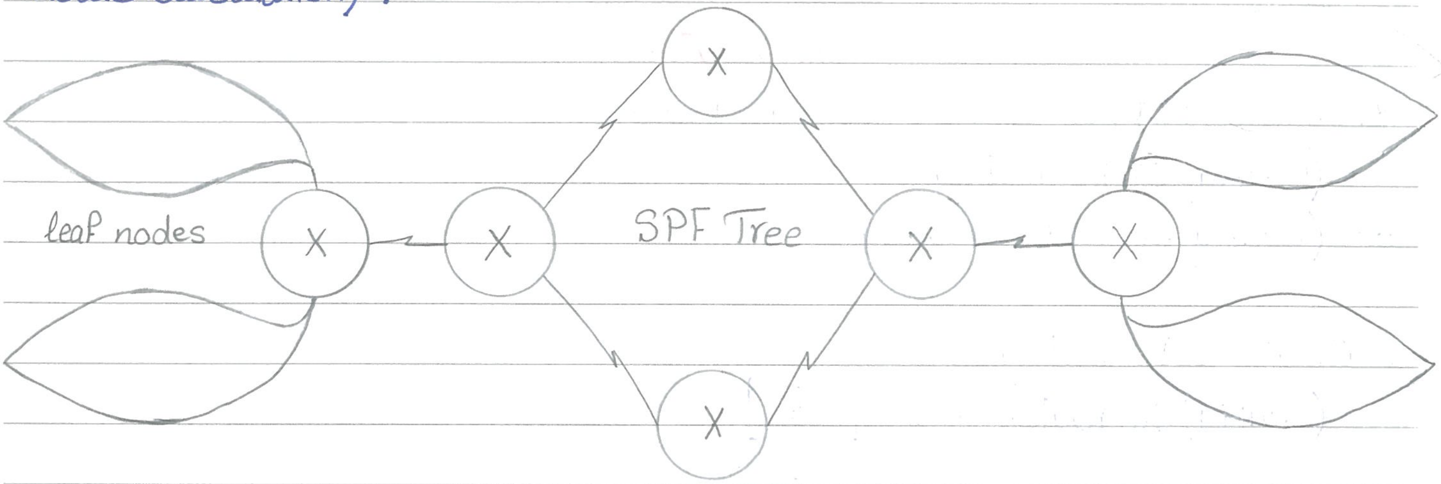
3. Active ISIS on interface:
   (Config)# interface ___
   (Config-if)# ip router isis
   OR
   (Config-if)# clns router isis

4. Choose router Level:
   (Config-router)# is-type {level-1 / level-1-2 / level-2 only}
   default

5. Choose isis metric: default-10
   (Config-if)# isis metric metric [delay-metric [expense-metric [errormetric]]] {level-1 / level-2}
   OR
   (Config-router)# metric default-value {Level-1 / Level-2}
   # Show isis route → L1 LSDB
   # Show clns route → L2 LSDB

④ Form Routing Table:

Router will run Dijkstra Algorithm to calculate the best path (Best to main nodes = IS).
ISIS consider IP networks a leaf nodes in a tree & use PRC (Partial Route Calculation).



Session 5 Part 3
Integrated IS-IS C/C's

- Link state routing standard protocal. Running on OSI model and now on TCP/IP model.
- Send updates using multicast MAC 0180.C200.0014 and 0180.C200.0015 and using multicast IP 224.0.0.19, 224.0.0.20 and 224.0.0.21.
  L1 update, L2 update and any update
- Classless protocal.
- Support manual summarization only.
  No auto summary available.
- Symbol in routing table "iL1" & "iL2"
  intra area networks & inter area networks
- Admin. Distance = 115 for TCP/IP model, = 110 for OSI model.
- Metric by default is called default & its default is 10/link.
  ISIS by configuration can add others metric (error, delay, expense).
- More scalable then OSPF (ISIS backbone is chain of L2 & L1/L2 routes).
- ISIS is less CPU intensive then OSPF (Use PRC to calculate sub network changes).

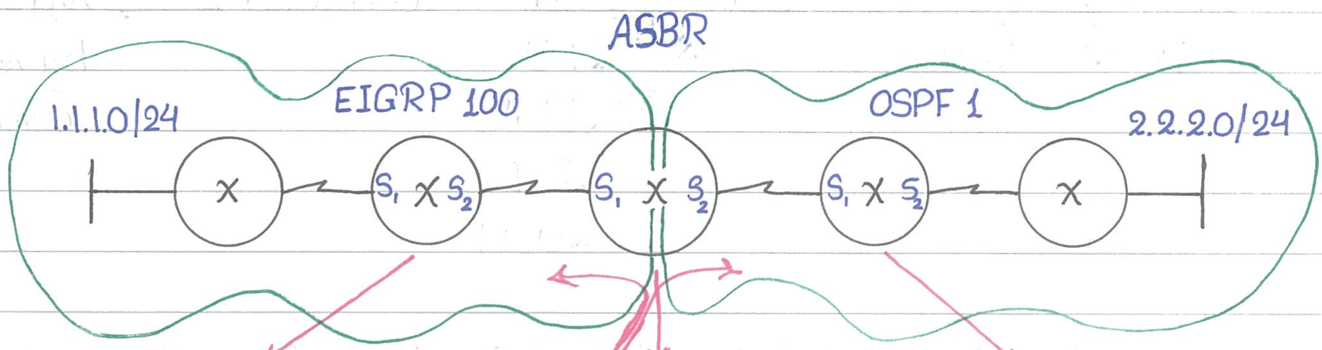
Session 6 Part 1
Manipulating Multiple Routing Protocols (Redistribution)

why we may need multiple routing protocals?

A. Boundary between ASs.

B. Different customer requirements that may differ then provider requirements.

C. Redistribute routing protocals in MP-BGP (L3 VPN = VRF).



D 1.1.1.0/24 S1 DEX 2.2.2.0/24 S2	D 1.1.1.0/24 S1 O 2.2.2.0/24 S2	O 2.2.2.0/24 S2 OE2 1.1.1.0/24 S1

ASBR(Config)# router OSPF 1

ASBR(Config-router)# redistribute eigrp 100 [options]

ASBR(Config)# router eigrp 100

ASBR(Config-router)# redistribute ospf 1 [options]

Session 6 Part 2

Considerations while redistribution

- Redistribution can be performed between any two protocals under, same routed protocal.

OSPF (IPv4) ⟷ RIP (IPv4)

OSPF (IPv4) ⟷~~✗~~ RIP (IPv6)

- Auto redistribution.

IGRP ⟷ (Same AS) EIGRP

- Redistribution can be done between any two routing methods.

EIGRP ⟷ OSPF, EIGRP ⟷ RIP, EIGRP ⟷ BGP, OSPF ⟷ RIP, OSPF ⟷ BGP, RIP ⟷ BGP

static → BGP, RIP, EIGRP, ISIS, OSPF

Connected → Any Protocal by network Command

⇒ when implementing redistributions the redistributed routes will obey the new domain rules:

- Administrative Distance:

The redistributed protocal inherit the admin. distance of the redistributing protocal.

OSPF:

(Config-router)# distance ospf external __ inter-area __ intra-area __

EIGRP:

(Config-router)# distance eigrp $\underset{in.}{\_\_}$ $\underset{ex.}{\_\_}$

Protocal	Cisco Admin Distance	Juniper Admin Distance	HP/Huawei Admin distance
Connected	0	0	0
static	0, 1	5	
RIP	120	100	
OSPF	110	internal, external 10, 150	
EIGRP	internal summary 90, 170, 5 external	N/A	
ISIS	115	l1, l2, l1, l2 15, 18, 160, 165 internal, external	
BGP	external 20, 200 internal	170	255

BGP:

(Config-router) # distance bgp ___ ___
internal external

All routing protocals :

(Config-router) # distance ___ [ACL #]
Network

Session 6 Part 3

- Metric :

Any protocal → X → RIP, EIGRP, IGRP metric ∞

Any protocal → X → OSPF Cost 20 , OE2, no subnets allowed.
OSPF "other process" → X → OSPF the same cost, OE2, no subnets allowed.
BGP → X → OSPF Cost 1 , OE2, no subnets allowed.

Any protocal → X → ISIS metric = 0 , iL2

(Config-router) # redistribute Protocol 2

Optional:

metric seed metric initial metric for redistributed routes

ospf only:
- match {internal | external 1 | external 2}
  O, OIA or OE1 or OE2
- metric-type {type-1 | type-2}
- subnets Consider subnets

{Level-1 | Level-2} Used for isis only

route-map name use route filter

Session 6 Part 4
Route-Filters

- Distribute List:

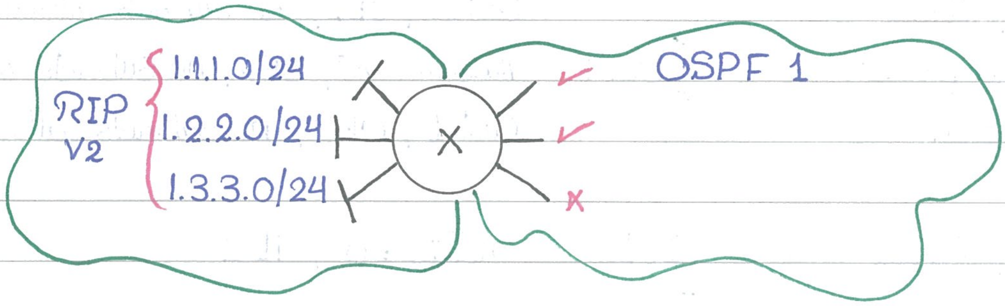
It is a filter used to permit or deny
- Incoming Updates.
- Outgoing Updates.
- Redistributed Updates.

Configuration:-

(Config)# router Protocol 1
(Config-router)# distribute-list ACL# { IN interface / Out interface / Out Protocol 2 }

It is not available with Link state protocols

ex:



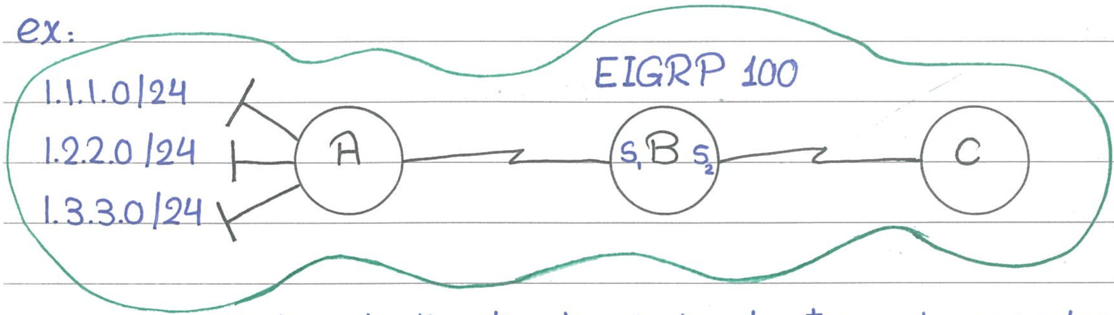
(Config)# access-list 64 deny 1.3.3.0
(Config)# access-list 64 permit any

OR

(Config)# access-list 64 permit 1.1.1.0
(Config)# access-list 64 permit 1.2.2.0

(Config)# router OSPF 1
(Config-router)# redistribute rip subnets
(Config-router)# distribute 64 out rip

ex:



we need B to get all networks but advertise only 1.1.1.0/24 & 1.2.2.0/24 to router C ...

(Config)# router eigrp 100
(Config-router)# distribute-list 64 out S2

_Distribute List:

with ACL:

(Config-router)# distribute-list acl# { IN / Out / Out

with Prefix-list:

(Config-router)# distribute-list prefix-list name { IN / Out / Out

with route-map:

(Config-router)# distribute-list route-map tag { IN / Out / Out

Session 6 Part 5

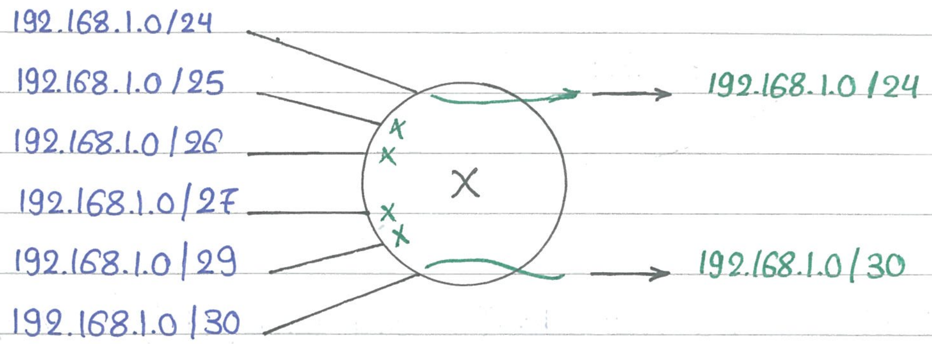
_Prefix-list:

(Config) # ip prefix-list name [Seq #] {permit|deny} Prefix

default 5, increment by 5

Prefix length
[Le ___] less than or equal
[ge ___] great than or equal

ex:



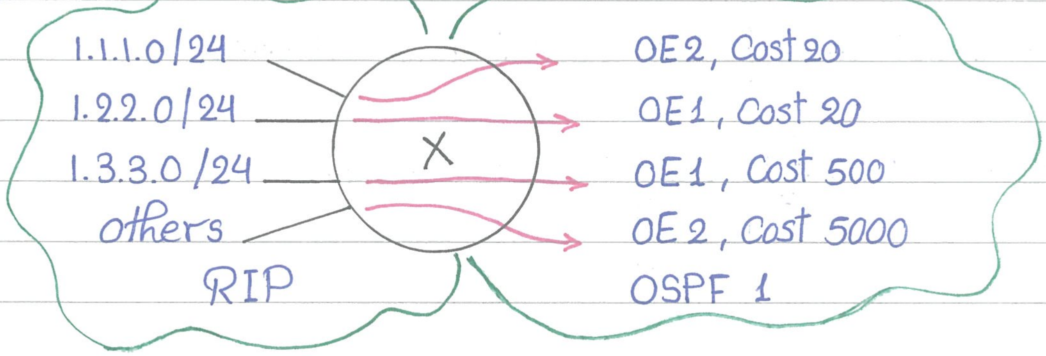
(Config) # ip prefix-list anwer deny 192.168.1.0/25 le 29
(Config) # ip prefix-list anwer permit 0.0.0.0/0 le 32 any
OR
(Config) # ip prefix-list anwer permit 192.168.1.0/24
(Config) # ip prefix-list anwer permit 192.168.1.0/30

Session 6 Part 6

_ Route-map:
It is a sophisticated ACL used to permit, deny & modify.

(Config) # route-map name {permit|deny} [Seq #] default 10 not increment
(Config-route-map) # match ip address acl #
or
(Config-route-map) # match ip address prefix-list name
metric, metric-type, interface, ip of next-hop, tag
(Config-route-map) # set metric ※
(Config-route-map) # set metric-type {type-1 | type-2}
(Config-route-map) # set level {1|2}

ex:



(Config) # router ospf 1
(Config-router) # redistribute rip subnets route-map nabil
OR
(Config-router) # distribute-list route-map nabil

(Config) # access-list 1 permit 1.1.1.0
(Config) # ip prefix-list 2 permit 1.2.2.0 /24
(Config) # access-list 3 permit 1.3.3.0

(Config) # route-map nabil permit
(Config-route-map) # match ip address 1

(Config) # route-map nabil permit 20
(Config-route-map) # match ip address prefix-list 2
(Config-route-map) # set metric-type type-1

(Config) # route-map nabil permit 30
(Config-route-map) # match ip address 3
(Config-route-map) # set metric 500
(Config-route-map) # set metric-type type-1

(Config) # route-map nabil permit 40
(Config-route-map) # set metric 5000

Session 7 Part 1
BGP overview

Border Gateway Protocol is an exterior gateway routing protocol that works between ASs

Group of devices under single technical administration (different routing policy)

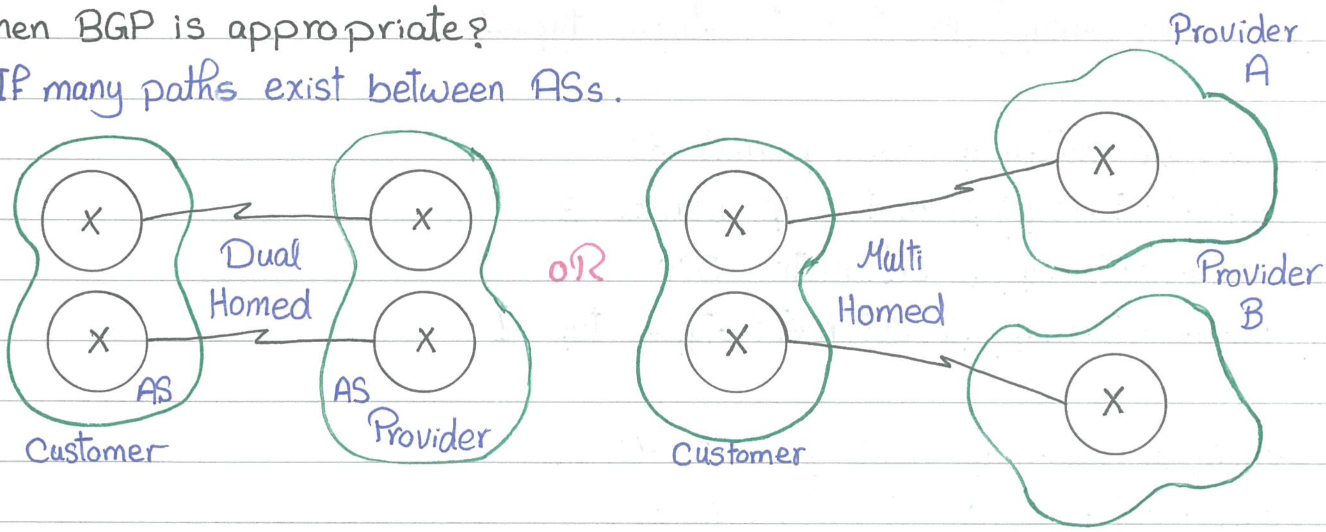
AS no. from IANA → IP, ASno.

Old	New
16-bit	32-bit

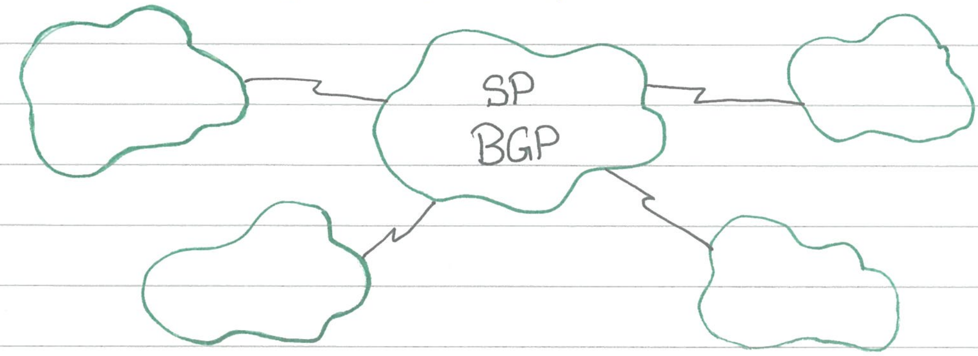
Private AS no. 64512 → 65535

when BGP is appropriate?

1. If many paths exist between ASs.



2. If AS is Transit AS (Service provider).



3. If dynamic routing policies are required.

⇒ The only acceptable dynamic Routing Protocal between ASs is BGP else use static

Session 7 Part 2

BGP C/C's

1. It is a path vector EGP standard.
   with details (all attributes), Advanced D.V

2. It is an application running over TCP port 179.
   - Segmentation
   - Reliability (Ack)
   - Error detection (CRC)
   - Flow control & error correction (windowing)

3. Classless protocal (FLSM, VLSM, Summarization, CIDR).
4. Optional Support Authentication.
5. Symbol in Routing table "B".
6. Admin. Distance = 20 ebgp, 200 ibgp.
   loop prevention mechanism in case of two ASBR

7. Use rich metric called attributes.
8. Use loop prevention mechanism.
   - Normal split horizon: route learnt from neighbor should never be advertised back to same neighbor.
   - BGP split horizon: route learnt from iBGP should never be advertised to another iBGP.
   - AS path list is used to prevent loops between ASs (router will check its own AS no. in AS path, if my AS no. exists, router should discard update).

9. Support dynamic policy.

Session 7 Part 3
BGP Tables

1. BGP Neighbor table :

Manual conf. for neighbors.

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

Show ip bgp Summary

Neighbor IP	State	Pfx rcd	Table ver	msg sent	msg recevied	AS	version
	idle Active Established						

2. BGP table = BGP topology = BGP data base :

All learnt routes

Show ip bgp

Network	Mask	Attributes

3. Routing table :

Best routes, best attributes.

* Show ip route bgp

B 1.1.1.0/24 [20/ MED], ip of N.H.

BGP Messages

1. Open msg: (startup @hello)

It Contains:
- RID.
- AS ※.

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

2. Keep alive msg (periodic hello):

Every 60 sec periodic hello.
Deadtime = invalid time = 180 sec.

3. Update msg:

It Contains NLRI (Network Layer Reachability Information) & Attributes.

other address families

VPN4 IPv4 IPv6 VPN6 Multicast IPv4 Multicast IPv6

4. Notification msg:

It exists if problem occurs between routers.
ex: Misconfiguration, version mismatch.

5. Route refresh:

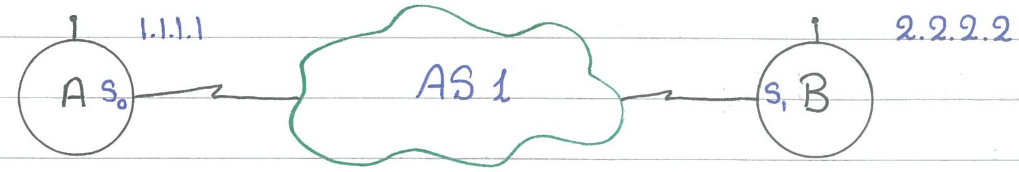
Used with clear command.

Session 7 Part 5
BGP Operation

@startup:

(Config)# router bgp AS#
(Config-router)# neighbor ip of neighbor remote-as neighbor AS#
(Config-router)# address-family ipv4-unicast
(Config-router-af)# neighbor ip of neighbor activate

} exist by default for ipv4 address family



1. Neighbor Discovery:

- Idle state: No exchange yet
  No route in routing table for that neighbor.

SyN (on port 179) →

← Ack / SYN

Ack →

3-way handshake

Active 1

- Connect state.
- Open Sent State:

open sent →

my RID, my AS#

- Open Confirm state:

← Open confirm

Active 2

- Established State.

→ Neighbor is not running bgp.

→ Neighbor running bgp with wrong peer.

← TCP RST msg

#debug ip tcp transaction

- eBGP neighbor should be directly connected by default.

    neighbor ip enable-connected-check, msgs TTL = 1.

- iBGP neighbors may not be directly connected by default.

    neighbor ip disable-connected-check, msgs TTL = 255.

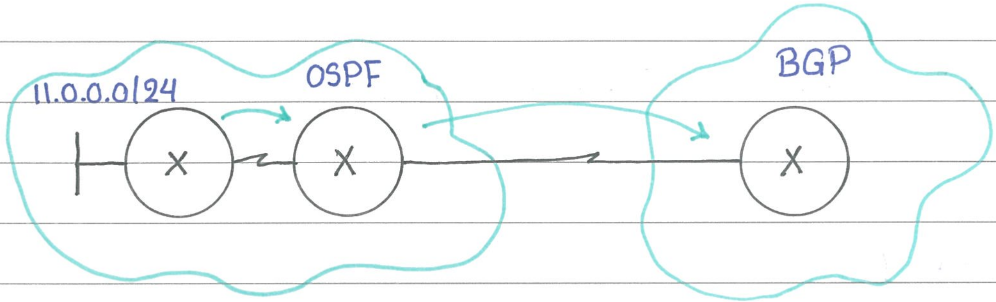
- TCP session destroy within 40 sec.

    other neighbor doesn't have route back ... or ... ACL exist.

Session 8 Part 1
BGP Considerations

1. Advertising Network (Publishing Networks in BGP):
"Injecting routes in BGP Table"

1.1. Redistribute IGP into BGP:
Connected static IGP



Routing Table

O 11.0.0.0/24

BGP Table

>11.0.0.0/24	?

router bgp 1
redistribute IGP route-map x

origin (attribute)
(?) incomplete

1.2. Network Command (Recommended):

(Config)# router bgp AS#
(Config-router)# network ______ [mask ______]

- If no mask is specified, default masks is assumed.
- Injected network should be exactly matched in routing table by IGP (Synchronized).

origin (attribute)
(i) network (IGP)

⇒ Origin attribute: i (IGP) < e (EGP) < ? (incomplete)
least is best...

Session 8 Part 2

2. Advertising Summary :

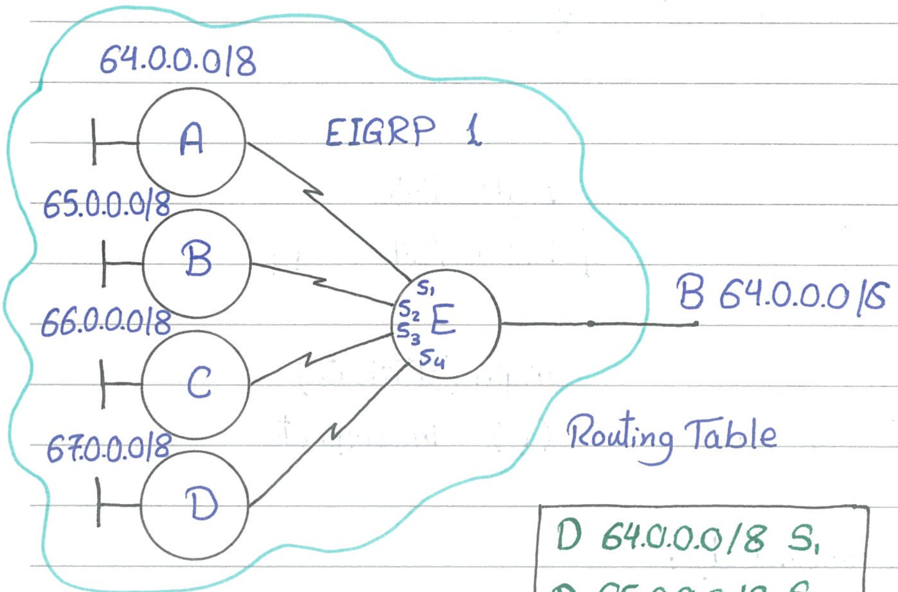
2.1. Network Command + Static route :

(Config)# router bgp AS#

(Config-router)# network 64.0.0.0 mask 252.0.0.0

+

(Config)# ip route 64.0.0.0 252.0.0.0 null 0



Routing Table

D	64.0.0.0/8	S_1
D	65.0.0.0/8	S_2
D	66.0.0.0/8	S_3
D	67.0.0.0/8	S_4
S	64.0.0.0/6	null0

BGP Table

>64.0.0.0/6

2.2. Aggregate address :

(Config)# router bgp AS#

(Config-router)# aggregate-address network mask [as-set] [summary-only]
[Suppress-list ※]

summary-only: Suppress all specific routes matching aggregate address

- Default will advertise aggregate route & specific routes.

- Condition: at least one specific route match the aggregate address should exist in BGP Table.

Routing Table:

D	64.0.0.0/8	S1
D	65.0.0.0/8	S2
D	66.0.0.0/8	S3
D	67.0.0.0/8	S4
B	64.0.0.0/6	null0

BGP Table:

>64.0.0.0/6
>65.0.0.0/8

(Config-router)# aggregate-address 64.0.0.0 252.0.0.0 summary-only

BGP Table:

valid

*> 64.0.0.0/6
s> 65.0.0.0/8

suppress

BGP Table:

> 64.0.0.0/6
> 65.0.0.0/8
> 66.0.0.0/8

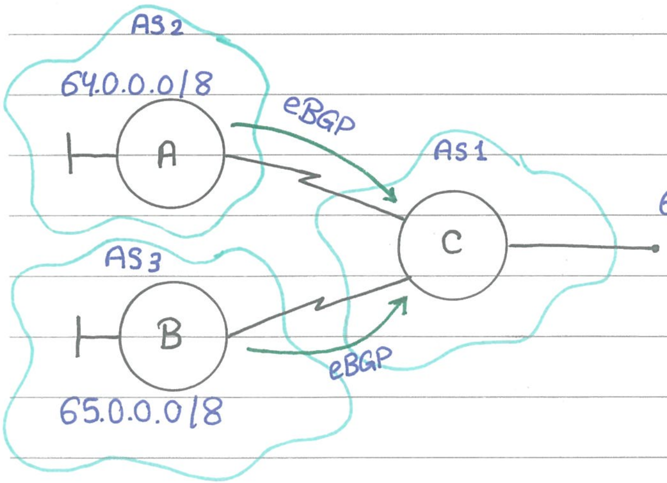
(Config-router)# aggregate-address 64.0.0.0 252.0.0.0 suppress-list 64

(Config)# access-list 64 permit 65.0.0.0

*> 64.0.0.0/6
s> 65.0.0.0/8
*> 66.0.0.0/8

⇒ Attributes: origin (i), Aggregator (AS#, RID), Atomic aggregate (0, 1)

0 → specific route, 1 → aggregated route



[as-set]

BGP Table:

*> 64.0.0.0/7	1, {2,3}
*> 64.0.0.0/8	2
*> 65.0.0.0/8	3

Session 8 Part 3

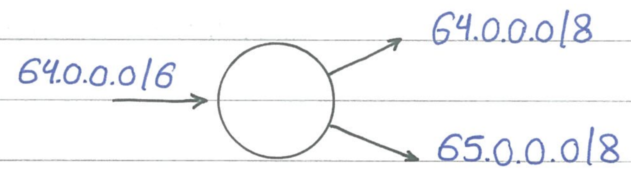
3. Advertising Specific routes under Condition:

Conditional route injection

inject-map , exist-map

Specific routes if summary exist

(Config-router) # bgp inject-map ______ exist-map ______
advertise received



(Config-router) # bgp inject-map anwar exist-map Zico

(Config) # route-map anwar permit

(Config-route-map) # set ip address prefix-list 65

(Config-router-map) # set ip address prefix-list 66

(Config) # ip prefix-list 65 permit 64.0.0.0/8

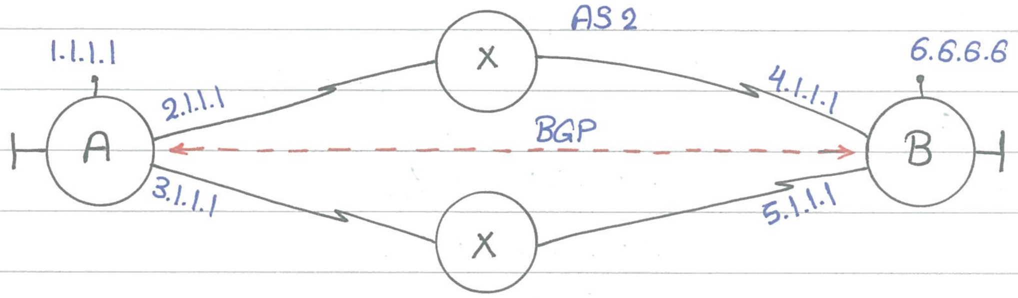
(Config) # ip prefix-list 66 permit 65.0.0.0/8

(Config) # route-map Zico permit

(Config-route-map) # match ip address prefix-list 64

(Config) # ip prefix-list 64 permit 64.0.0.0/6

4. Update Source behaviour:



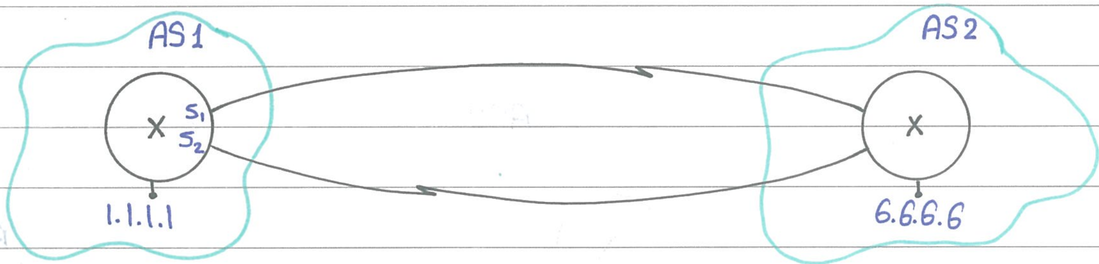
(Config) # router bgp 2
A(Config-router) # neighbor 6.6.6.6 remote-as 2
A(Config-router) # neighbor 6.6.6.6 update-source loopback0

B (Config-router) # neighbor 1.1.1.1 remote-as 2
B (Config-router) # neighbor 1.1.1.1 update-source loopback0

5. Multihop behaviour:

- IBGP neighbor by default may not be directly connected.
  (Config-router) # neighbor ______ disable-connected-check.
  BGP msg TTL = 255 (by default).

- EBGP neighbor by default should be directly connected.
  (Config-router) # neighbor ______ enable-connected-check
  BGP msg TTL = 1 (by default).



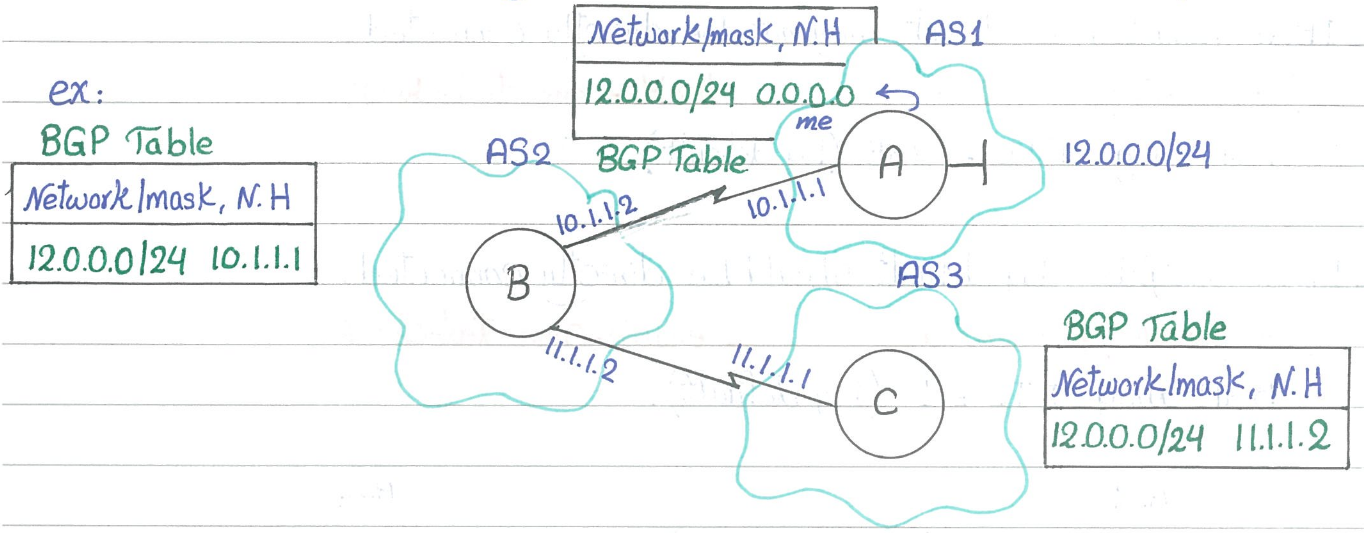
(Config) # ip route 6.6.6.6 255.255.255.255 S1
(Config) # ip route 6.6.6.6 255.255.255.255 S2
(Config) # router bgp 1
(Config-router) # neighbor 6.6.6.6 remote-as 2
(Config-router) # neighbor 6.6.6.6 update-source lo0
(Config-router) # neighbor 6.6.6.6 disable-connected-check   TTL = 1
OR
(Config-router) # neighbor 6.6.6.6 ebgp-multihop [__]   TTL = 255
OR
(Config-router) # neighbor 6.6.6.6 ttl-security-check 2   TTL = 255
Check TTL = 255 - ( ) = 253 ...

Session 9 Part 1
BGP Consideration

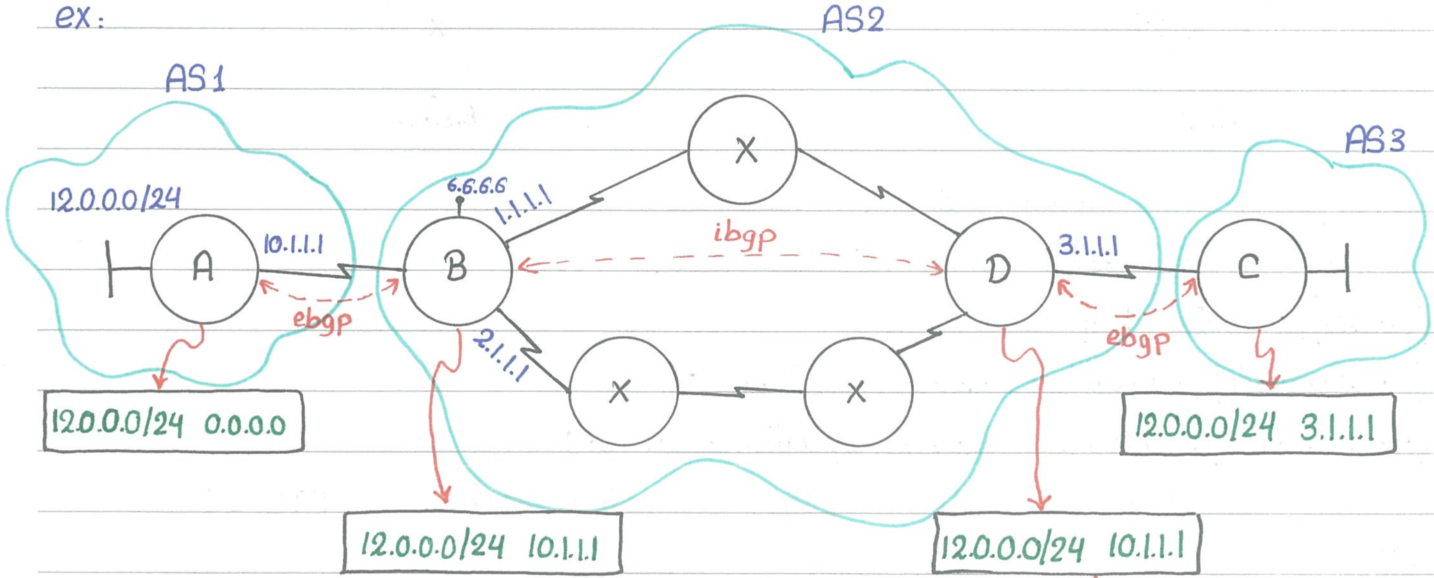
5. Next hop behavior :

- BGP is an AS by AS routing protocal not router by router routing Protocal, so in BGP next hop is router in next AS.
- BGP next hop attribute is changed in eBGP sessions, while kept unchanged in iBGP sessions.
- Special case if eBGP neighbors are in a shared media (Multiple Access).

ex:



ex:



(Config) # router bgp 2
(Config-router) # neighbor ___D___ next-hop-self
ip of nei.
To override that behaviour.

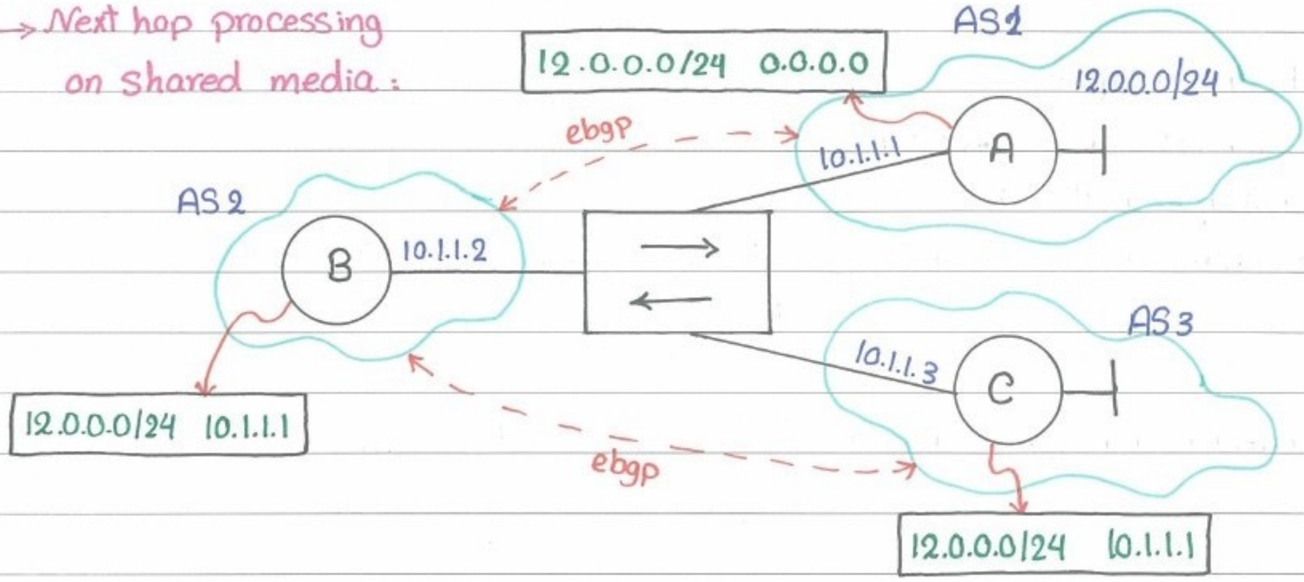
12.0.0.0/24 6.6.6.6

- Redistribute Connected into BGP.

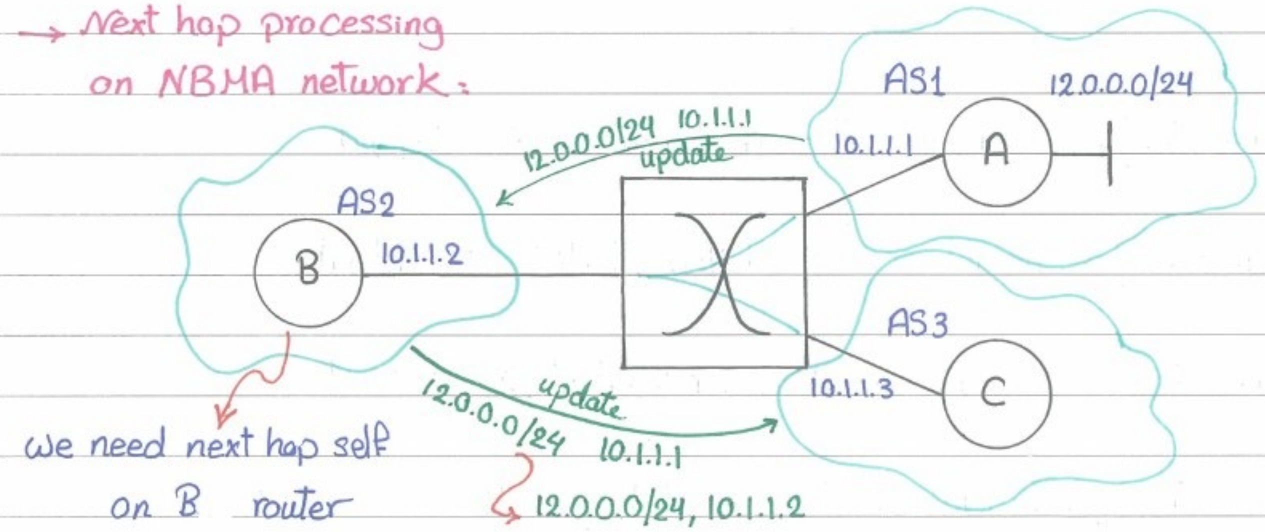
(Config)# router OSPF 1

(Config-router)# redistribute Connected

→ Next hop processing on shared media:

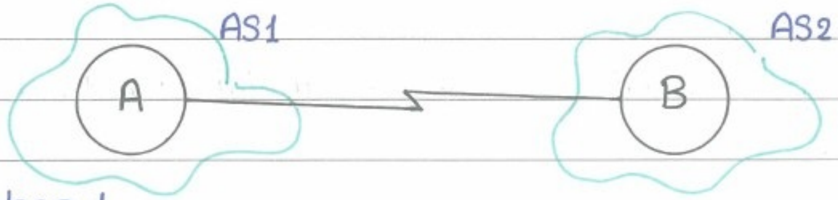


→ Next hop processing on NBMA network:



Session 9 Part 2

6. Authentication:



(Config)# router bgp 1

(Config-router)# neighbor B password Cisco

Using Hashed method (MD5)...

7. Peer Group :

→ Before peer group :

(Config) # router bgp 2

(Config-router) # neighbor ip1 ⋮ ip15 remote-as AS#

(Config-router) # neighbor ip1 ⋮ ip15 password ____

(Config-router) # neighbor ip1 ⋮ ip15 update-source lo0

(Config-router) # neighbor ip1 ⋮ ip15 ebgp-multihop ~

(Config-router) # neighbor ipx route-map x in/out

(Config-router) # neighbor ipx distribute-list x in/out

(Config-router) # neighbor ipx prefix-list x in/out

(Config-router) # neighbor ipx next-hop-self

120 Command

→ peer group :

- Simpler Configuration.
- Dynamic peer update (prepare one update for the peer group).

(Config) # router bgp 2

(Config-router) # neighbor WE peer-group

peer group name

(Config-router)# neighbor $\underset{\substack{\vdots \\ \text{ip 15}}}{\overset{\text{ip 1}}{\_\_\_\_\_\_}}$ peer-group WE

(Config-router)# neighbor WE remote-as 2

(Config-router)# neighbor WE password cisco

(Config-router)# neighbor WE timers ___ ____

(Config-router)# neighbor WE update-source l_0 0

(Config-router)# neighbor WE route-map $\underline{x}$ in|out

(Config-router)# neighbor WE next-hop-self

(Config-router)# neighbor WE route-reflector-client 23 Command

→ Peer Group Limitations :

- Neighbor Can be only in one peer-group.
- Peer group cannot mix iBGP & eBGP neighbor.
- Neighbor in a peer group Cannot have a special filter.

Session 9 Part 3

→ Peer Template :

- Peer Session template : Commands related to neighborship peer group for general Commands that is not depending on certain address family "(Config-router-stmp)# "

- Peer Policy template : Commands related to updates peer group for specific Commands that is under a specific address family "(Config-router-ptmp)# "

(Config)# router bgp 2
(Config-router)# neighbor ___ip1___ inherit peer-session _A_
(Config-router)# neighbor ___ip2___ inherit peer-session _B_
(Config-router)# address-family ipv4-unicast
(Config-router-af)# neighbor ___ip1___ inherit peer-policy _C_

(Config-router)# template peer-session _A_
(Config-router-stmp)# remote-as 1
(Config-router-stmp)# password cisco
(Config-router-stmp)# update-source lo0
(Config-router-stmp)# inherit peer-session _B_

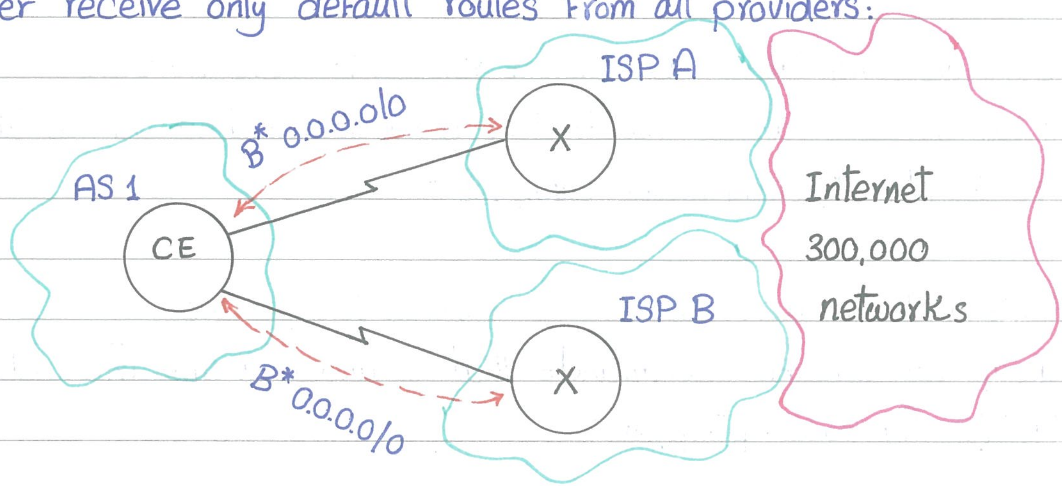
(Config-router)# template peer-session B
(Config-router-stmp)# ebgp-multihop

(Config-router)# template peer-policy _C_
(Config-router-ptmp)# weight _____
(Config-router-ptmp)# route-map _____ in/out
(Config-router-ptmp)# route-reflector-client
(Config-router-ptmp)# next-hop-self

Session 9 Part 4

8. Multihoming:

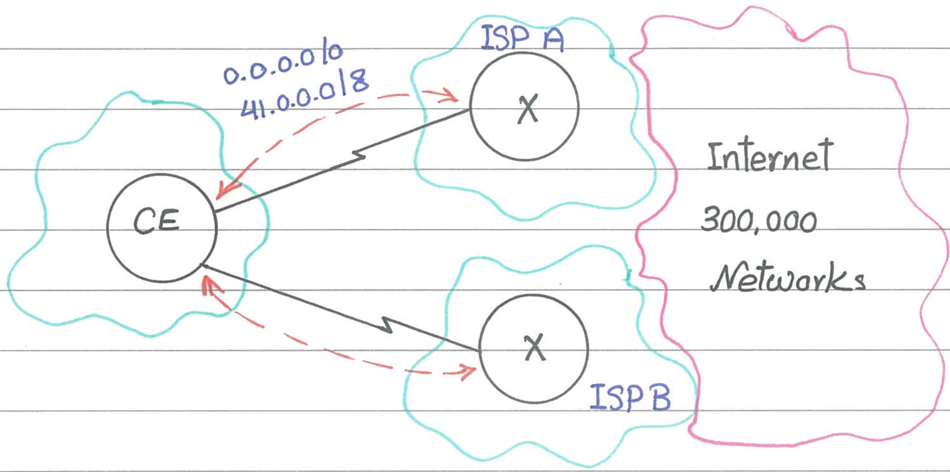
- Customer receive only default routes from all providers:



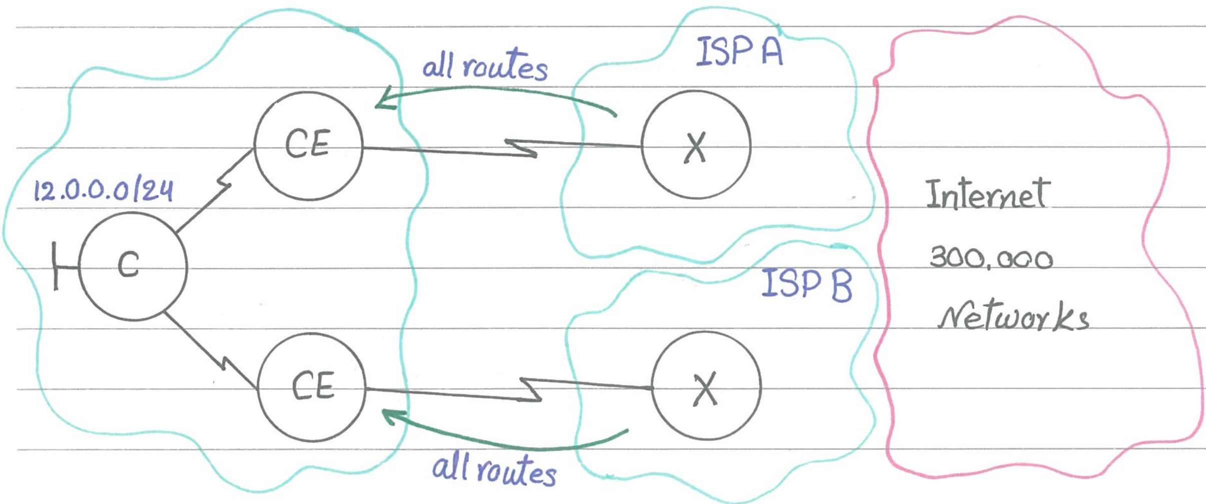
ISP (Config) # router bgp x
ISP (Config-router) # neighbor CE remote-as y
ISP (Config-router) # neighbor CE default-originate
ISP (Config-router) # neighbor CE prefix-list x out

ISP (Config) # ip prefix-list x permit 0.0.0.0/0

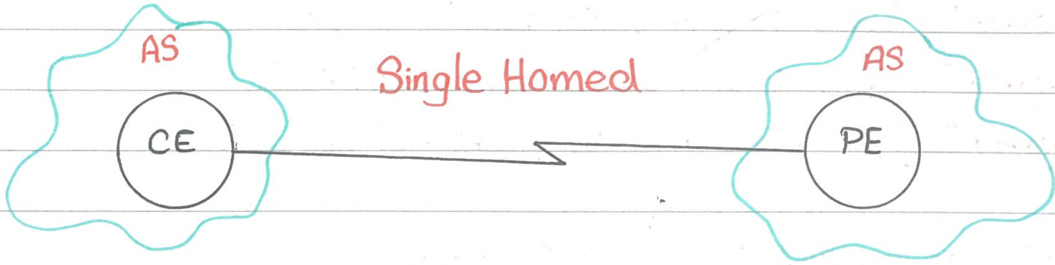
- Customer receive default routes + SP specific routes :

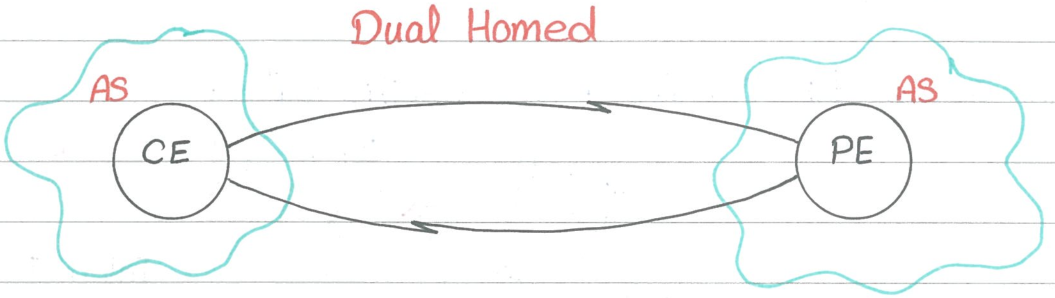


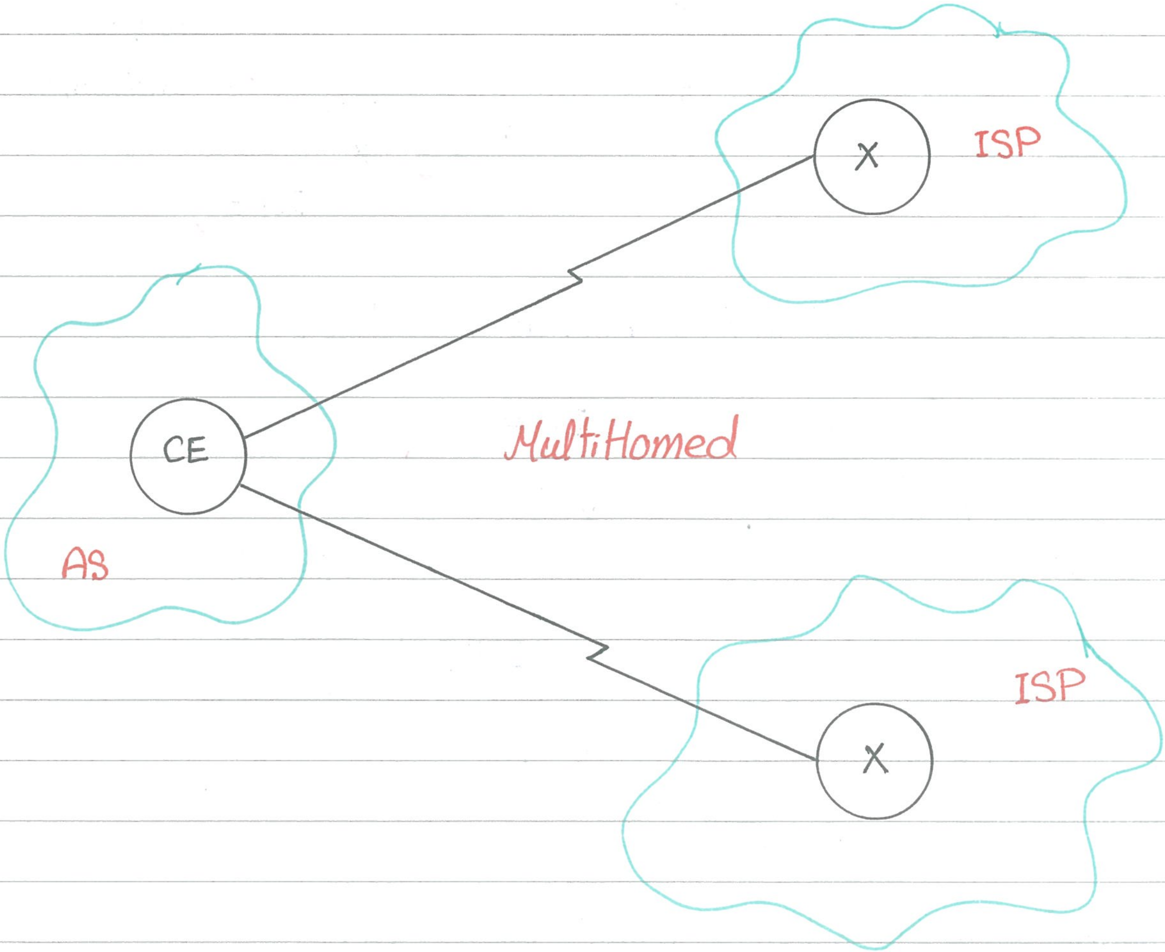
- Customer receive all routes from all providers :



CE (Config) # ip prefix-list 2 permit 12.0.0.0 /24
↳ To avoid customer network to become transit AS for SP ...

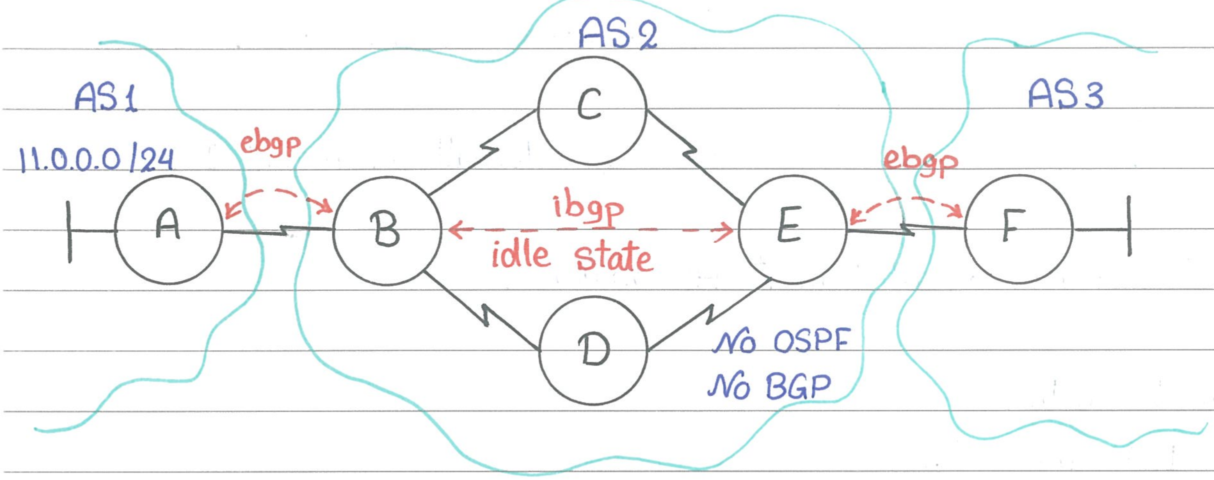

Single Homed
AS
CE
AS
PE


Dual Homed
AS
CE
AS
PE


MultiHomed
AS
CE
ISP
X
ISP
X

Session 10 Part 1
BGP Requirements in Transit AS

1. Run BGP on Border routers & don't run IGP inside transit AS.

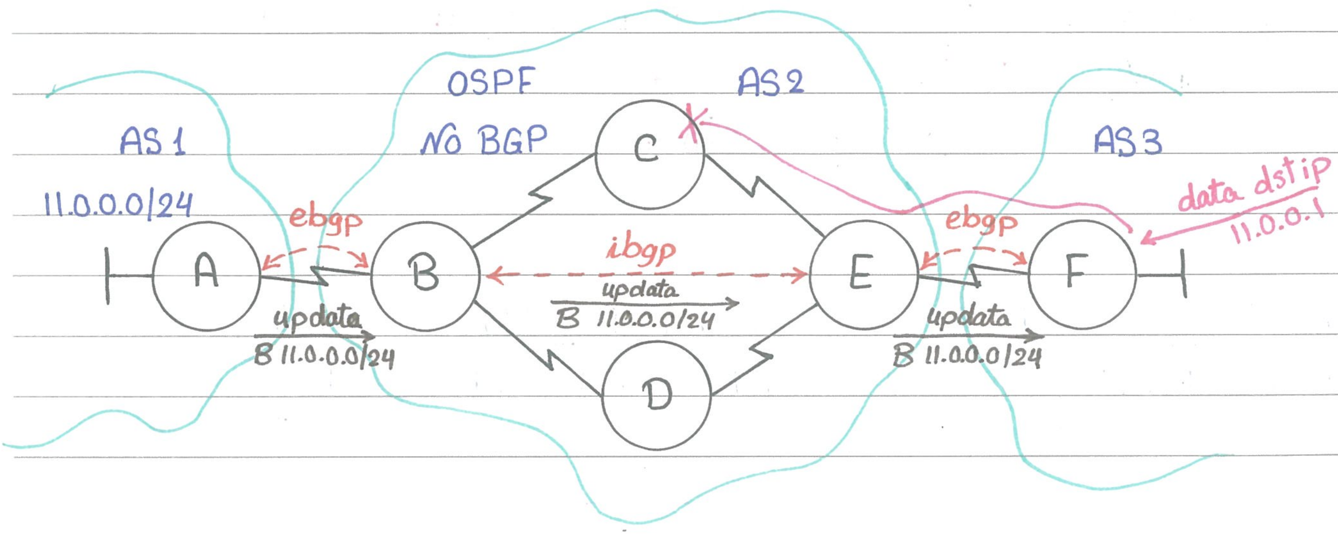


BGP @ Change batched updates:
- every 30 sec (eBGP).
- every 5 sec (iBGP).

We need to run IGP inside transit AS:
- BGP neighbor establishment.
- Data Forwarding is based on recursive lookup.

Session 10 Part 2

2. Run BGP on Border routers & run IGP inside transit AS.



Synchronization Rule:

- Routes learnt by iBGP neighbor should never be advertised to any neighbor (iBGP or eBGP) unless it is Synchronized.
  - Know by IGP B should redistribute BGP into IGP
  - To avoid black holes.

(Config)# router bgp AS#

(Config-router)# no synchronization ← default on recent IOS

- iBGP should run on all transit AS routers.

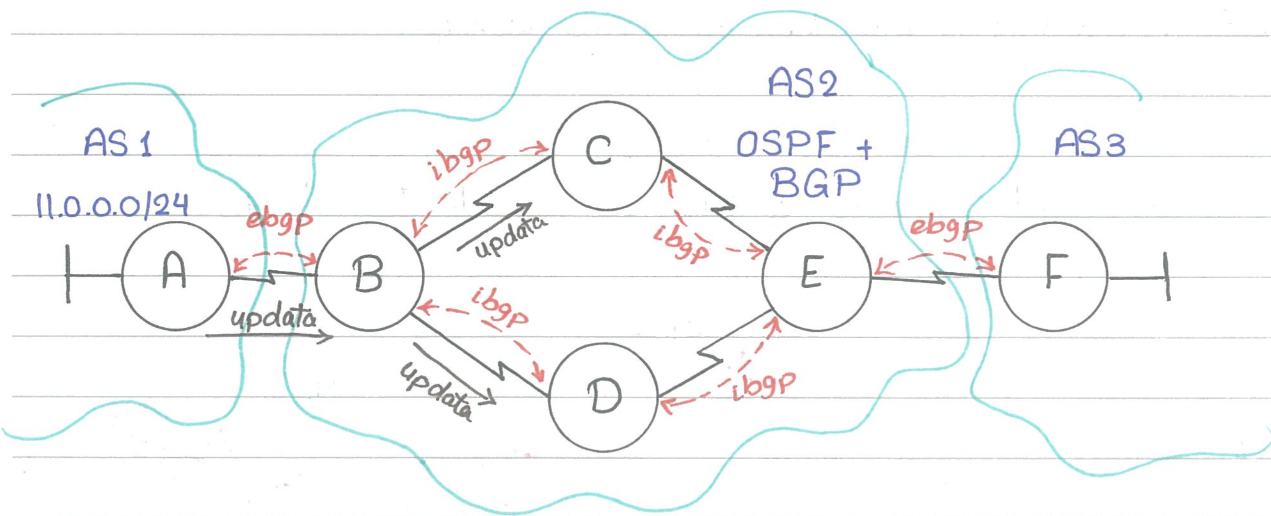
Split Functionality:

iBGP & IGP Interaction:

- Internal routes are IGP responsibility.
- External routes are iBGP responsibility.

Session 10 Part 3

3. Run BGP on all transit AS routers & run IGP inside on all transit AS routers.



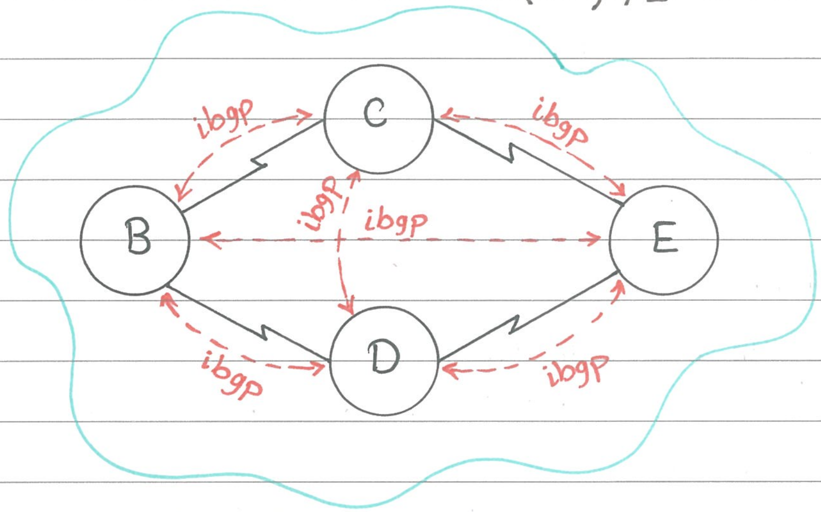
To avoid loops inside AS: BGP obey BGP splithorizon rule.

- Routes learnt from iBGP should never be advertised to another iBGP.

- Run BGP on all transit AS routers in full mesh fashion.

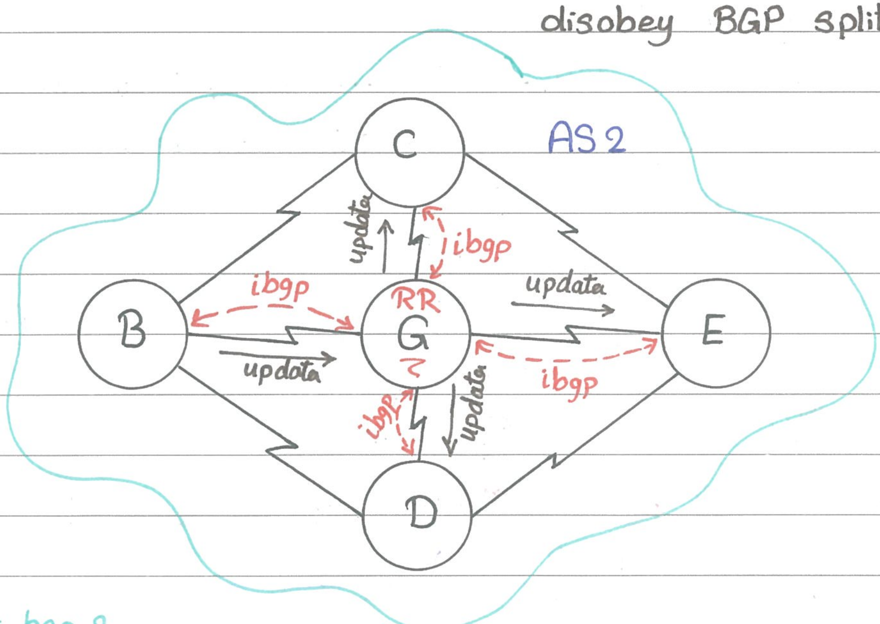
large no. of neighborships

$n(n-1)/2$



- Run BGP in transit AS as star topology (Route-Reflector).

disobey BGP splithorizon rule



B,C,D,E :

(Config)#router bgp 2

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

G :

(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. Run IGP on all transit AS routers & Run BGP on all transit AS.

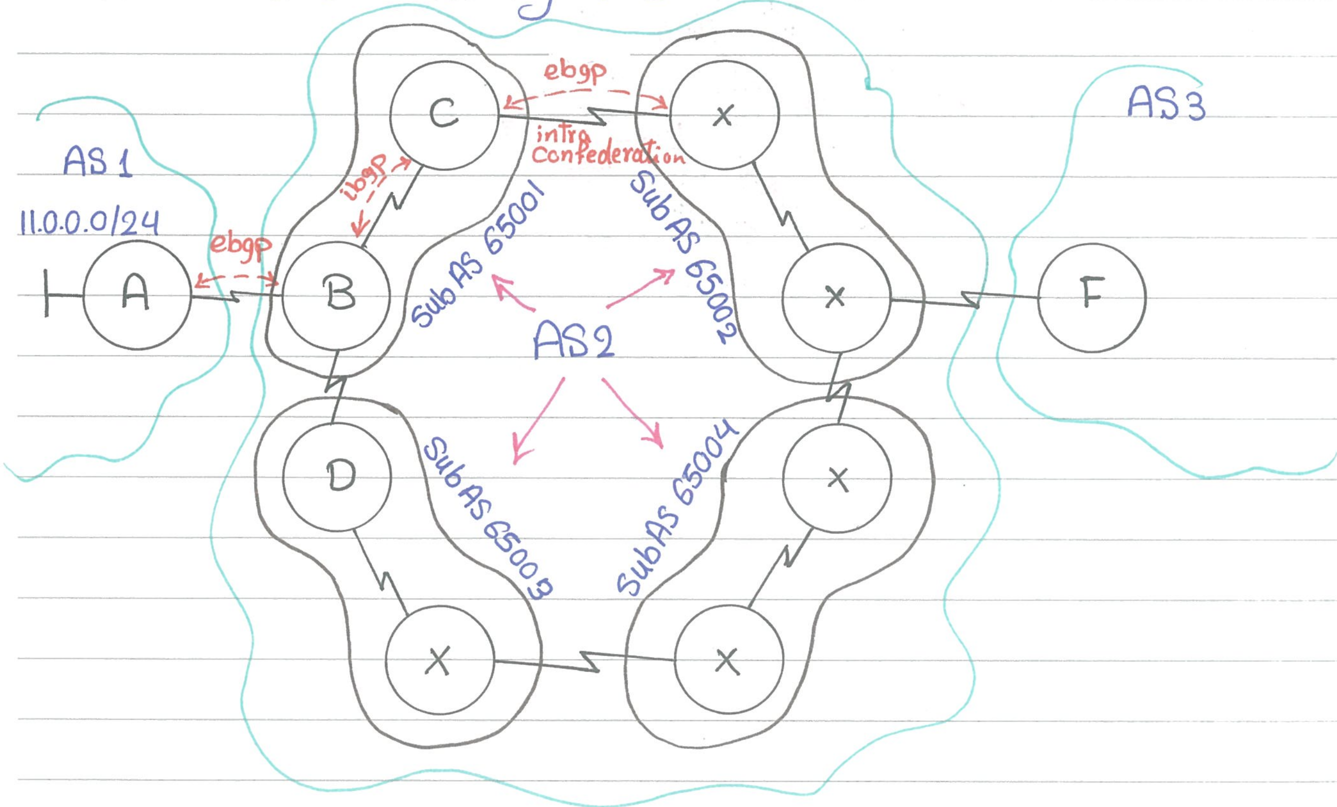
either :
- Full mesh BGP neighborship.

OR - Route-Reflector.

OR - Confederations.

⇒ BGP Confederation:

- Divide main AS into sub ASs.
  - main AS → Confederation
  - sub ASs → Private AS (64512-65535)
- Confederation act as :
  - * eBGP in neighborship establishment (between two sub ASs).
    (update-source loopback - ebgp multihop)
  - * iBGP in update transfer.
    (local preference - N.H. - MED - ...) except AS Path list will follow ebgp rules ( ) ≡ intra confederation
- All Confederation running 1 IGP.

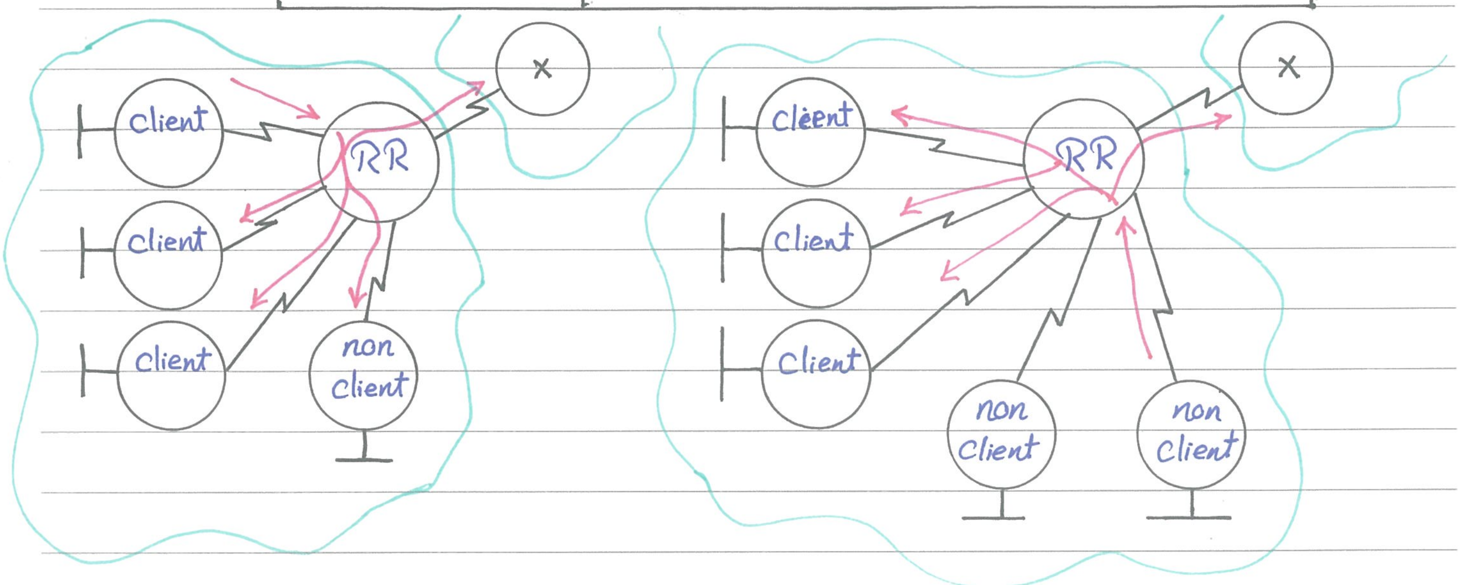


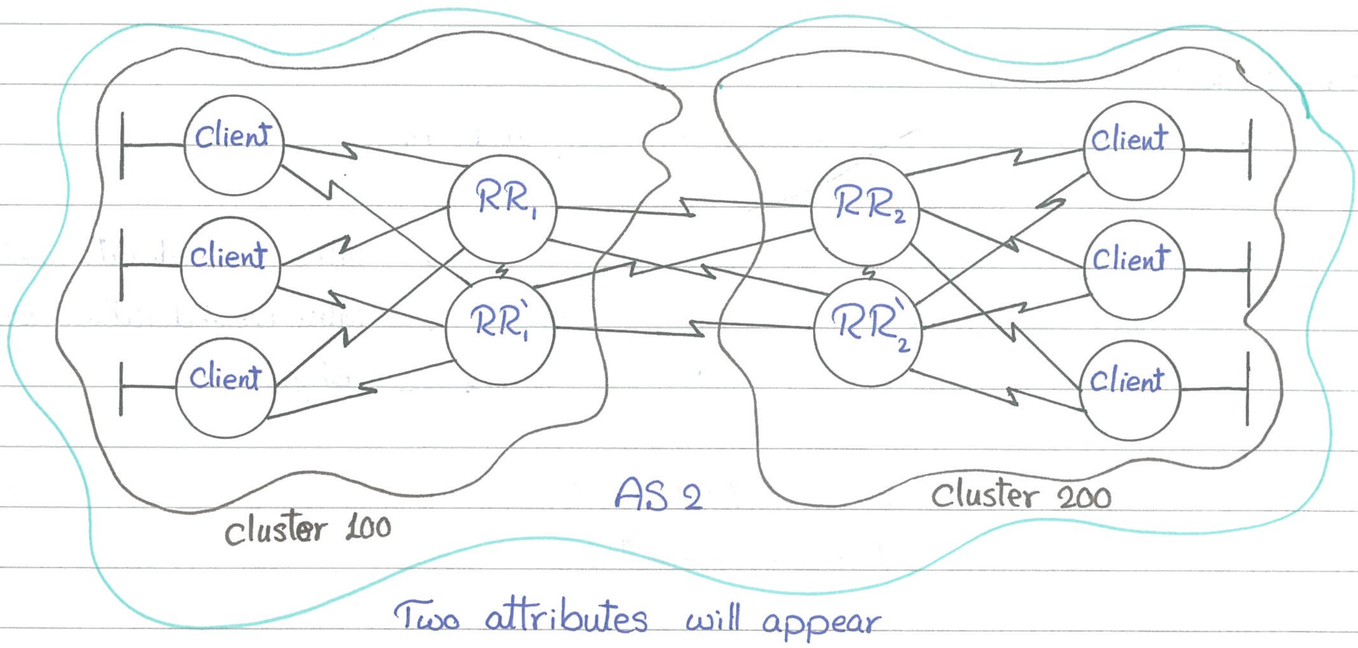
B: (Config)# router bgp 65001
(Config-router)# bgp Confederation-id 2 → main AS
(Config-router)# bgp Confederation peer 65003
(Config-router)# neighbor D remote-as 65003 ← intra Confederation ebgp
(Config-router)# neighbor C remote-as 65001 ← intra Confederation ibgp
(Config-router)# neighbor A remote-as 1 ← ebgp

Session 10 Part 5
Route-Reflector

_Rules:

Routes from	Advertised to
ebgp	Any router
ibgp	ebgp only
Client	Any router (ebgp, client, non client)
Non Client	ebgp + Client only





Two attributes will appear
- Cluster list (loop prevention mechanism)
(100 , 200)
- originator Id (RID of RR)

RR :

(Config)# router bgp 2
(Config-router)# bgp cluster-id 100
(Config-router)# neighbor ______ remote-as 2
(Config-router)# neighbor ______ route-reflector-client

Session 11 Part 1
BGP Consideration & Requirements

BGP Neighbor Discovery:

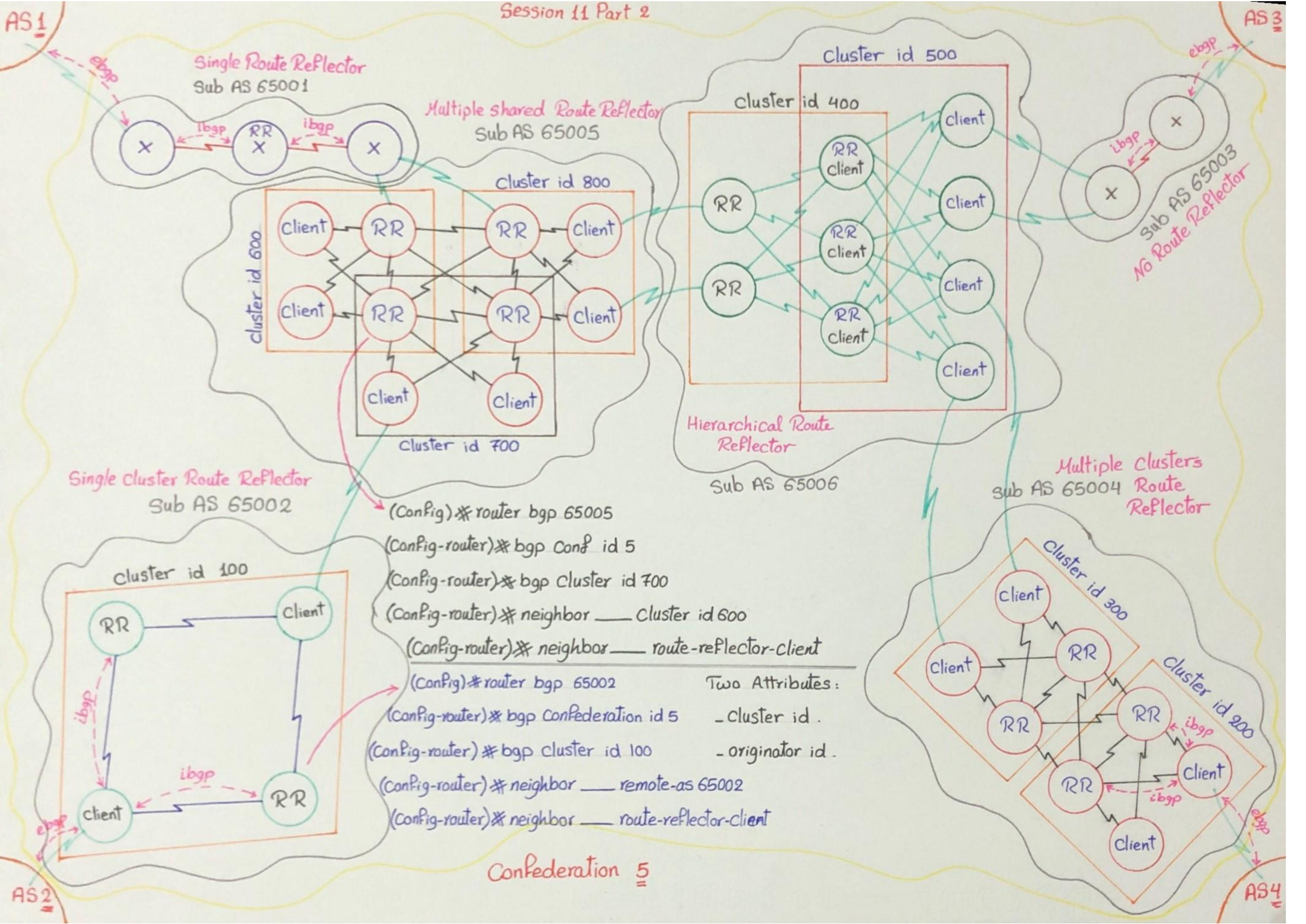
1. Neighbor Command.
2. Neighbor Should be reachable.
   using IGP → Connected, static, RIP, OSPF, ...
3. Source of update.
4. eBGP multihop (eBGP neighbor may not directly Connect).

#Show ip bgp Summary
#Show ip bgp neighbor ip of neighbor

BGP Routes Discovery:

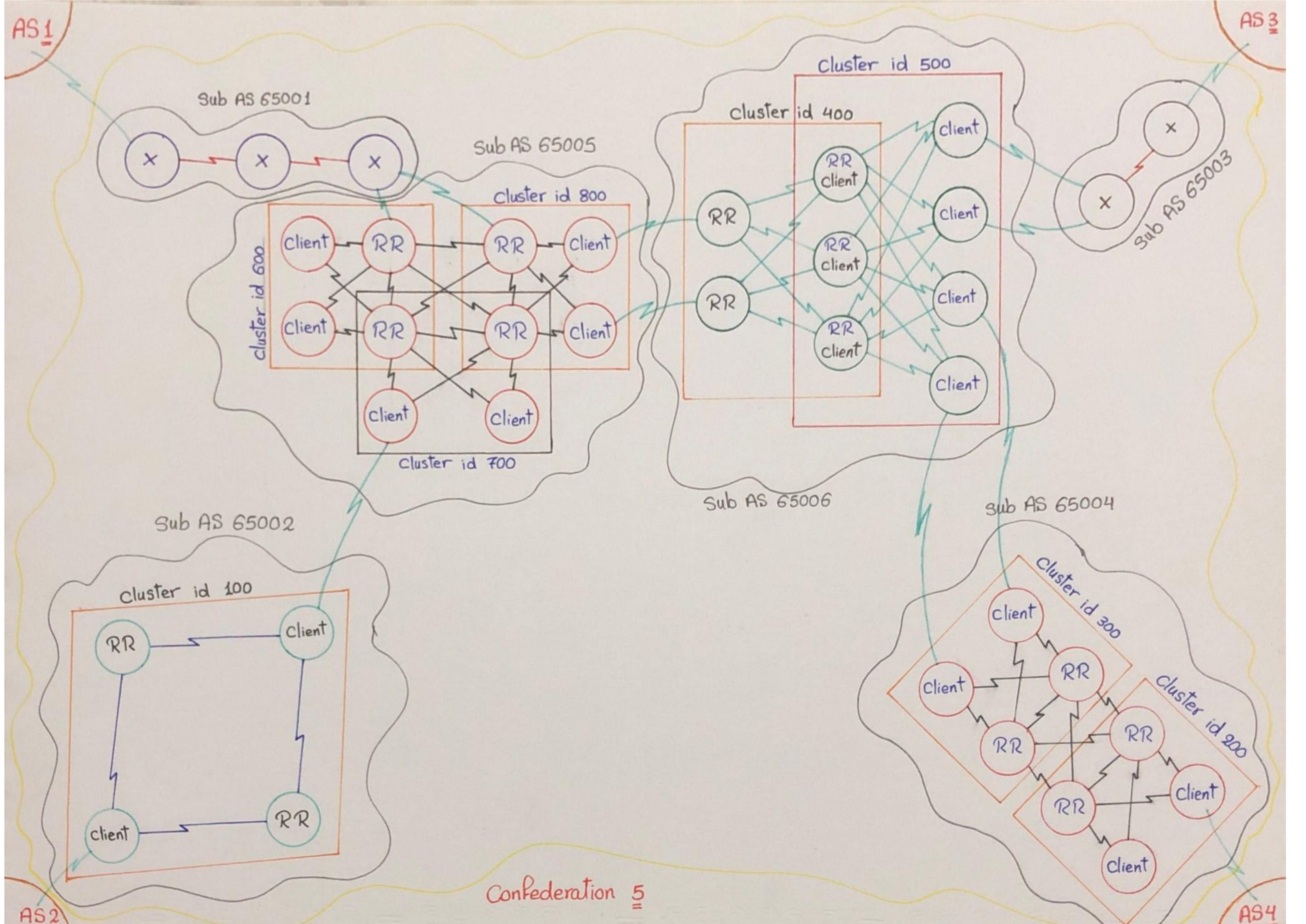
1. Advertise routes into BGP (inject routes in BGP table).
   network aggragate address injectmap/exist map
2. Disable Synchronization.
   (Config-router)# no sync
3. Next hop of update reachable.
   (Config-router)#neighbor ___ip___ next-hop-self
4. BGP Splithorizon:
   - BGP Full Mesh.
   - BGP Confederation.
   - BGP Route-Reflectors.

→ If neighbor AS is w ngly Configured, Flapping state between idle & Active state with notification msg.




```
(Config)# router bgp 65005
(Config-router)# bgp Conf id 5
(Config-router)# bgp Cluster id 700
(Config-router)# neighbor ___ Cluster id 600
(Config-router)# neighbor ___ route-reflector-client
```

```
(Config)# router bgp 65002
(Config-router)# bgp Confederation id 5
(Config-router)# bgp cluster id 100
(Config-router)# neighbor ___ remote-as 65002
(Config-router)# neighbor ___ route-reflector-client
```



AS 1
AS 3
AS 2
AS 4
Sub AS 65001
Sub AS 65005
Sub AS 65006
Sub AS 65003
Sub AS 65002
Sub AS 65004
Cluster id 500
Cluster id 400
Cluster id 800
cluster id 600
Cluster id 700
Cluster id 100
Cluster id 300
Cluster id 200
Client
RR
RR Client
Confederation 5

Session 11 Part 3

BGP Path Selection

N W L O A   O M N i   O I I I I

0. Next hop should be reachable.
1. Highest weight by default 0, except if your router is the originator.. the network weight = 32 768   (0-65535)...
2. Highest local preference by default 100.
3. Self originated. N.H 0.0.0.0 is prefered.
4. Least AS path list.
5. Least origin (i < e < ?).
6. Least MED.
7. Neighbor eBGP prefered over iBGP.
8. For iBGP:
   - Unreflected route prefered over Reflected Route. no originator id
   - Least cluster list is prefered.
   - Least IGP metric.
   - Least Router ID.
   - Least Router IP. (IP of interface received route from it)...

BGP Attributes

w ano La ac OCM

Session 12 Part 1
BGP Algorithm for Best Path Selection

→ N WLOA OMNi OIIII iBGP Neighbor

next hop reachable
Highest weight
Highest local Preference
self originated
Shortest AS Path List
least origin
least MED
eBGP Neighbor prefered over iBGP Neighbor
originator Cluster Id
IGP Metric
least RID
least RIP

→ N WLOA OMN OII eBGP Neighbor

Oldest Router (more stable)
least RID
least RIP

BGP by default choose only one best path ...

(Config-router) # bgp best path ___Attribute___ ignore

(Config-router) # maximum-paths ___1-6___ 1 by default eBGP

(Config-router) # maximum-paths iBGP ___1-6___ 1 by default iBGP

Equal Load Sharing:
Same Attributes till IGP Metric "N WLOA OMNI" ...

Unequal Load Sharing:
using BW attribute (extended Community attribute)
(Config-router) # bgp dmz-link bw

(Config-if) # bandwidth ______
in Kbps

Session 12 Part 2
BGP Attributes Classification

MP-BGP reachable → NLRI
unreachable

W ano La ac OC MMM

W → Cisco attribute
weight
(Not advertised)
= locally significant

La → well Known discretionary
* local Preference
* Atomic aggregate

OC → optional non Transitive
. if a router doesn't need that attribute will strip it off. ينزع
* Originator Id.
* Cluster list. * MED.

ano → well Known mandatory
. well Known by all BGP implementations.
. mandatory = exist in every updates.
* AS Path list
* Next hop
* Origin

ac → optional Transitive
. not Known by all BGP implementations.
. Transitive even if attribute not Known by router, transfer it.
* Aggregator Id.
* Community (standard, extended).

eBGP iBGP Confederation RR MP-BGP

Session 12 Part 3
Attributes

_ Origin Attribute:
Describe how update was injected in BGP Table. Least origin is best.

i < e < ?

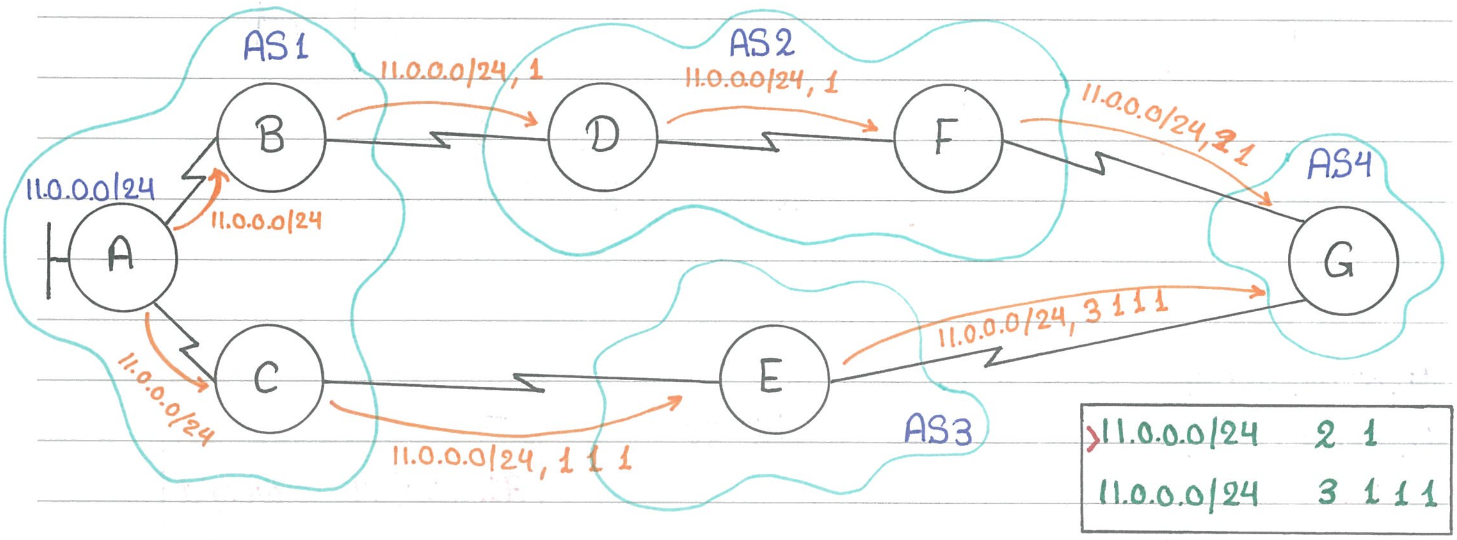
i	e	?
. network Command.	. Redistribute.	. Redistribute.
. aggregate address.	EGP → BGP	IGP → BGP

- Next hop Attribute :

Next hop is router in next AS. It is not changed in iBGP, changed only in eBGP sessions unless next-hop-self command is used.

- AS Path:

Least AS path list is prefered AS no. is prepended only in eBGP updated & not prepended in iBGP update.



c(Config) # route-map x permit
c(Config-route-map) # match ip address 11
c (Config-route-map) # set as-path prepend 1 1
c (Config) # router bgp 1
c (Config-router) # neighbor E route-map x out

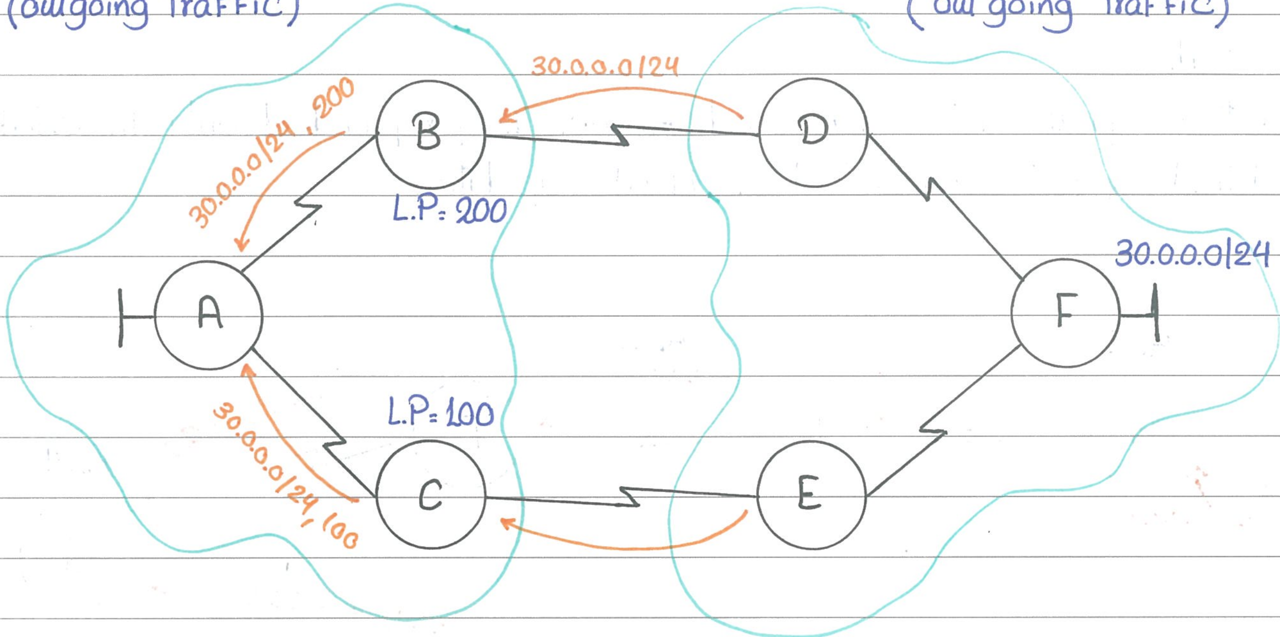
Session 12 Part 4

- weight :

affect incoming update
(outgoing traffic)

- local Preference :

affect incoming update
(outgoing traffic)



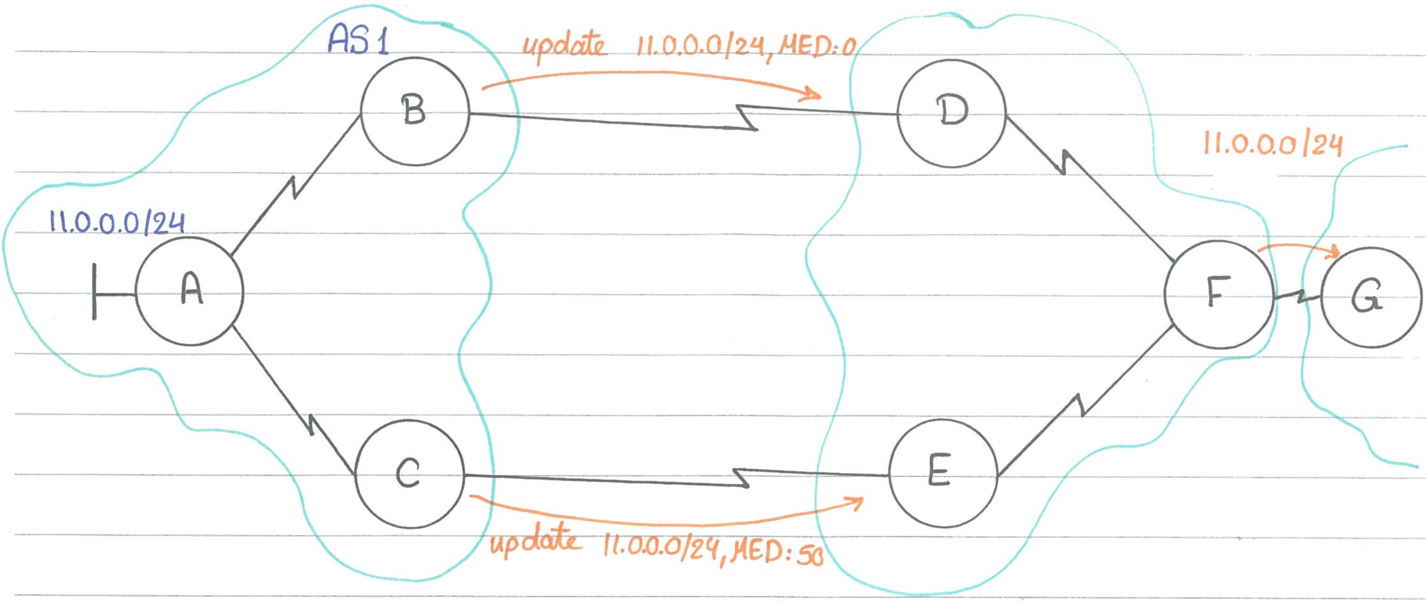
A(Config)# router bgp 1
A(Config-router)# neighbor B weight 50
OR
A(Config)# route-map x permit
A(config-route-map)# match ip address 30
A(Config-route-map)# set weight 50
A(Config)# router bgp 1
A(Config-router)# neighbor B route-map x in

A

30.0.0.0/24		weight
> via	B	50
	C	0

B(Config)# router bgp 1
B(Config-router)# bgp default local-preference 200
OR
B(Config)# route-map x permit
B(Config-route-map)# match ip address 30
B(Config-route-map)# set local-preference 200
B(Config)# router bgp 1
B(Config-router)# neighbor D route-map x in

30.0.0.0/24		L.P
> via	B	200
	C	100



- AS Path list:
  outgoing update
  (incoming traffic).

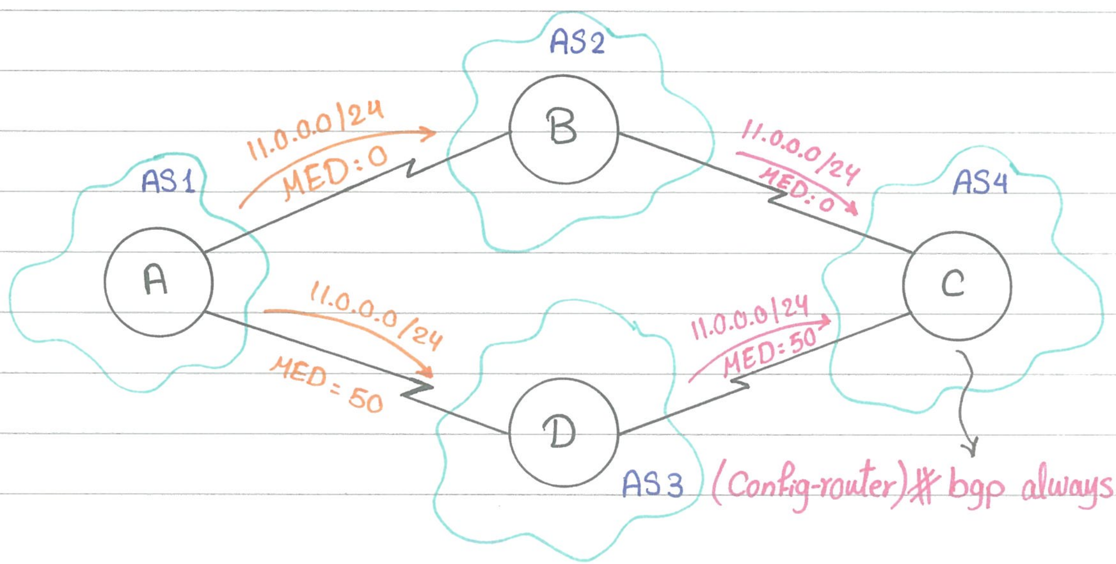
- MED: Multi Exit Discriminator
  by default = 0, least is best.
  outgoing update (incoming traffic).

C (Config) # router bgp 1
C (config-router) # default-metric 50

OR

C (Config) # route-map x permit
C (Config-route-map) # match ip address 11
C (Config-route-map) # set metric 50
C (Config) # router bgp 1
C (Config-router) # neighbor E route-map x out

11.0.0.0/24		metric
> via	D	0
	E	50

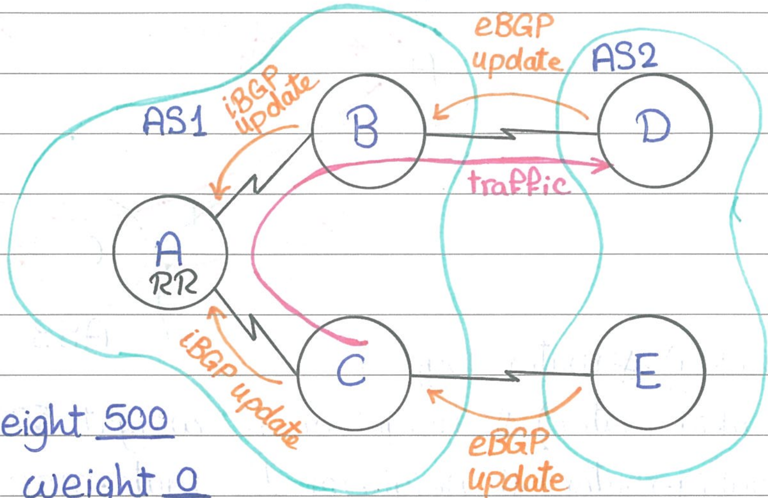


(Config-router) # bgp always-compare-med

Session 13
Advanced Case Studies

_Influencing policy using weight : outgoing traffic

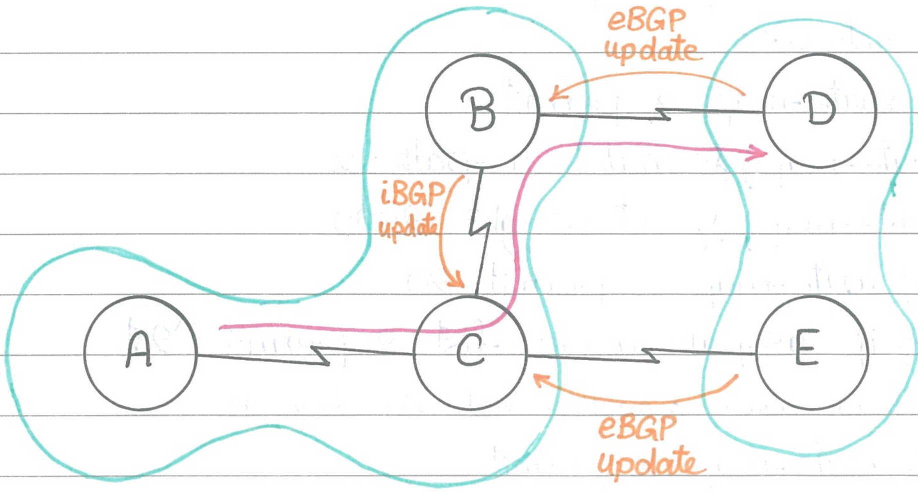
Case 1 :



A(config) # router bgp 1
A(config-router) # neighbor B weight 500
A(config-router) # neighbor C weight 0

C(config) # router bgp 1
C(config-router) # neighbor A weight 500

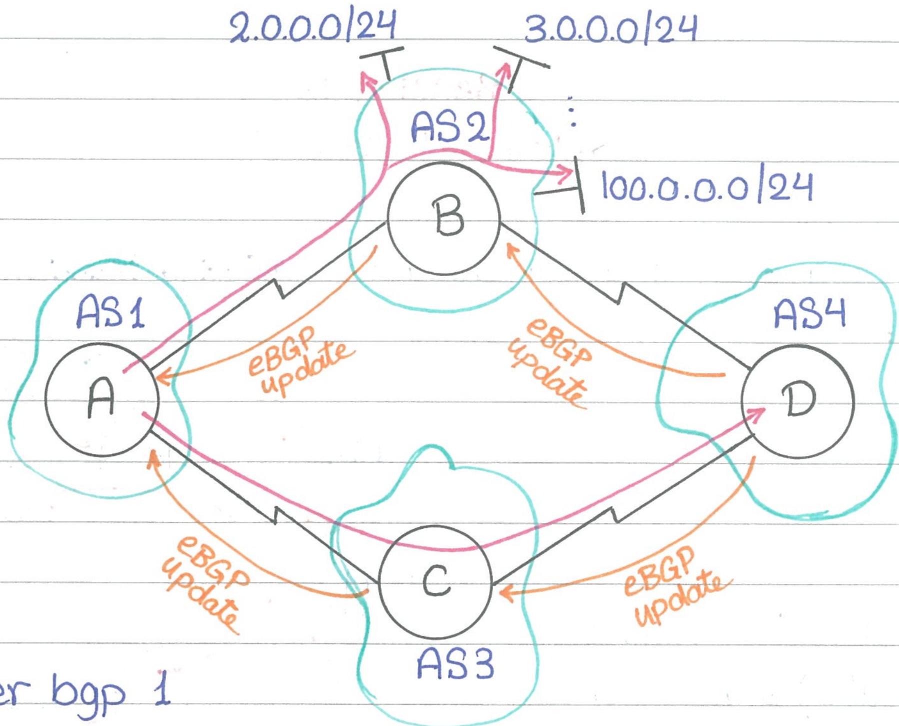
Case 2 :



C(config) # router bgp 1
C(config-router) # neighbor B weight 500

B(config) # router bgp 1
B(config-router) # neighbor D weight 500

Case 3 :



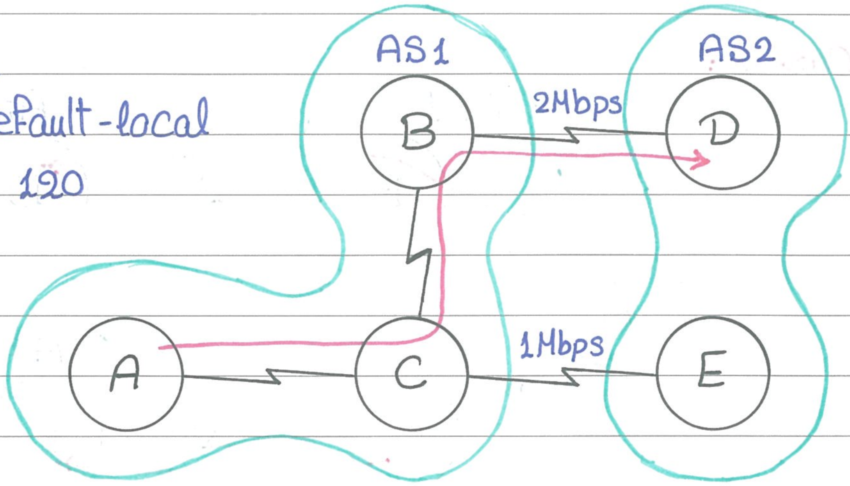
A(Config)#router bgp 1
A(Config-router)# neighbor C weight 500
A(Config-router)# neighbor B route-map x in
For 2.0.0.0/24 only
A(Config)# route-map x permit
A(Config-route-map)# match ip address prefix-list 2
A(Config-route-map)# set weight 2000
A(Config)# route-map x permit 20
For AS2 networks
A(Config)# route-map x permit
A(Config-route-map)# match as-path 2
A(Config-route-map)# set weight 2000
A(Config)# route-map x permit 20
A(Config)# ip as-path access-list 2 permit ^2$
For network 101 from C & another networks from B
A(Config)# route-map x permit
A(Config-route-map)# match ip address 101
A(Config-route-map)# set weight 300
A(Config)# route-map x permit 20
A(Config-route-map)# match as-path 2
A(Config-route-map)# set weight 2000
A(Config)# route-map x permit 30

Session 13 Part 2

- Influencing policy using local preference: outgoing traffic

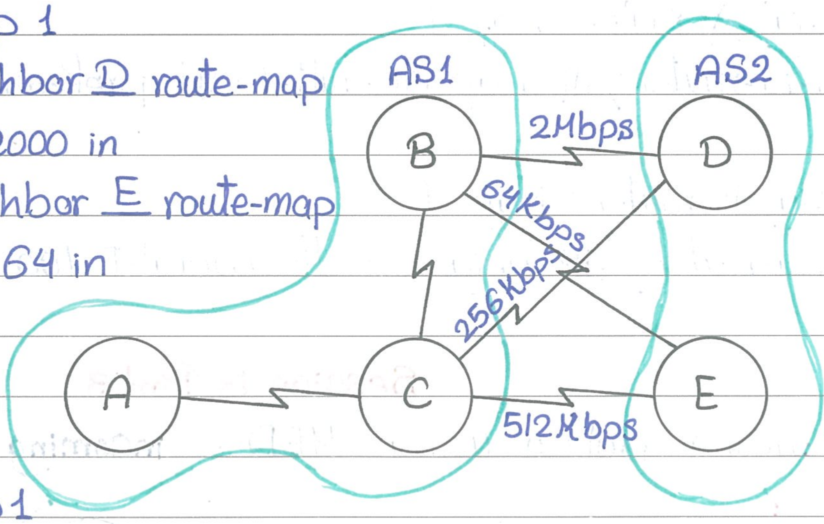
Case 1:

B(Config)# router bgp 1
B(Config-router)# bgp default-local preference 120



Case 2:

B(Config)# router bgp 1
B(Config-router)# neighbor D route-map 2000 in
B(Config-router)# neighbor E route-map 64 in



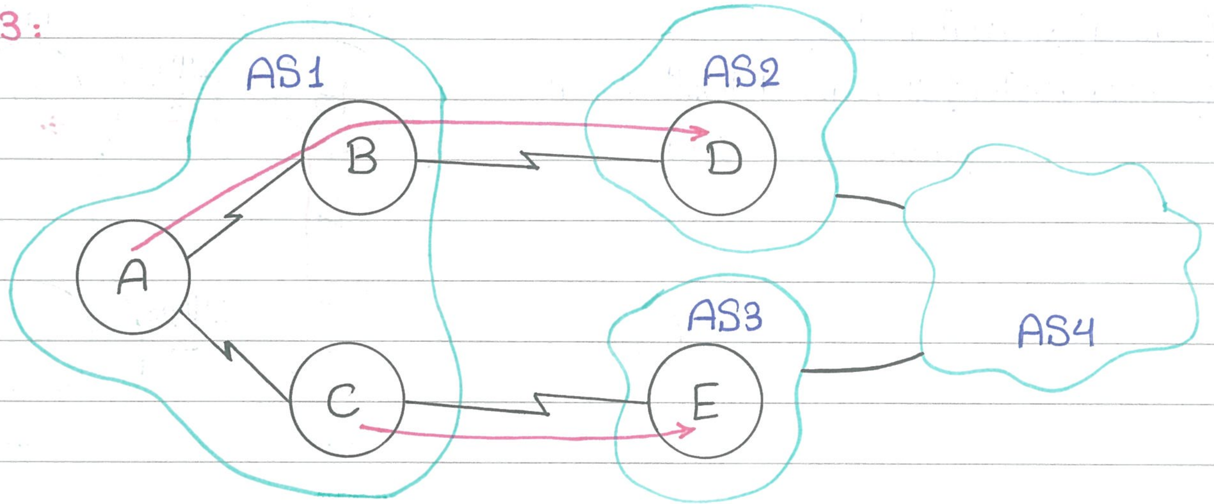
C(config)# router bgp 1
C(Config-router)# neighbor D route-map 256 in
C(Config-router)# neighbor E route-map 512 in

B(Config)# route-map 2000 permit
B(Config-route-map)# set local preference 2000
B(Config)# route-map 64 permit 20
B(Config-route-map)# set local preference 64

C(Config)# route-map 512 permit
C(Config-route-map)# set local preference 512

C(Config)# route-map 256 permit 20
C(Config-route-map)# set local preference 256

Case 3:



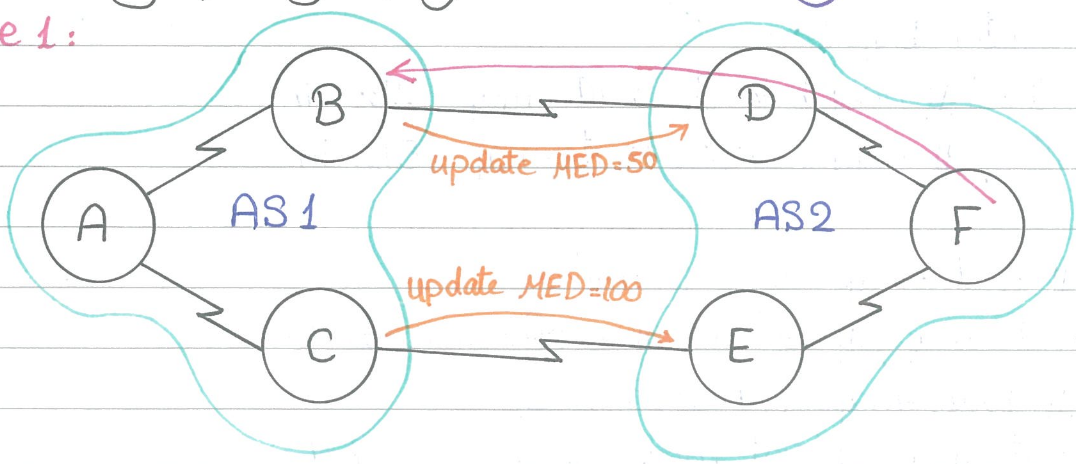
B(Config)# router bgp 1
B(Config-router)# bgp default-local preference 120

C(Config)# router bgp 1
C(config-router)# neighbor E weight 100

Session 13 Part 3

- Influencing policy using MED: incoming Traffic

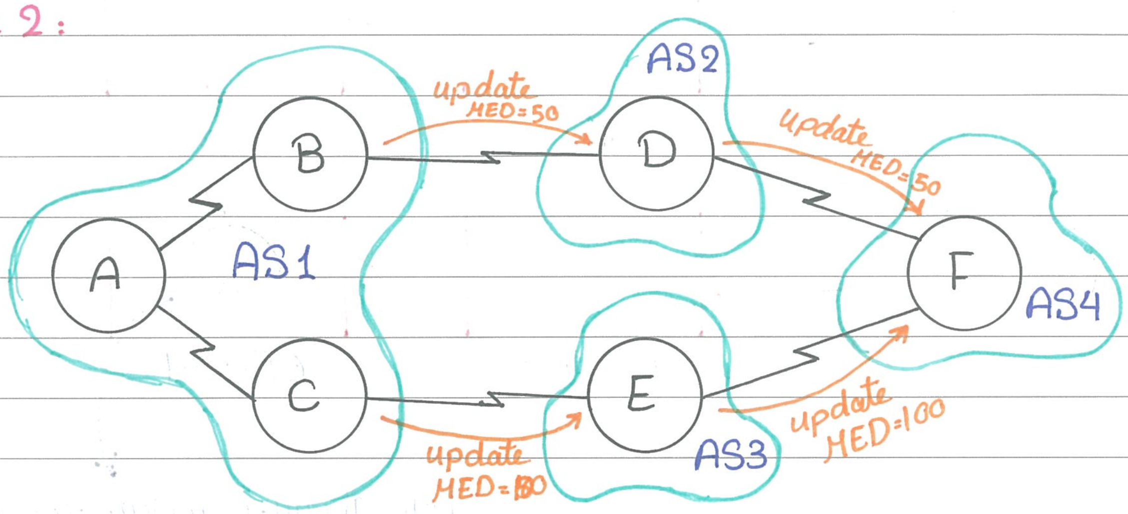
Case 1:



B(Config)# router bgp 1
B(Config-router)# default-metric 50

C(Config)# router bgp 1
C(Config-router)# default-metric 100

Case 2 :

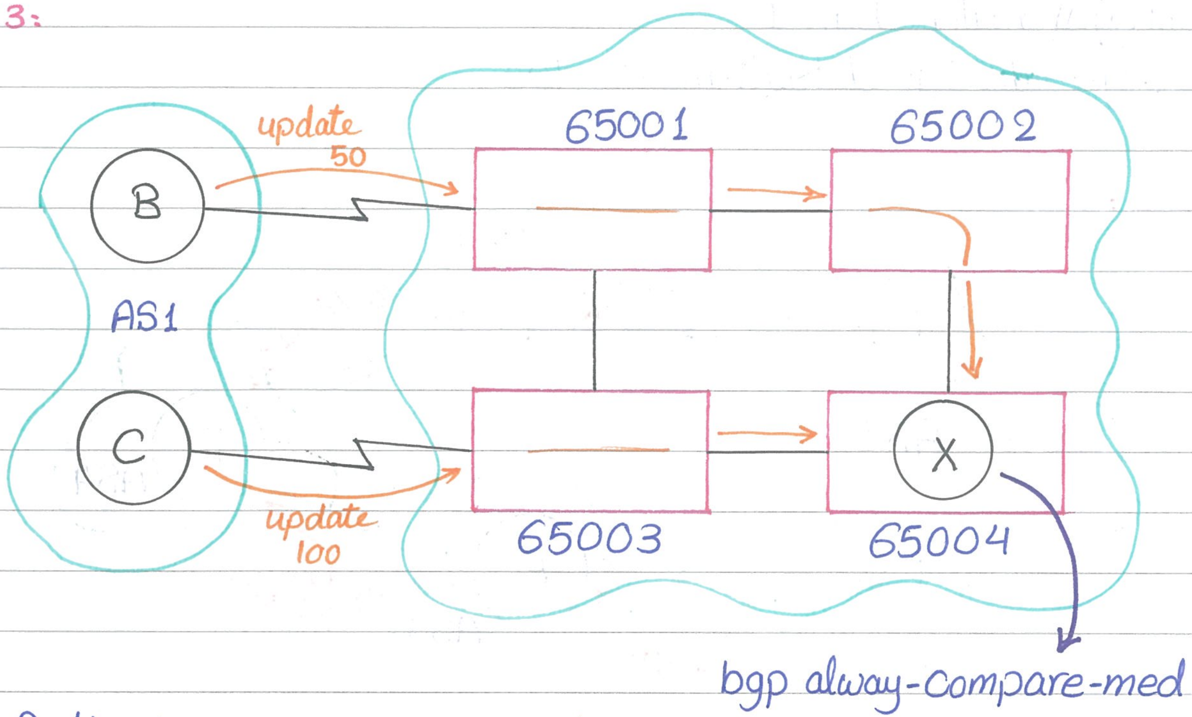


D(Config)# router bgp 2
D(Config-router)# neighbor F route-map x out
D(Config)# route-map x permit
D(Config-route-map)# set metric 50

E(Config)# router bgp 3
E(Config-router)# neighbor F route-map x out
E(Config) # route-map x permit
E(Config-route-map)# set metric 100

F(Config)# router bgp 4
F(Config-router)# bgp alway-Compare-med

Case 3:



default MED = 0 in same vendors

Standard Missing-Med by default ∞

(Config) # router bgp 2

(Config-router) # bgp bestpath med missing-med-worst

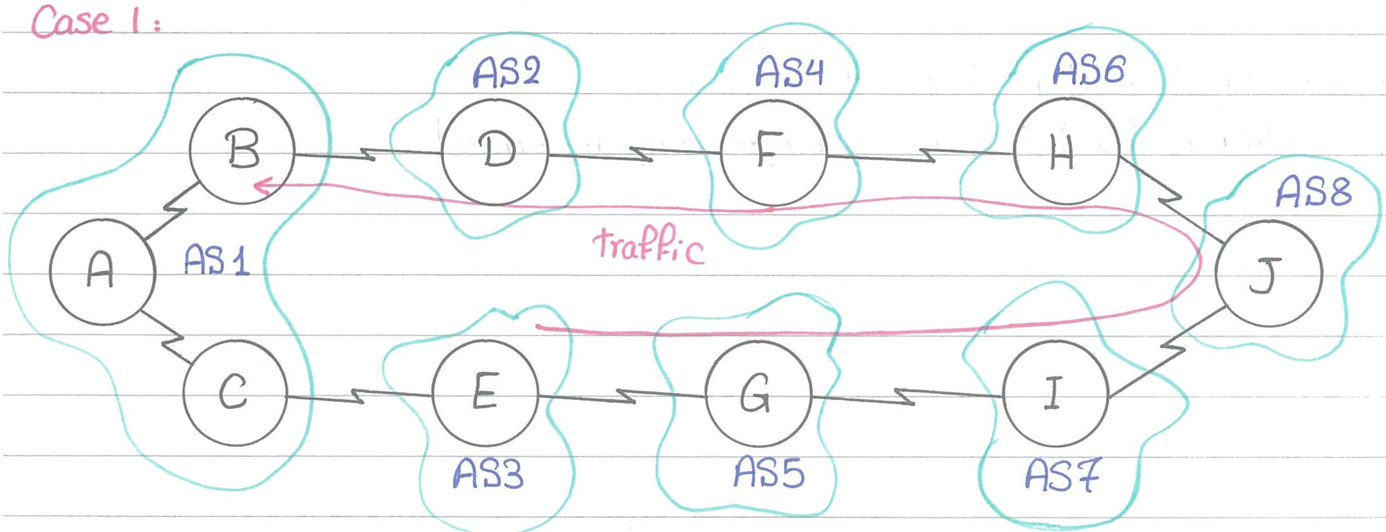
OR

(Config-router) # bgp bestpath med missing-as-worst

Session 13 Part 4

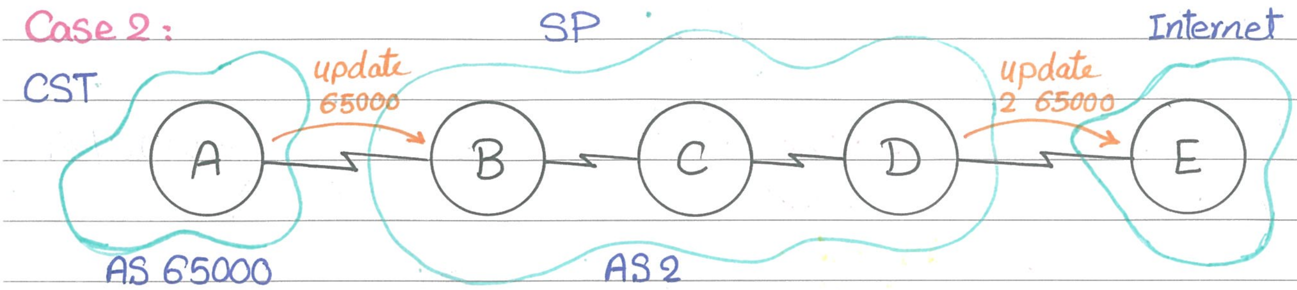
- Influencing policy using AS Path List : incoming traffic

Case 1:



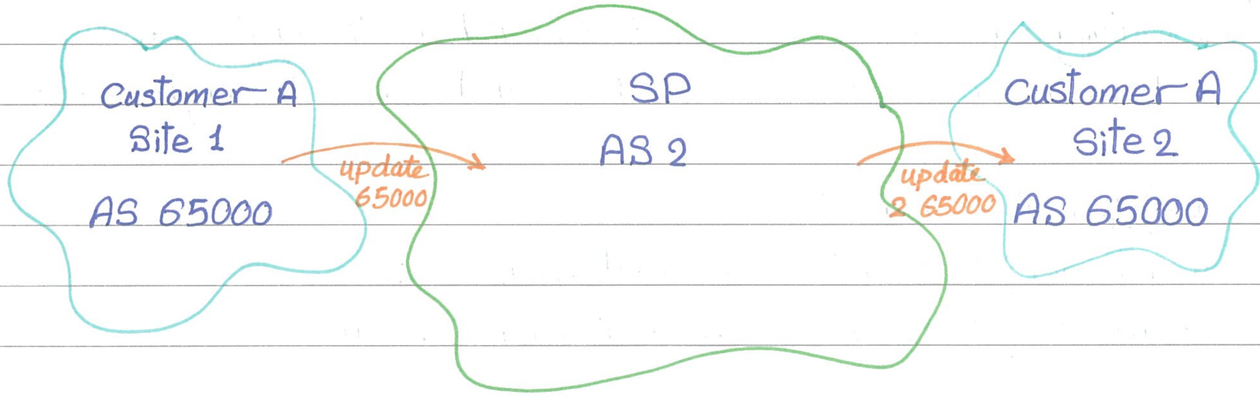
C(Config)# route-map X permit
C(Config-route-map)# set as-path prepend 1 1 1 1 1 1 1 1 1

Case 2:



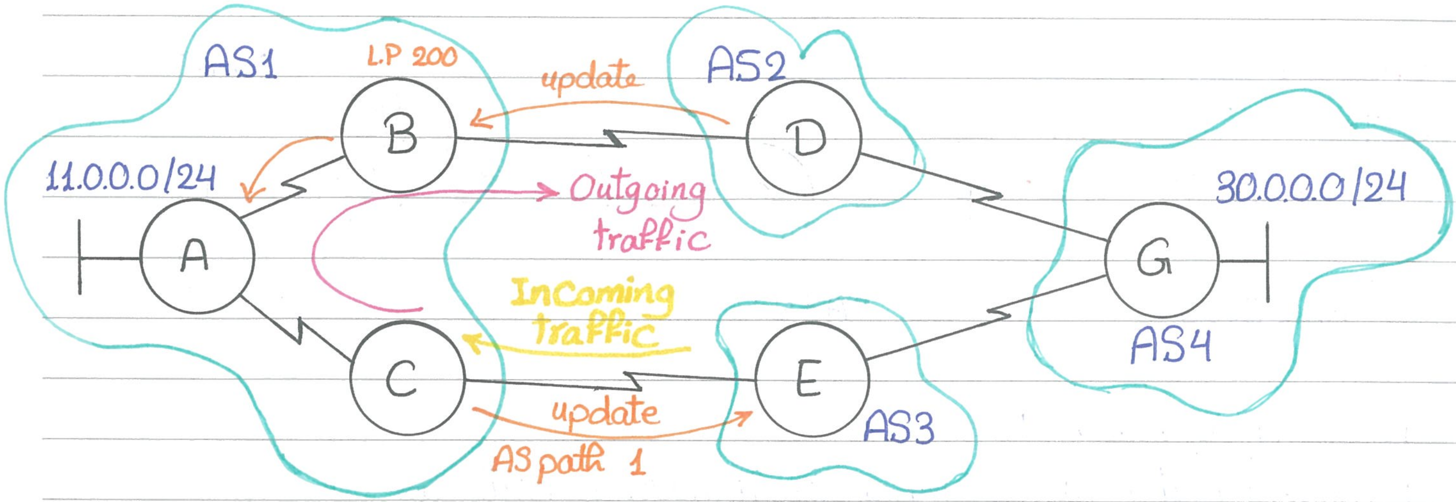
D(Config)# router bgp 2
D(Config-router)# neighbor E remove-private-as

Case 3:



E(Config)# router bgp 65000
E(Config-router)# neighbor D allowas-in ← neglect AS path loop prevention check
OR
D(Config)# router bgp 2
D(Config-router)# neighbor E asoverride

Session 14 Part 1
Asymetric Routing Case Study



Required:

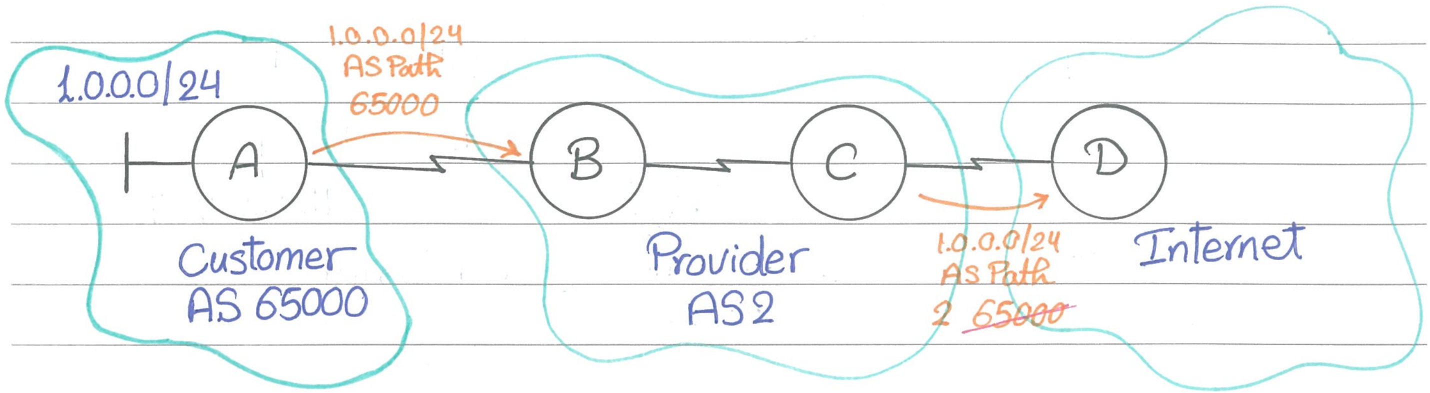
* Outgoing traffic for AS1 should go through AS2.
* Incoming traffic for AS1 should come through AS3.

B(Config)# router bgp 1
B(Config-router)# neighbor D route-map x in
B(Config-router)# neighbor D route-map y out

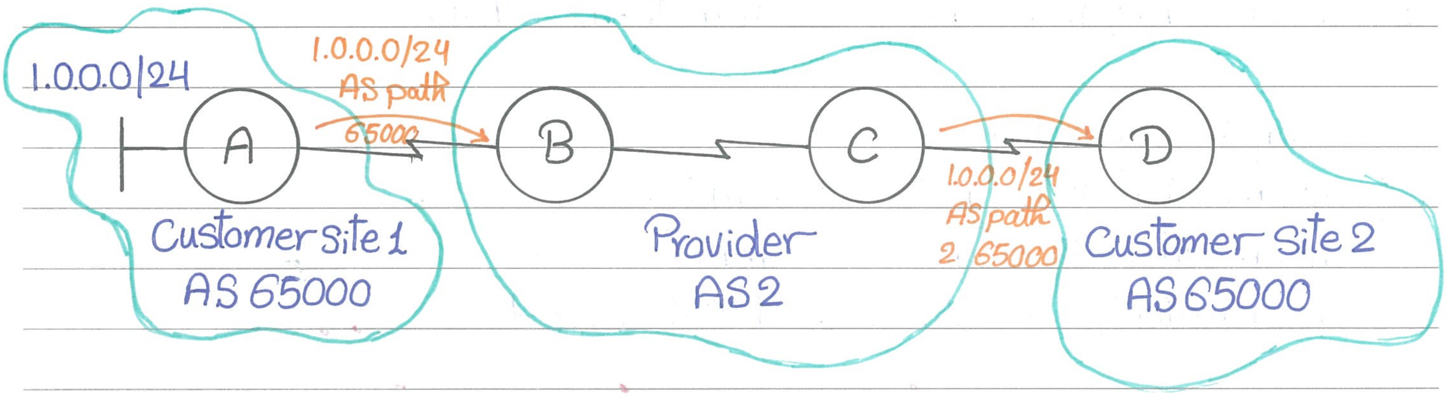
B(Config)# route-map x permit
B(Config-route-map)# set local-preference 200

B(Config)# route-map y permit
B(Config-route-map)# set as-path prepend 1 1 1 1

Session 14 Part 2
AS Translation



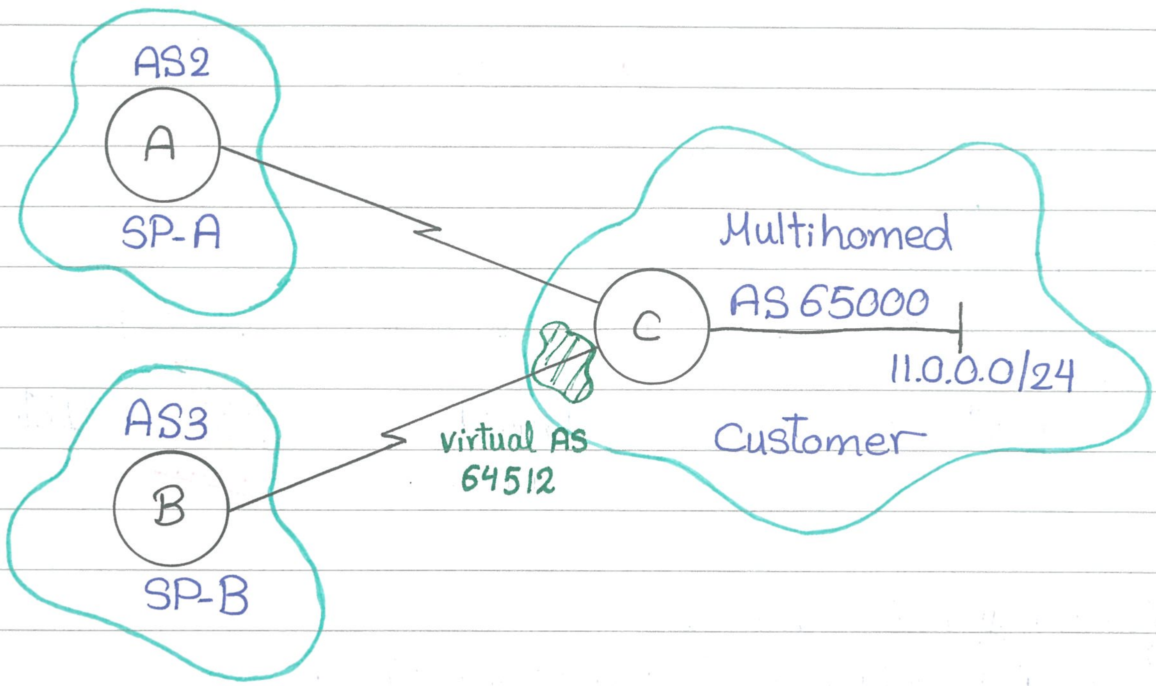
C(Config)# router bgp 2
C(config)# neighbor D remove-private-as



D(Config)# router bgp 65000
D(Config-router)# neighbor C allowas-in → stop AS path list loop Prevention check

OR

C(Config)# router bgp 2
C(Config-router)# neighbor D as-override → 1.0.0.0/24, AS path 2 2



A(Config-router)# neighbor C remote-as 65000
B(Config-router)# neighbor C remote-as 64512

C(config)# router bgp 65000
C(Config-router)# neighbor A remote-as 2
C(Config-router)# neighbor B remote-as 3
C(Config-router)# neighbor B local-as 64512 ...

[no-prepend] [replace-as] [dual-as]

- no-prepend: Don't prepend while Receiving update
- replace-as: Don't prepend while sending update
- dual-as: Neighborship established using local as or main as

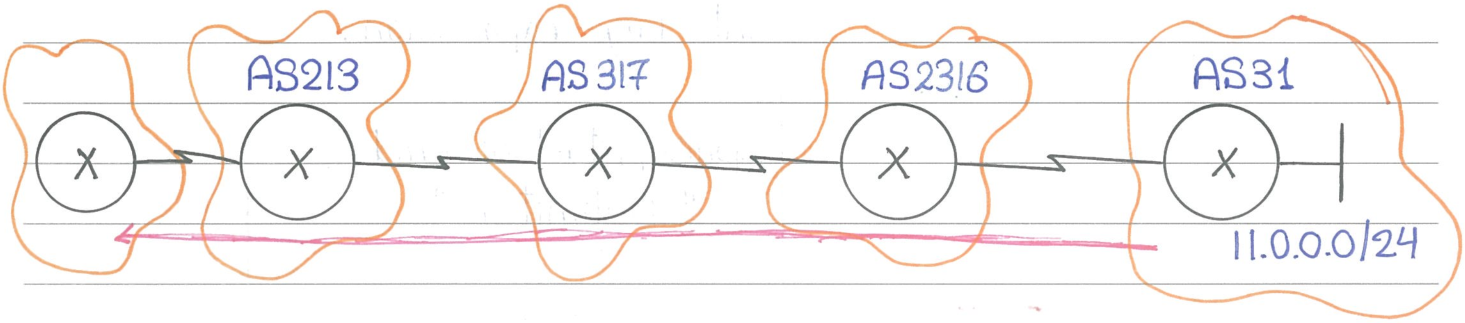
Session 14 Part 3
AS-Path Access list
(AS-Path Filter list)

(Config-router)# neighbor ______ Filter-list AS-Path ACL#

[weight #] {in|out}

Create AS path ACL:

(Config)# ip as-path access-list # {Permit|deny} Regular Expression



AS Path list — 11.0.0.0/24 →

213 317 2316 31

213 ↓ last AS "begging of string"

31 ↓ 1st AS "end of string"

ex: Permit 31 — 213 317 2316 31 (1 2 3)

ex: Permit 21|31 — 213 317 2316 31 (1 2 3 4)

ex: Permit (213|218)_31 — 213 317 2316 31 (1)

213 317 1218 316 31 (1 2)

ex: Permit [123].[3-5] — 213 317 2316 31 (1 2) ex : Permit _2_ عدت على AS 2

ex : Permit ^21_31 $ route خرج من AS31 وعدى على AS21 وبعدين جالي

Regular Expression	Description
|	OR
(	Parentheses used to include small expression into large expression.
_	Space, start OR end "Delimiter"
[ ]	Serial Number
.	Any Character include Space
^	Begging of string
$	End of string
*	Repeat zero or more
?	Repeat zero or one
+	Repeat 1 or more

Session 14 Part 4

Community Attribute

- It is a mean of tagging routes in order to apply policy using attributes or to apply filter.

- It is a more generic attribute that can be mapped to other attribute values.

- By default all networks belong to Community called Internet.
  more general Community

- Community is 32-bit, 64-bit & sometimes more.

- Community is either standard or extended.
  standard: Not send by default
  extended: Send by default
  ex: dmz-link BW, RT, SOO, VPN label...

(Config-router)# neighbor ___ send-community

every SP have like the below:

Community	meaning
2:1	L.P = 200
2:2	AS-Prepend twice
2:3	AS-Prepend three
2:4	no-advertise
2:5	no-export
2:6	local-as
2:7	Internet

2:1 – 2:3: Attribute

2:4 – 2:7: Filters
- don't send update to any router
- don't advertise to real eBGP nei.
- Advertice to iBGP only
- Any

Use route-map:

(Config) # route-map ____ permit

(Config-route-map) # match ip address <u>ACL *</u>
as-path <u>AS-Path ACL *</u>
Community <u>Community ACL *</u>

(Config-route-map) # set local preference ____
as-path prepend _ _ _
Community ______

Community ACL:

(Config) # ip Community-list $\frac{1\text{-}99}{\text{Standard}}$ {permit|deny} <u>Community</u>

OR

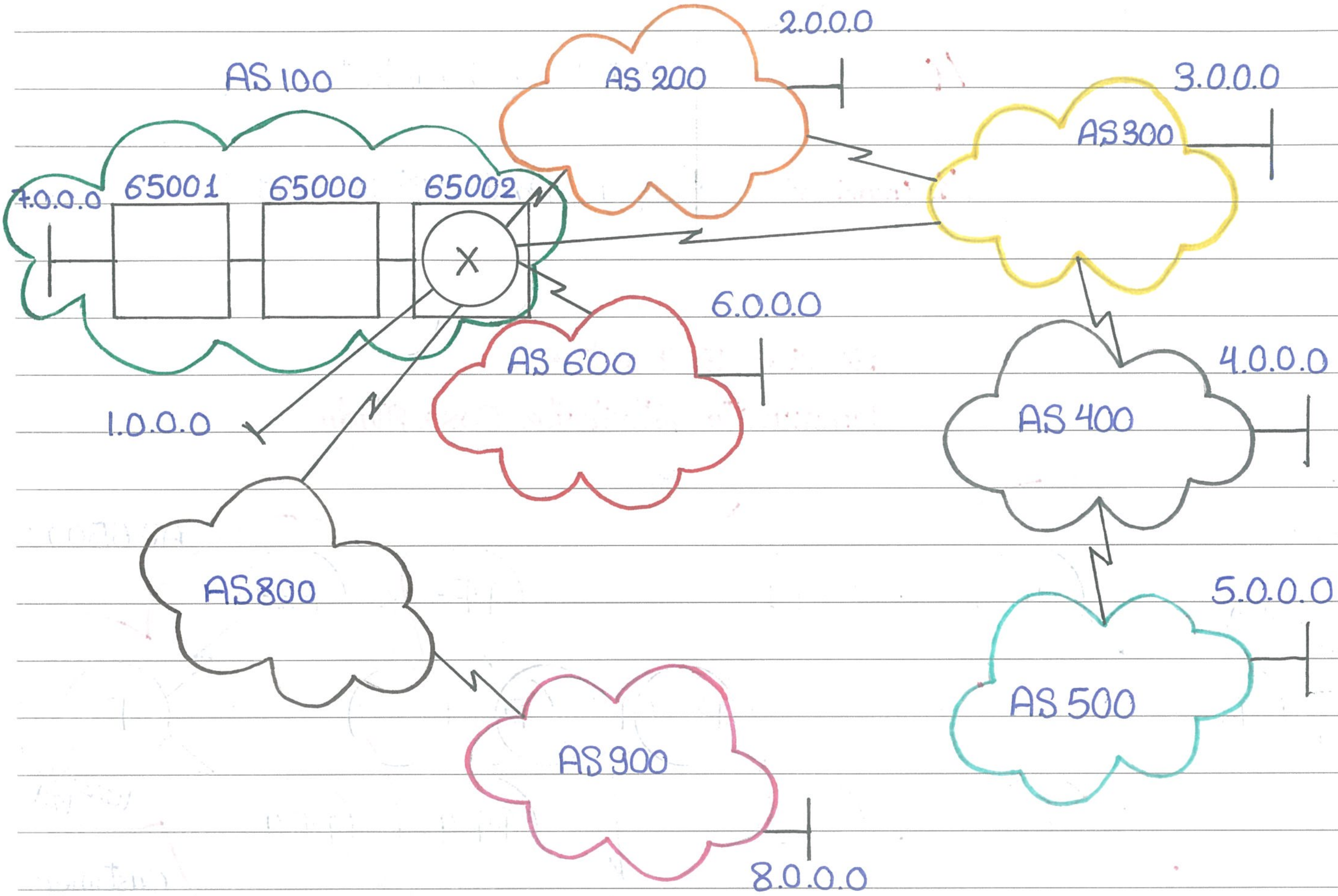
(Config) # ip Community-list $\frac{100\text{-}199}{\text{expanded}}$ {permit|deny} <u>regular expression</u>

ex: 10:103, 10:104, 10:203, 10:204

10:[1-2]0[3-4].

Session 15

— AS Path Regular Expression —



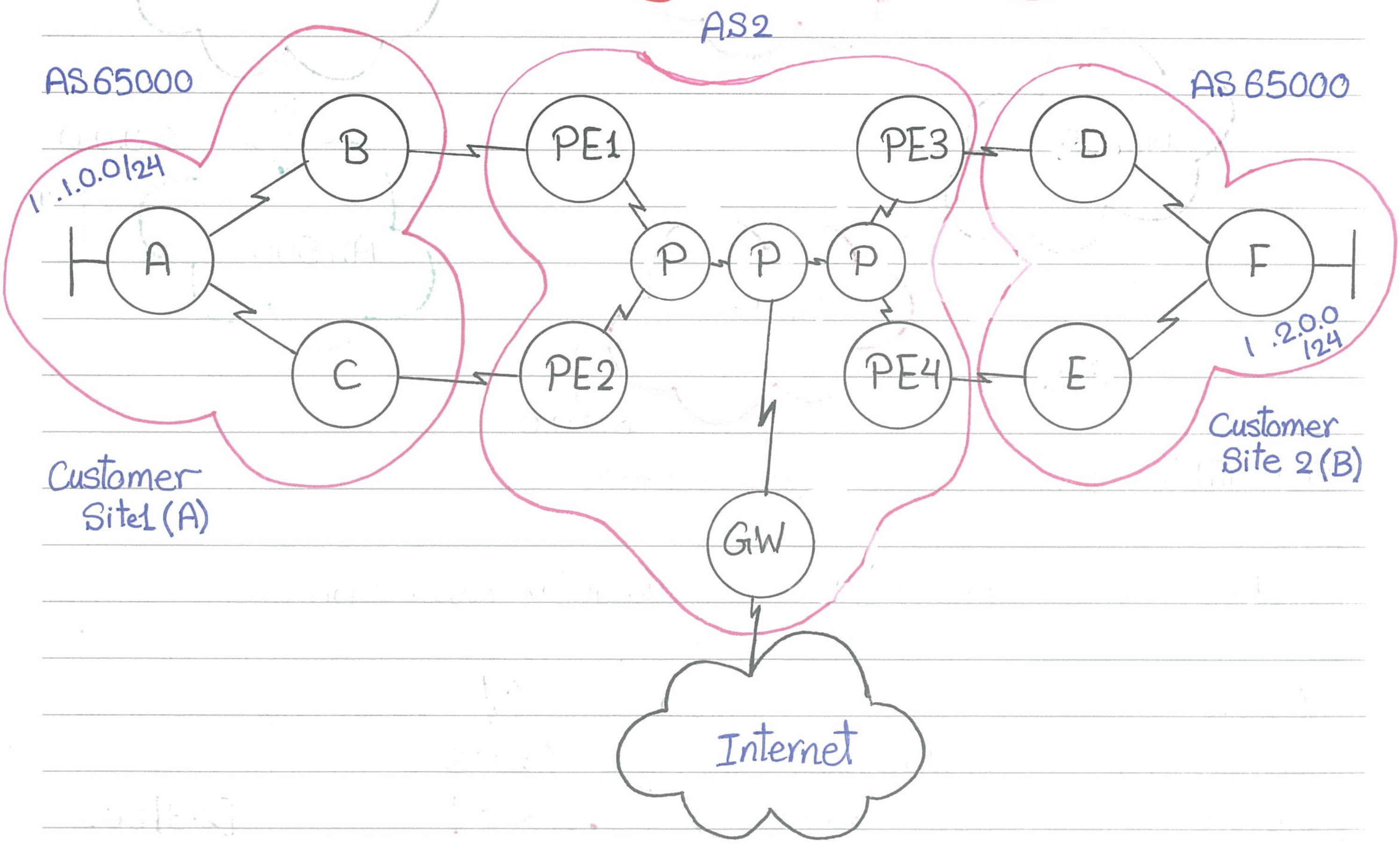
BGP Table : #show ip bgp regular expression

Network	AS Path	Regular Expression	
1.0.0.0		^$	
2.0.0.0	200	^200$	
3.0.0.0	200 300	._300$	
4.0.0.0	200 300 400	._300_.	
5.0.0.0	300 400 500	^300_	
6.0.0.0	600 600 600	(600_)(/1)*	(600_)+
7.0.0.0	(65000 65001)	/(	
8.0.0.0	800 800 900 900	(800_)(/1)(900_)(/2)	

Regular Expression	Description
/(	Match on bracket
/1 (number)	Copy & Paste 1st bracket

Session 15 Part 2

Community Attribute Case Study



PE (Config)# route-map x permit
PE (Config-route-map)# match Community ACL"1"
PE (Config-route-map)# set as-path prepend 65000 65000 65000 65000

PE (Config)# ip Community-list 1 permit 2:4

C (Config) # route-map y permit
C (Config-route-map) # match ip address 1
C (Config-route-map) # set Community 2:4 2:200

C (Config) # router bgp 65000
C (config-router) # neighbor PE2 send-Community

GW (config) # route-map z permit
GW (Config-route-map) # match Community 2:200
GW (Config-route-map) # set Community no-export

PEs (Config) # route-map W permit
PEs (Config-route-map) # match ip address 1
PEs (Config-route-map) # set Community 2:200 additive

Add new community to old community

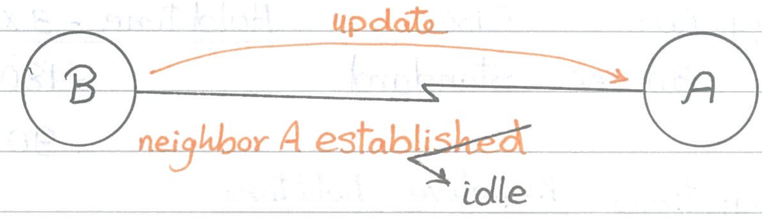
Session 15 Part 3

For any BGP Policy to be applied we need to clear bgp session with neighbor.

* Option 1 : Hard clear

clear ip bgp { neighbor | * }

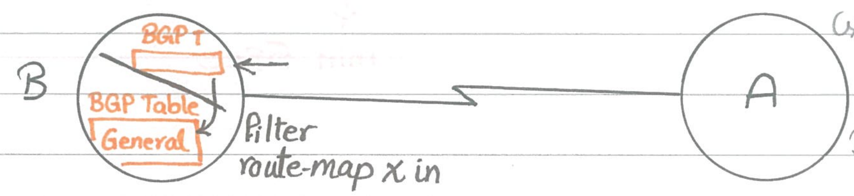
All neighbors



* Option 2 : Soft clear (Config-router) # neighbor A soft-reconfiguration in

clear ip bgp neighbor soft in

نسخة من routes اللي A بيبعتها بتتخزن في BGP Table مخصوص

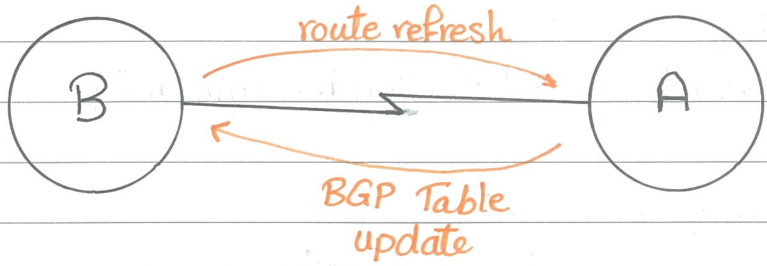


كل nei. بيتخزنله BGP Table مخصوص في memory

* Option 3 : Route Refresh

#clear ip bgp _neighbor_ soft in

BW خسرتني

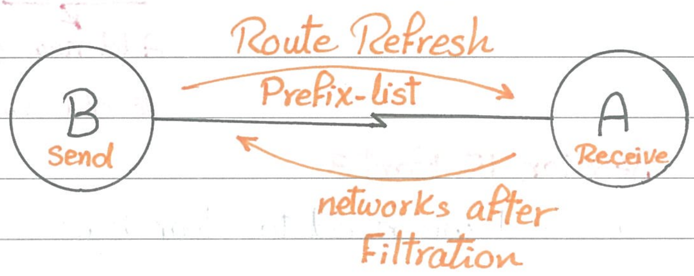


* Option 4 : ORF (Outbound Route Filter)

B (Config-router)# neighbor A capability orf _Prefix-list_ [send / Receive / both]

B (Config-router)# neighbor A prefix-list _x_ in

#Clear ip bgp _neighbor_ prefix-list in



Router A "Received"

Session 15 Part 4
BGP Convergence

- Neighborship :

Keepalive every 60 sec Cisco
30 sec standard

Hold time = 3 x Keepalive
= 180 sec Cisco
= 90 sec other vendors

(Config-router)# bgp timer _keepalive_ _hold time_

OR

(Config-router)# neighbor ______ timer _Keepalive_ _holdtime_

↓ min 5sec

Session 17

MPLS

LDP Protocal : @startup

[0] LDP Router ID :

0.1 Manual :

(Config)# mpls ldp router-id interface name

0.2 Automatic :

- Highest Loopback IP .
- Highest Physical*Interface (Active) IP .

(1) LDP Neighbor Discovery :

exchange of hello (dst IP : 224.0.0.2, dst Port : 646).

(2) LDP Label Discovery :

exchange of labels .

⇒ Label Conditional advertisement :

(Config)# mpls ldp advertise-label [for ____ to ____]

ACL Prefixes ACL neighbor

Routing Table

↓

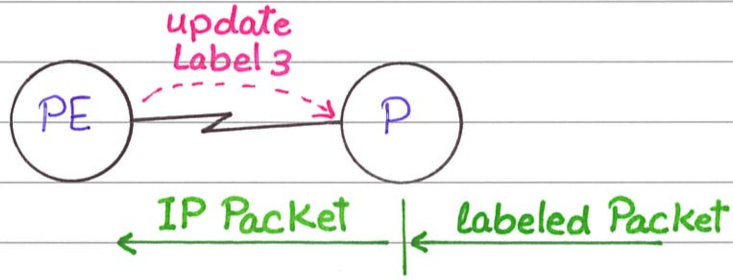
LIB Table (label Info Base)

↓

LF-IB Table (label Forward Info Base)

Best path using labels

⇒ Penultimate Hop Popping (PHP):



Label 3
"implicit null"
يعني P هيشيل label وبالتالي
lose experimental bits
to keep it

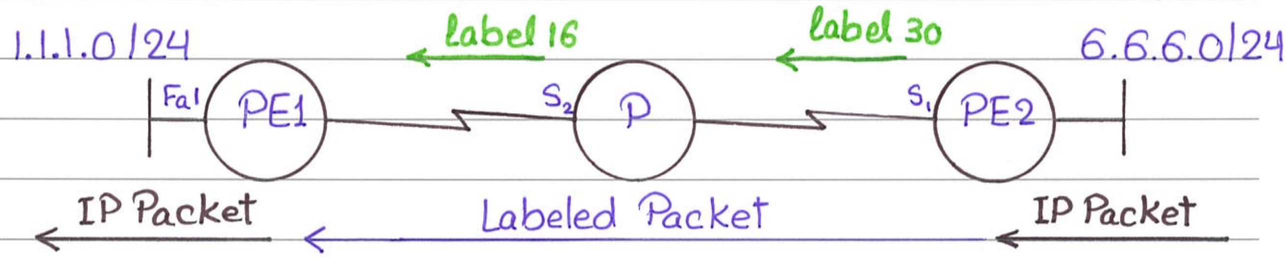
(Config)# mpls ldp explicit-null
label 0

— MPLS Application —

1. UniCast Routing:

FEC (Forward Equivalent Class) ≡ DST IP uniCast ≡ label

ال label بيعبرعن ايه



PE1 1.1.1.0/24

In label	Out Label	Interface
16	Untagged	Fa 1

PE2 1.1.1.0/24

In label	Outlabel	Interface
untagged	30	S_1

P 1.1.1.0/24

In label	Out Label	Interface
30	16	S_2

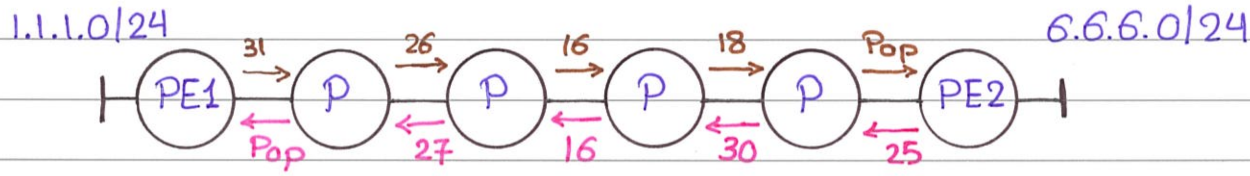
⇒ TTL Propagation :

IP Packet ← TTL = 254 IP Packet ← TTL = 255

(Config)# no mpls ip propagate-ttl

Session 17 Part 2

⇒ LSP label Switch Path :

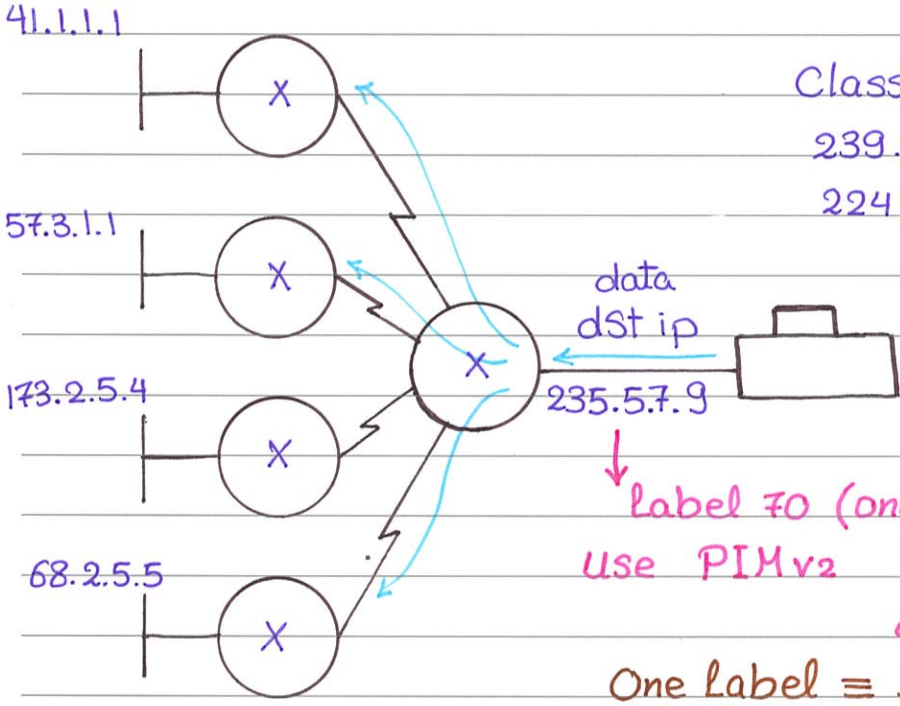


LSP = 25, 30, 16, 27 then pop —
LSP = 31, 26, 16, 18 then pop — Build by LDP

(Config-if)# mpls ip

2. Multicast IP Routing :

FEC ≡ DST IP MultiCast



Class D
239. x. x. x
224. x. x. x

↓ label 70 (one send & many received)

use PIMv2 has mpls label distribution feature

One label ≡ Multiple Destination

Routing Table

41.1.1.0	S1
57.3.1.0	S2
173.2.5.4	S3
68.2.5.0	S4

⇔

PIMv2
multicast routing table

238.5.7.9	S1,S2,S4

Show ip mroute

3. QoS Quality of Service :

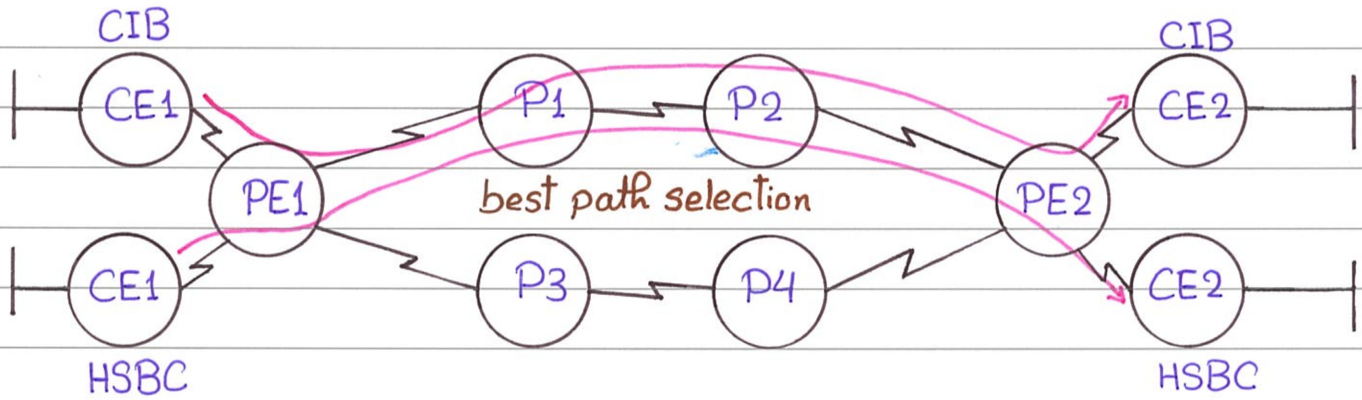
FEC ≡ Class of Service .

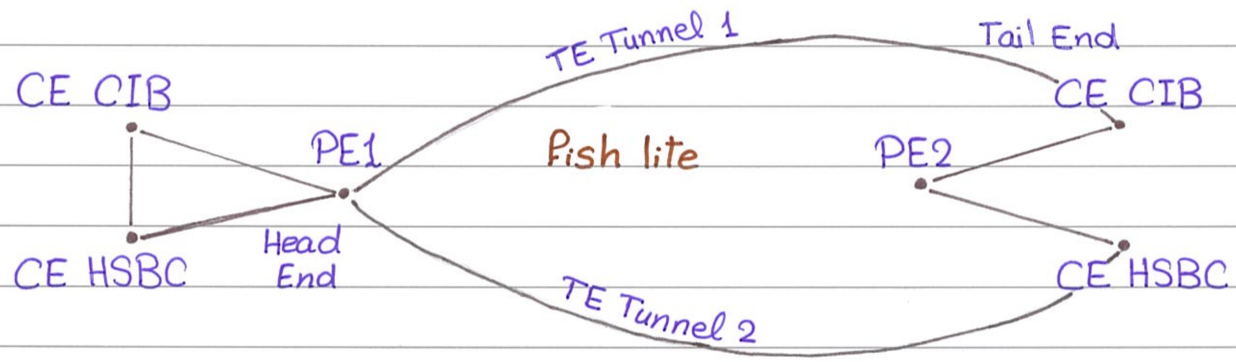
Label reflect traffic Class .

Session 17 Part 3

4. MPLS Traffic Engineering :

Using all available resources (dynamic TE)





MPLS need 2 labels & Sometimes 3 labels

Use LDP → head end / Tail end

RSVP = Resource Reservation Protocal → Build Tunnels .

OSPF or ISIS (as must use one of them)
to can detect the below:

- Maximum BW
- Available BW
- Used BW
- Reserved BW
- Priority

⇒ OSPF v2 :

- Type 9 LSA , Type 10 LSA & Type 11 LSA is called .. Opaque LSA .. used with MPLS TE contains info above .

  9. Link local between 2 Routers   10. Intra Area Area local   11. AS-wide

- Type 8 LSA + Type 5 LSA when using BGP
  8. hold BGP attributes.   5. NLRI.

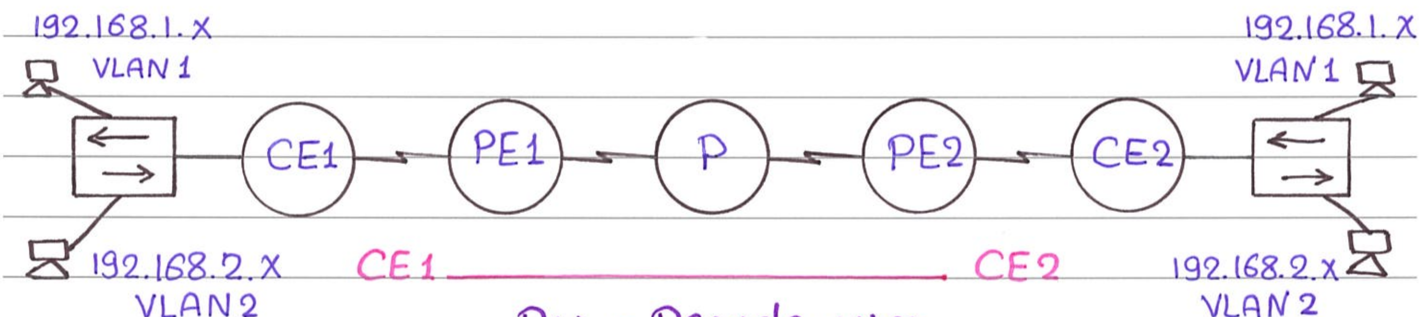
  not used

⇒ ISIS :

TLV 22 , TLV 135

Session. 17 Part 4

5. Layer 2 VPN :



- PW ≡ Pseudo wire
- VPLS ≡ Virtual Private LAN Service
- EVN ≡ Easy Virtual Network

6. Layer 3 VPN :

.. first we need to classify VPN ..

Session 17 Part 5

VPN Classification

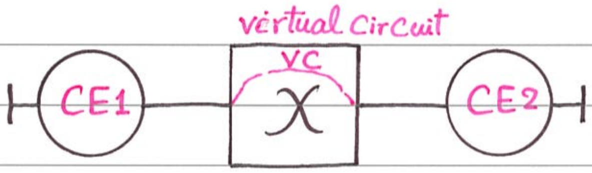
- Intranet VPN :
  VPN between different branches of same Company .
- Extranet VPN :
  VPN between different sites of different Companies .
- Access VPN :
  VPN using dial up or broadband or 4G network.
  VPDN ≡ Virtual Private Dial up Network .

- Overlay VPN:
  Service provider doesn't participate in customer routing.
- Peer to Peer VPN:
  Service provider participates in customer routing.

- Tunneling :
  - L2 tunneling:
    L2TP, L2F, PPPP
  - L3 tunneling:
    GRE , IPSec .

- Simple VPN :
  All customer site share same VPN .
- Complex VPN :
  Customer sites can share many different VPN.
  - Overlapping VPN.
  - Centralised service VPN.
  - Management VPN.
- Hierarchical VPN:
  - Inter AS VPN .
  - CSC ≡ Carrier Supporting Carrier .

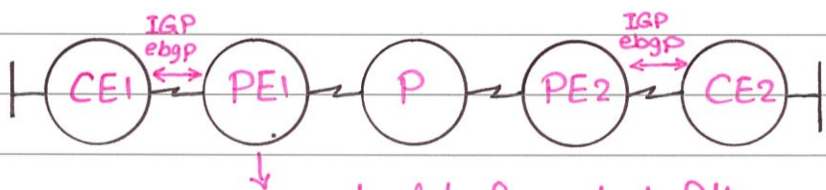
→ Overlay VPN:



- HDLC , PPP .
- X.25, FR, ATM .

disadvantage:
- Control .
- Security.

→ Peer to Peer VPN:



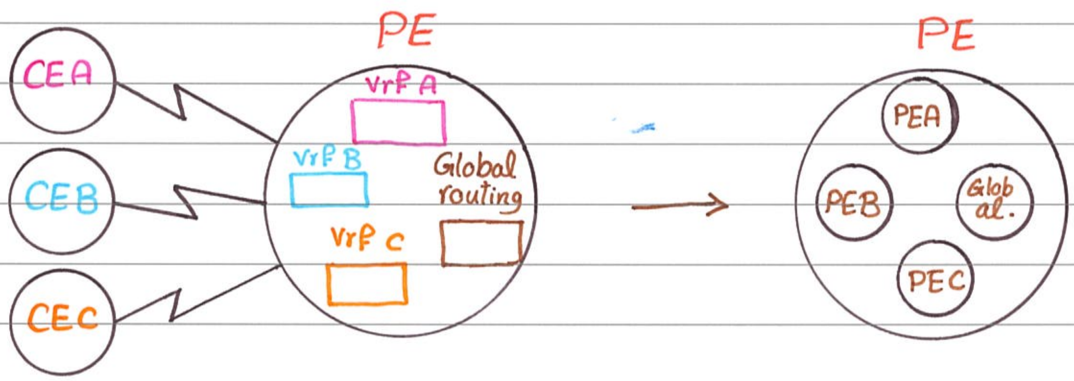
need alot of packets filter & route filter ...

Session 18
MPLS L3 VPNs

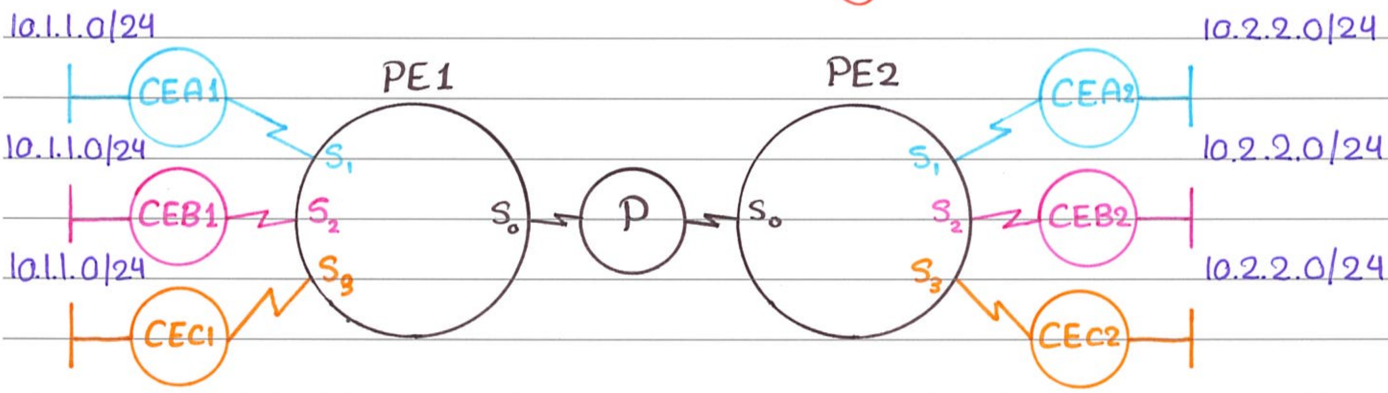
We can implement :

- Intranet VPN (Sites of same enterprise).
- Extranet VPN (Sites of differetnet companies).
- Overlay VPN (IP address overlapping).
- Peer-to-peer VPN.
- Simple VPN.
- Complex VPN.
- Hierarchical VPN.
- Tunneling.

VRF (Virtual Routing & Forwarding):



Session 18 Part 2
MPLS L3 VPNs using VRFs



On PE1 :

- Create VRF :

(Config) # ip vrf A

(Config-vrf) # vpn id OUI : VPN Index

optional

(Config-vrf) # rd 2:1

(Config-vrf) # route-target 2:100

RD = Route Distinguisher used to Separate IP network overlapping, will Create new address-family VPNv4
RD : IPaddress ≅ 96 bits

- Activate VRF :

(Config) # interface S1

(Config-if) # ip vrf forwarding A

(Config-if) # ip address ______ ______

(Config) # ip vrf B

(Config-vrf) # vpn id ___ : ___

(Config-vrf) # rd 2:2

(Config-vrf) # route-target 2:200

(Config) # interface S2

(Config-if) # ip vrf forwarding B

(Config-if) # ip address ______ ______

Route-Target Option :

(Config-vrf) # route-target [import | export | both] ______

receive (import), send (export), by default (both)

- Selective route target

On PE2 :

- Import RT :

(Config) # ip vrf A

(Config-vrf) # rd 2:1

(Config-vrf) # route-target 2:100

(Config-vrf) # import map x

(Config) # route-map x permit

(Config-route-map) # match ip address 1

(Config) # access-list 1 permit 10.1.1.0

- Export RT :

(Config) # ip vrf B

(Config-vrf) # rd 2:2

(Config-vrf) # export map Y

(Config-vrf) # route-target 2:1000

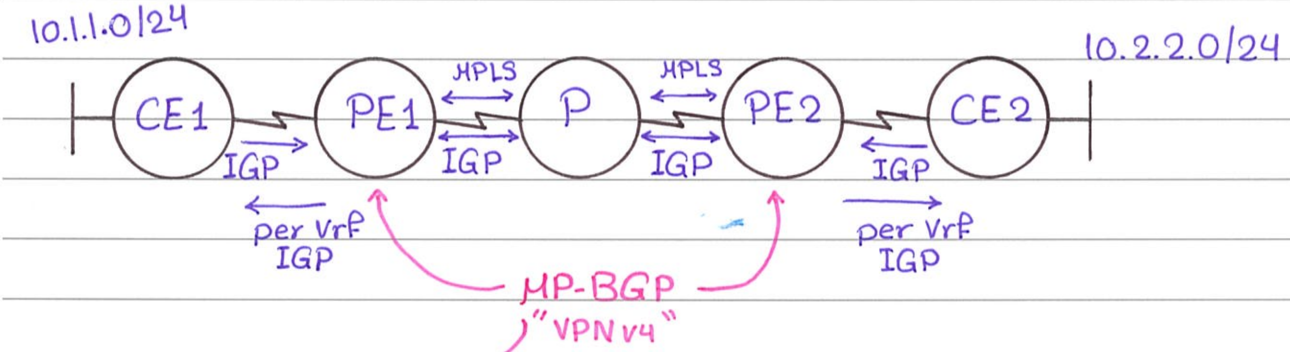
(Config) # route-map Y permit

(Config-route-map) # match ip address 2

(Config-route-map) # set extcommunity rt 2:200 additive

(Config) # access-list 2 permit 10.2.2.0

Session 18 Part 3
MPLS L3VPN routing Scheme



Other address-families then IPv4 uniCast

VPN v4 Update :

NLRI + Attributes

RD : Network/mask, RT & VPN label &
SOO Site of Origin (optional)

ex : 2:1 : 10.1.1.0/24 , RT = 2:100 , VPN label = 16
2:1 : 10.3.3.0/24 , RT = 2:100 , VPN label = 17

CE1 Routing Table:

C	10.1.1.0 /24	e_1
R	10.2.2.0 /24	S_1

⟵ L3VPN Target ⟶

CE2 Routing Table:

C	10.2.2.0 /24	e_2
R	10.1.1.0 /24	S_0

PE₁(Config-router) # network ________
PE₁ (Config-router) # redistribute bgp 2 metric transparent

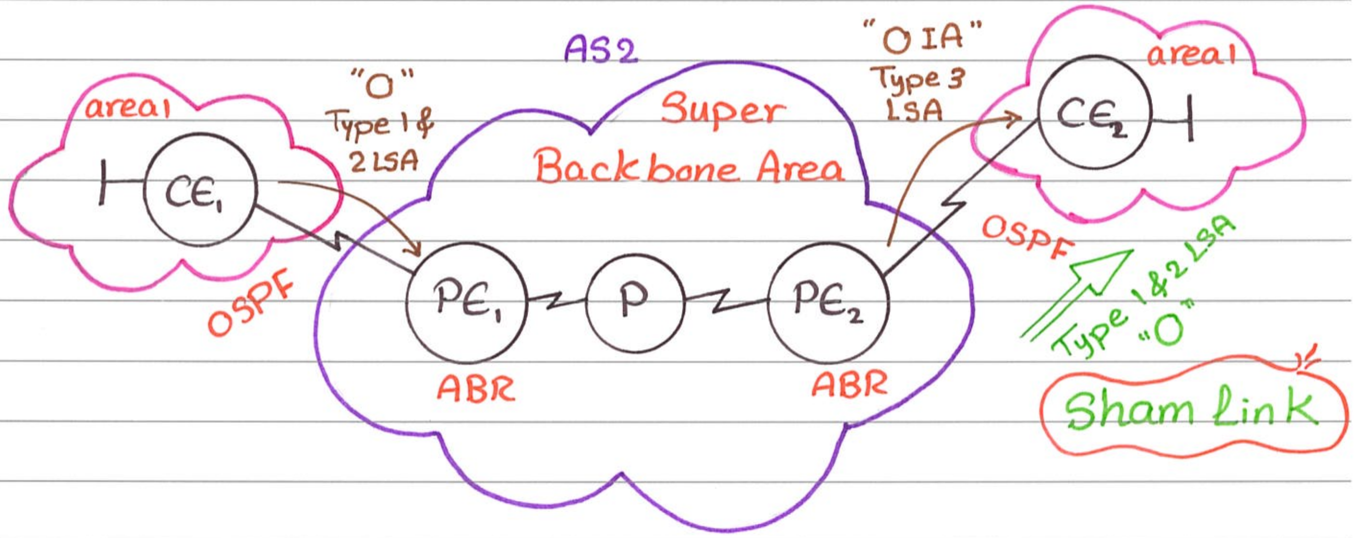
PE₁(Config) # router bgp 2
PE₁ (Config-router) # address-family ipv4 vrf A
PE₁ (Config-router) # redistribute rip

_ OSPF V2 :

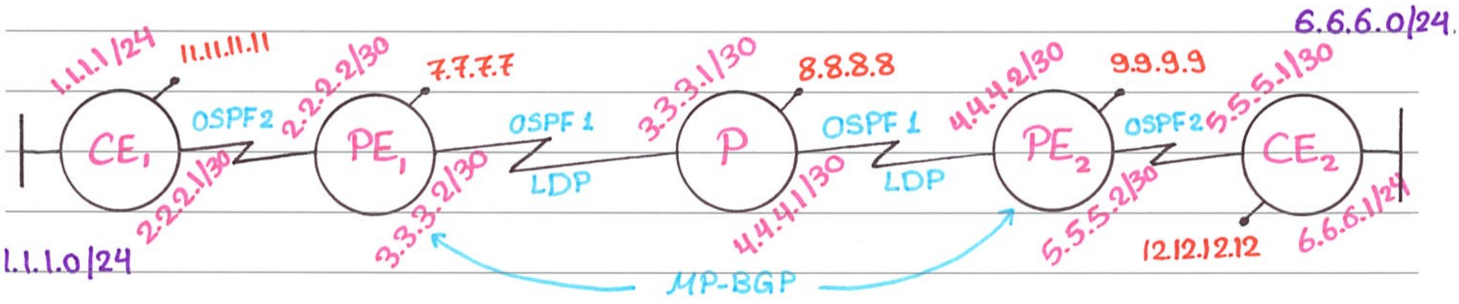
CE₁ (Config) # router ospf 1
CE₁ (Config-router) # network ______ ______ area 1

PE₁ (Config) # router ospf 1 vrf A
PE₁ (Config-router) # network 10.5.5.2 0.0.0.0 area 1
PE₁ (Config-router) # redistribute bgp 2 subnets

PE₁ (Config) # router bgp 2
PE₁ (Config-router) # address-family ipv4 vrf A
PE₁ (Config-router-af) # redistribute ospf 1 vrf A



Session 20



P# Show ip route

O	1.1.1.0 /24	110/3	3.3.3.2	Fast Ethernet 0/0
O	2.2.2.0 /30	110/2	3.3.3.2	Fast Ethernet 0/0
C	3.3.3.0 /30	directly Connected		Fast Ethernet 0/0
C	4.4.4.0 /30	directly Connected		Fast Ethernet 0/1
O	5.5.5.0 /30	110/11	4.4.4.2	Fast Ethernet 0/1
O	6.6.6.0 /24	110/21	4.4.4.2	Fast Ethernet 0/1
O	7.7.7.7 /32	110/2	3.3.3.2	Fast Ethernet 0/0
C	8.8.8.8 /32	directly Connected		Loopback 0
O	9.9.9.9 /32	110/2	4.4.4.2	Fast Ethernet 0/1
O	11.11.11.11 /32	110/3	3.3.3.2	Fast Ethernet 0/0
O	12.12.12.12 /32	110/12	4.4.4.2	Fast Ethernet 0/1

P# Conf t
P(Config)# int f0/0
P(Config-if)# mpls ip
P(Config-if)# mpls label protocal ?
  both use LDP or TDP
  ldp use LDP (default)
  tdp use TDP
P(Config-if)# int f0/1
P(Config-if)# mpls ip

P# 7.7.7.7
Trying 7.7.7.7 ... open

PE1 # Conf t
PE1(Config) # int f0/0
PE1(Config-if) # mpls ip

PE1 # 9.9.9.9
Trying 9.9.9.9 ...open

PE2 # Conf t
PE2(Config) # int f0/1
PE2(Config-if) # mpls ip

P # Show mpls interfaces

Interface	IP	Tunnel	Operational
FastEthernet 0/0	Yes (ldp)	No	Yes
FastEthernet 0/1	Yes (ldp)	No	Yes

P# show mpls ldp neighbor

Peer LDP Ident	Local LDP Ident	TCP Connection
7.7.7.7 : 0	8.8.8.8 : 0	7.7.7.7.646 – 8.8.8.8.24997
9.9.9.9 : 0	8.8.8.8 :0	9.9.9.9.11726 – 8.8.8.8.646

P# Show mpls forwarding-table

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Outgoing interface	Next Hop
20	Pop tag	7.7.7.7/32	Fa0/0	3.3.3.2
21	Pop tag	9.9.9.9/32	Fa 0/1	4.4.4.2

PHP

```
P# 7.7.7.7
Trying 7.7.7.7 ...open

PE1 # Conf t
PE1(Config)# ip vrf a
PE1(Config-vrf)# rd 1:1
PE1(Config-vrf)# route-target ?
      both        import & export
      export      export
      import      import
PE1(Config-vrf)# route-target import 2:1
PE1(Config-vrf)# import map x
PE1(Config-vrf)# export map y
PE1(Config-vrf)# exit
PE1(Config)# access-list 6 permit 6.6.6.0
PE1(Config)# access-list 1 permit 1.1.1.0
PE1(Config)# route-map x
PE1(Config-route-map)# match ip address 6
PE1(Config-route-map)# exit
PE1(Config)# route-map y
PE1(Config-route-map)# match ip address 1
PE1(Config-route-map)# set extcommunity ?
      rt     Route Target extended Community
      soo    Site-of-Origin extended Community
PE1(Config-route-map)# set extcommunity rt 2:2 additive

PE1(Config-route-map)# do show run
            ip vrf a
            rd 1:1
            import map x
            export map y
            route-target import 2:1
```

PE1(Config-route-map)# do telnet 9.9.9.9
Trying 9.9.9.9 ...Open

PE2# Conf t
PE2(Config)# ip vrf a
PE2(Config-vrf)# rd 1:1
PE2(Config-vrf)# route-target export 2:1
PE2(Config-vrf)# route-target import 2:2
PE2(Config-vrf)# exit
PE2(Config)# exit
PE2# exit
PE1(Config-route-map)# do show route-map
route-map X, permit, Sequence 10
  Match Clauses:
    ip address (access-list): 6
route-map Y, permit, Sequence 10
  Match Clauses:
    ip address (access-list): 1
  Set Clauses:
    extended Community RT: 2:2 additive

PE1(Config-route-map)# exit
PE1(Config)# int f0/1
PE1(Config-if)# ip vrf forwarding a
PE1(Config-if)# ip address 2.2.2.2 255.255.255.252
PE1(Config-if)# router bgp 2
PE1(Config-router)# neighbor 9.9.9.9 remote-as 2
PE1(Config-router)# neighbor 9.9.9.9 update-source L0
PE1(Config-router)# address-family vpnv4
PE1(Config-router-af)# neighbor 9.9.9.9 activate
PE1(Config-router-af)# neighbor 9.9.9.9 next-hop-?
next-hop-self next-hop-unchanged

PE1 (Config-router-af) # neighbor 9.9.9.9 next-hop-self
PE1 (Config-router-af) # ^Z
PE1 # 9.9.9.9
Trying 9.9.9.9 ... open

PE2 # Conf t
PE2 (Config) # router bgp 2
PE2 (Config-router) # neighbor 7.7.7.7 remote-as 2
PE2 (Config-router) # neighbor 7.7.7.7 update-source L0
PE2 (Config-router) # address-family vpnv4
PE2 (Config-router-af) # neighbor 7.7.7.7 activate
PE2 (Config-router-af) # neighbor 7.7.7.7 next-hop-self
PE2 (Config-router-af) # ^Z

PE2 # Show ip bgp Summary

Neighbor	AS	PfxRcd
7.7.7.7	2	0

PE2 # exit
PE1 # Config t
PE1 (Config) # router ospf 2 vrf a
PE1 (Config-router) # network 2.2.2.2 0.0.0.0 area 0
PE1 (Config-router) # do telnet 2.2.2.1 /vrf a
Trying 2.2.2.1 ... open

CE1 # Show run
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0

CE1 # exit

```
PE1(Config-router)# redistribute bgp 2 subnets
PE1(Config-router)# exit
PE1(Config)# router bgp 2
PE1(Config-router)# address-family ipv4 vrf a
PE1(Config-router-af)# redistribute ospf 2 vrf a
PE1(Config-router-af)# do telnet 9.9.9.9
Trying 9.9.9.9 ... open

PE2# Conf t
PE2(Config)# do show run
            ip vrf a
            rd 1:1
            route-target export 2:1
            route-target import 2:2

PE2(Config)# int F0/0
PE2(Config-if)# ip vrf forwarding a
PE2(Config-if)# ip address 5.5.5.2 255.255.255.252
PE2(Config-if)# router ospf vrf a
PE2(Config-router)# network 5.5.5.2 0.0.0.0 area 0
PE2(Config-router)# redistribute bgp 2 subnets
PE2(Config-router)# exit
PE2(Config)# router bgp 2
PE2(Config-router)# address-family ipv4 vrf a
PE2(Config-router-af)# redistribute ospf 2 vrf a
PE2(Config-router-af)# ^Z
PE2#
PE2# show ip route
```

O	3.3.3.0 /30	110/2	4.4.4.1	FastEthernet 0/1
C	4.4.4.0 /30	directly connected		FastEthernet 0/1
O	7.7.7.7 /32	110/3	4.4.4.1	FastEthernet 0/1
O	8.8.8.8 /32	110/2	4.4.4.1	FastEthernet 0/1

C 9.9.9.9 directly Connected Loopback0

PE2 # show ip route vrf a

B	1.1.1.0 /24	200/2	7.7.7.7	
C	5.5.5.0 /30	directly Connected		Fast Ethernet 0/0
O	6.6.6.0 /24	110/20	5.5.5.1	Fast Ethernet 0/0
O	12.12.12.12 /32	110/11	5.5.5.1	Fast Ethernet 0/0

PE2 # 12.12.12.12 /vrf a
Trying 12.12.12.12 ... Open

CE2 # show ip route ospf
OIA 1.1.1.0 /24 110/12 5.5.5.2 Ethernet 3/0

CE2 # exit
PE2 # show ip cef vrf a 1.1.1.0
1.1.1.0 /24
outer label inner label
nexthop 4.4.4.1 FastEthernet 0/1 label 20 16

PE2 # show mpls forwarding-table 7.7.7.7

Local Label	Outgoing Label or VC	Prefix or Tunnel Id	Outgoing Interface	Next Hop
20	20	7.7.7.7/32	Fa0/1	4.4.4.1

PE2 # show ip bgp vpnv4 vrf a labels

Network	Next Hop	In label / out label
1.1.1.0 /24	7.7.7.7	nolabel / 16
5.5.5.0/30	0.0.0.0	16 / no label (a)
6.6.6.0 /24	5.5.5.1	17 / no label
12.12.12.12 /32	5.5.5.1	22 / no label

PE2 # 12.12.12.12 /vrf a
Trying 12.12.12.12 ... open

CE2 # Show ip route

OIA	1.1.1.0 /24	110/12	5.5.5.2	Ethernet 3/0
C	5.5.5.0 /30	directly Connected		Ethernet 3/0
C	6.6.6.0 /24	directly Connected		Ethernet 3/1
C	12.12.12.12 /32	directly Connected		Loopback.0

CE2 # Show ip ospf database

OSPF Router with ID (12.12.12.12)(Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Seq #
5.5.5.2	5.5.5.2	0x80000002
7.7.7.7	7.7.7.7	0x80000005
8.8.8.8	8.8.8.8	0x80000004
9.9.9.9	9.9.9.9	0x80000004
11.11.11.11	11.11.11.11	0x80000003
12.12.12.12	12.12.12.12	0x80000006

Net Link States (Area 0)

Link ID	ADV Router	Seq #
2.2.2.1	11.11.11.11	0x80000002
3.3.3.1	8.8.8.8	0x80000002
4.4.4.1	8.8.8.8	0x80000002
5.5.5.1	12.12.12.12	0x80000001

Summary Net Link States (Area 0)

Link ID	ADV Router	Seq #
1.1.1.0	5.5.5.2	0x80000001

```
CE2 # exit
PE2 # exit
P> 7.7.7.7
Trying 7.7.7.7 ... Open

PE1 # Config t
PE1(Config) # int lo 2
PE1(Config-if) # ip vrf forwarding a
PE1(Config-if) # ip address 13.13.13.13 255.255.255.255
PE1 (Config-if) # router bgp 2
PE1 (Config-router) # address-family ipv4 vrf a
PE1 (Config-router-af) # network 13.13.13.13 mask 255.255.255.255
PE1 (Config-router-af) # exit
PE1 (Config) # router ospf 2 vrf a
PE1 (Config-router) # area 0 sham-link 13.13.13.13 14.14.14.14
PE1 (Config-router) # ^Z
PE1 # 9.9.9.9
Trying 9.9.9.9 ... open

PE2 # Conf t
PE2 (Config) # int lo2
PE2 (Config-if) # ip vrf forwarding a
PE2(Config-if) # ip address 14.14.14.14 255.255.255.255
PE2(Config-if) # router bgp 2
PE2(Config-router) # address-family ipv4 vrf a
PE2(Config-router-af) # network 14.14.14.14 mask 255.255.255.255
PE2 (Config-router-af) # router ospf 2 vrf a
PE2 (Config-router) # area 0 sham-link 14.14.14.14 13.13.13.13
PE2(Config-router) # ^Z
PE2 # 7.7.7.7
Trying 7.7.7.7 ... open
```

PE1_NCR # show ip ospf int br

Interface	Area	IP / mask	State
Lo 0	0	11.11.11.11 /32	LOOP
Fa 0/1	0	5.5.5.2/30	BDR

PE1_NCR # Show ip ospf neighbor

Neighbor ID	State	Address	Interface
12.12.12.12	FULL / DR	5.5.5.1	FastEthernet 0/1

PE1_NCR # 12.12.12.12
Trying 12.12.12.12 ...Open

PE2_NCR # traceroute vrf cib 1.1.1.1 source 6.6.6.1
1 1.1.1.1

PE2_NCR # Show ip route vrf cib

B	1.1.1.0 /24	200/0	11.11.11.11	
C	6.6.6.0 /24	directly Connected		Ethernet 3/1

PE2_NCR # 7.7.7.7
Trying 7.7.7.7 ...open

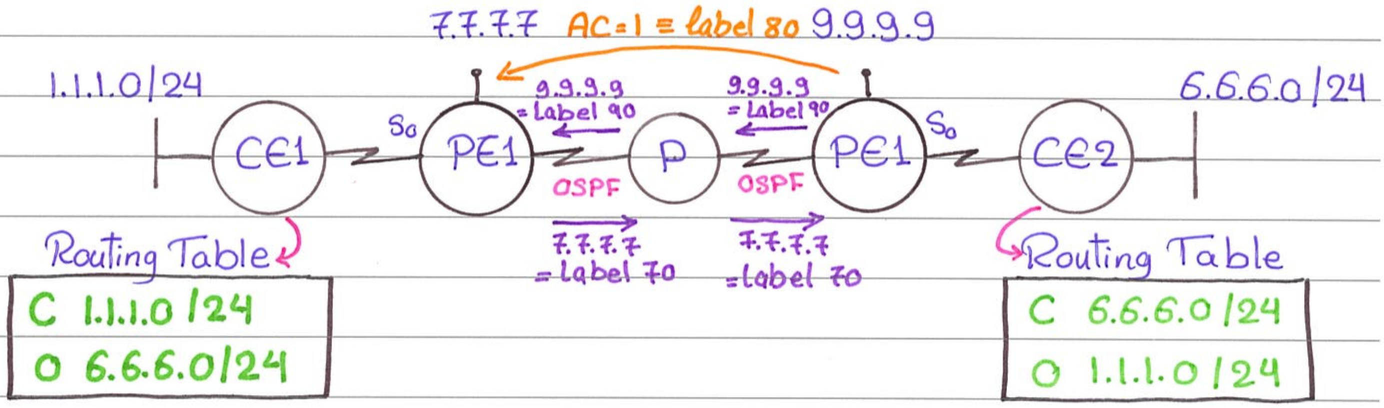
PE1_OBS # show mpls forwarding table

17	Pop tag	8.8.8.8 /32	Fa 0/0	3.3.3.1
18	Pop tag	4.4.4.0 /30	Fa 0/0	3.3.3.1
29	19	9.9.9.9 /32	Fa 0/0	3.3.3.1
22		l2ckt (3)	none	point2point

PE1_OBS # Show mpls l2transport vc detail
Destination address : 9.9.9.9 , VC ID : 3 , VC Status : UP

Session 24
L2 MPLS VPN

- VPWS (Virtual Private Wire Serv [redacted]



PE1 (Config) # interface S0
PE1 (Config-if) # no ip address
PE1 (Config-if) # xconnect $\underbrace{9.9.9.9}_{\text{IP of next PE}}$ $\underbrace{1}_{\text{VC id}}$ encapsulation mpls

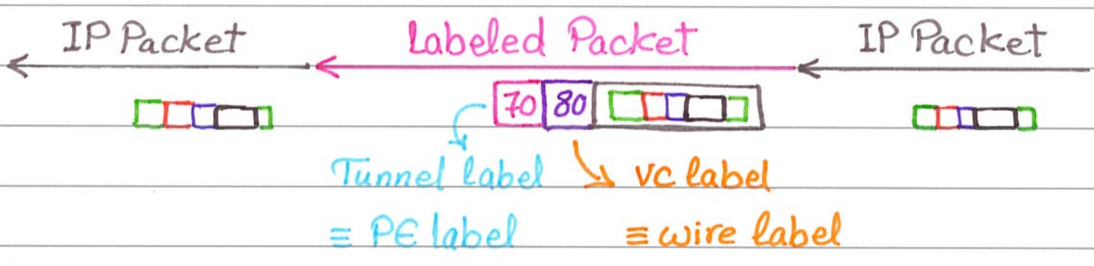
mpls → using LDP

PE2 (Config) # interface S0
PE2 (Config-if) # no ip address
PE2 (Config-if) # xconnect 7.7.7.7 1 enc mpls

→ PW Operation :-

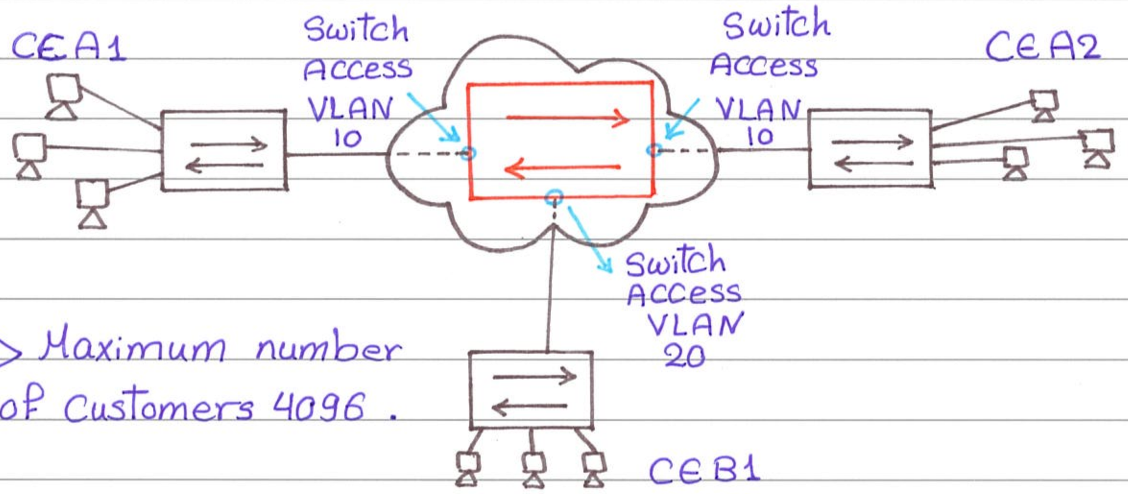
1. Auto Discovery:
   PE try to discovery other PE using normal LDP ⇒ discovery tunnel Label

2. Signaling:
   Each PE will map the AC ≡ VC with label using Targeted LDP ⇒ discovery VPN label ≡ discovery VC label



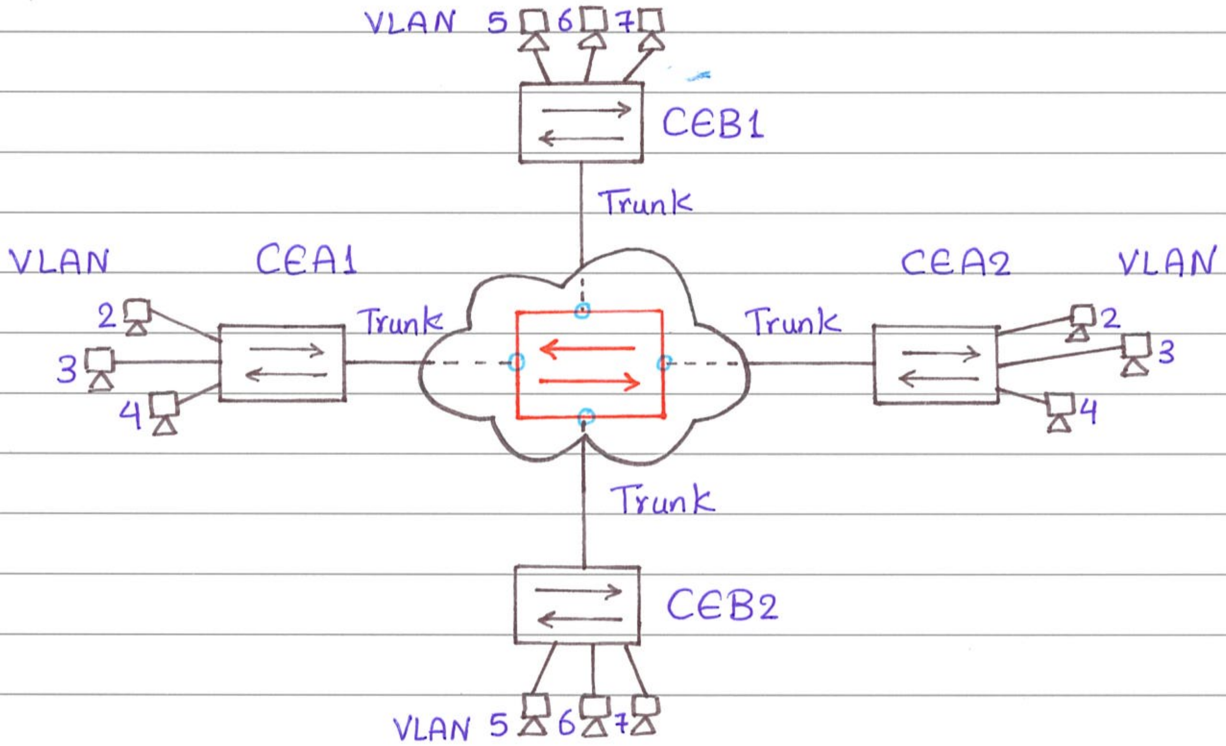
Session 24 Part 3
VPLS

[1] TLS Transparent LAN Service :



⇒ Maximum number of Customers 4096 .

[2] DVS Directed VLAN Services :



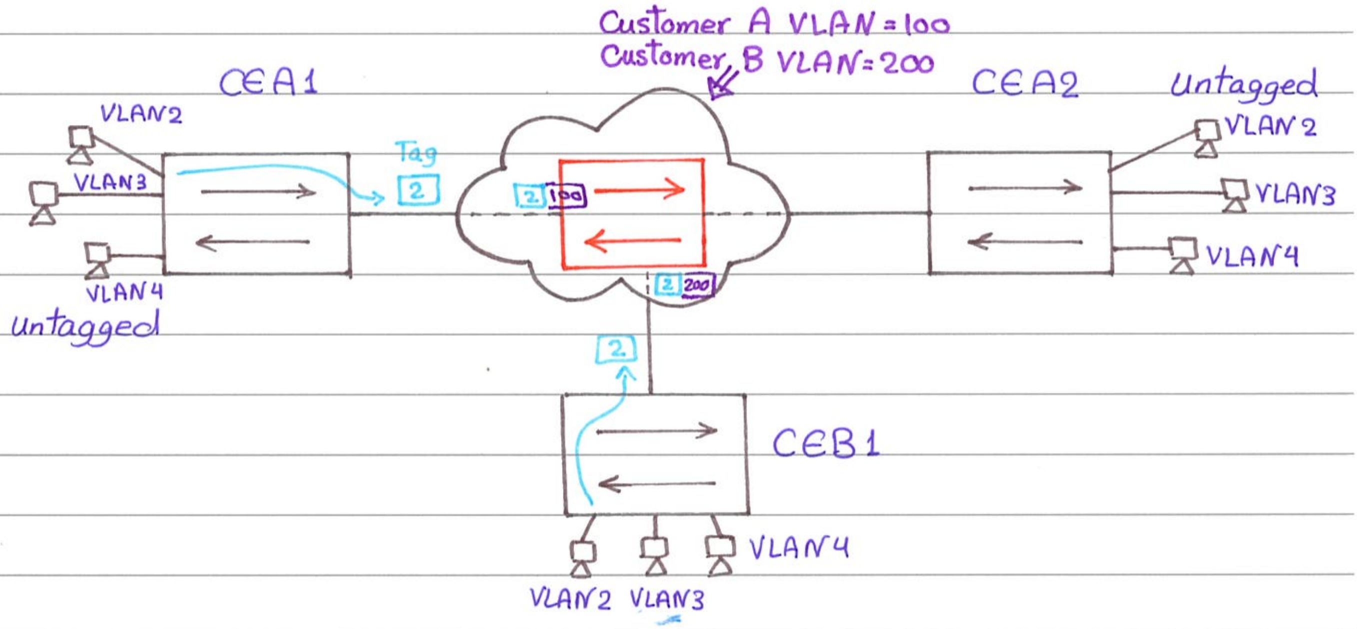
(Config-if)# Switchport mode trunk
(Config-if)# Switchport trunk allowed VLAN 2,3,4 (2-4)

(Config-if) # switchport trunk allowed VLAN [add | remove] #

⇒ If each customer has 10 VLAN,
Service Provider can serve 409 customer only.

Session 24 Part 4

3 QinQ Double tagging :



DST MAC	SRC MAC	dot1q tag	Type	Packet	CRC	normal	

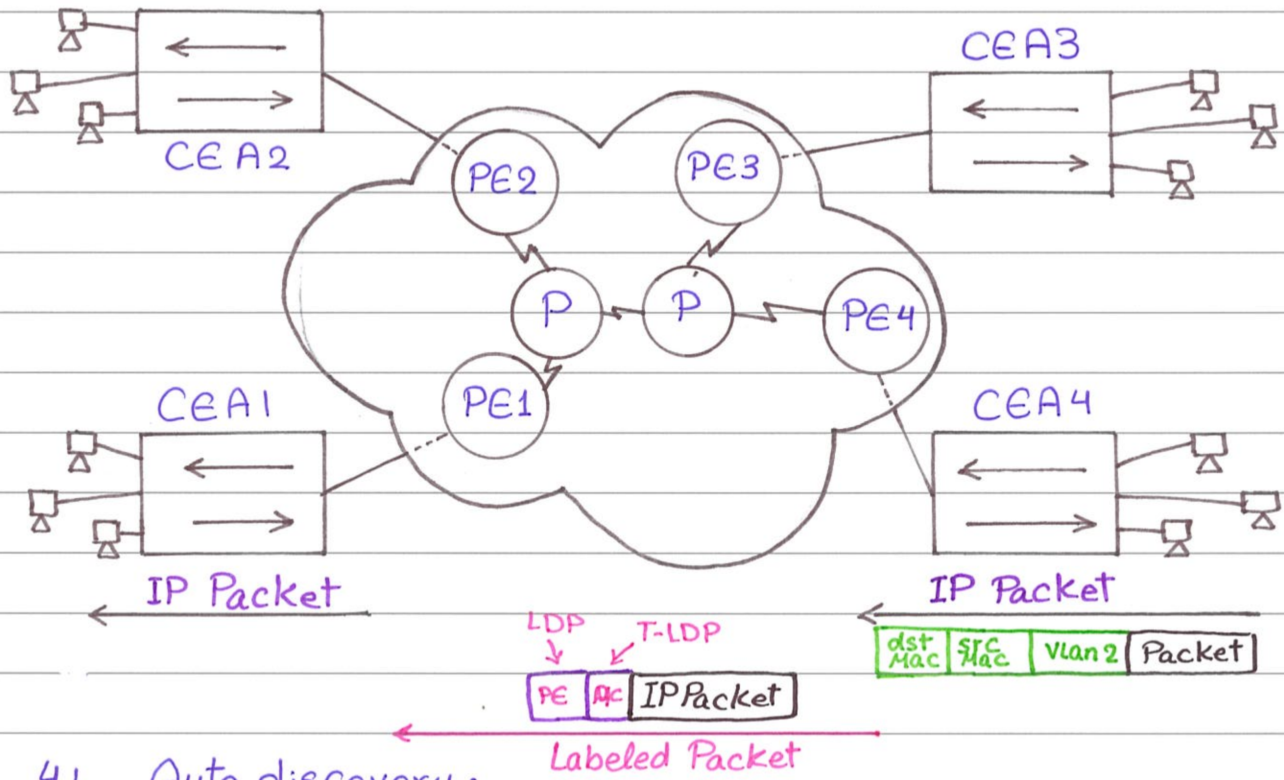
DST MAC	SRC MAC	dot1q tag	dot1q tag	Type	Packet	CRC	QinQ

Customer ID = 100 ↑   ↖ VLAN 2

⇒ SP can serve 4096 customers.

(Config-if) # switchport mode dot1q tunnel
(Config-if) # switchport access vlan 100

4 EOMPLS Ethernet Over MPLS :



4.1 _ Auto discovery :

PE discover other PEs using LDP or MP-BGP (new address family called L2 VPN VPls).

4.2 _ Signaling :

Each AC should be mapped with label using Targeted-LDP or MP-BGP .

On PE1 using LDP & T-LDP :

Creation

(Config) # L2 vfi Context CIB ⇒ Virtual Forwarding Instance

(Config-vfi) # vpn id 100

(Config-vfi) # neighbor IP of PE2|PE3|PE4 encapsulation mpls

(Config) # interface ____ Activation

(Config-if) # xconnect vfi CIB

PE1 using MP-BGP:

(Config) # L2VPN vfi CIB
(Config-vfi) # vpn id 1 ⇒ RD = 2 : 1 RT = 2 : 1
(Config-vfi) # rd ______
(Config-vfi) # route-target ______

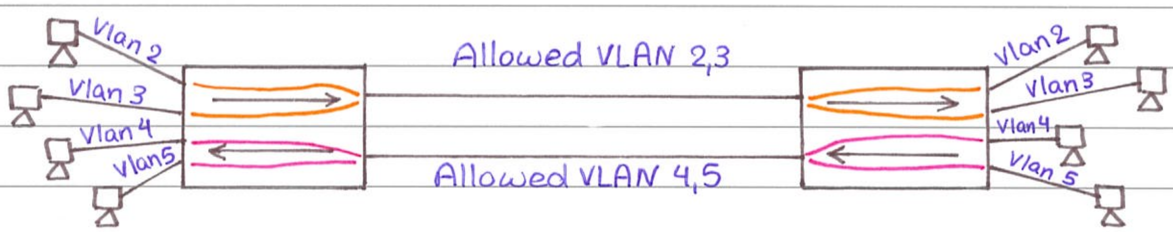
AS# Vpn id AS# Vpn id

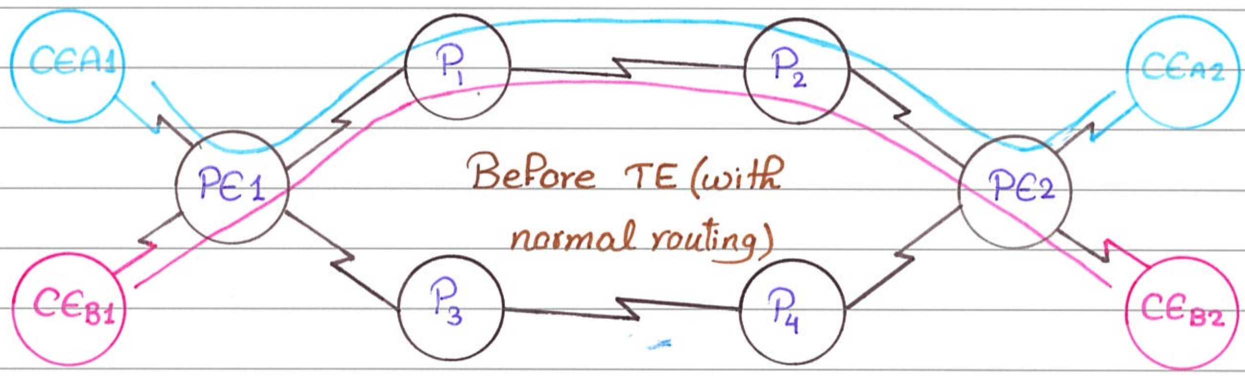
OR

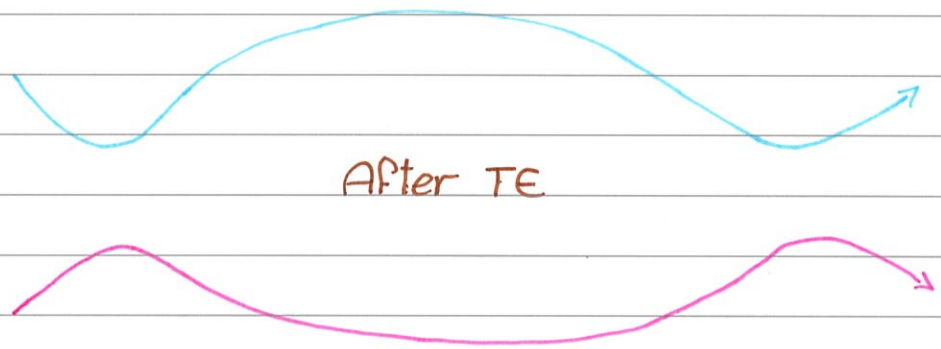
(Config) # router bgp 2
(Config-router) # neighbor PE 2|3|4 remote-as 2
(Config-router) # neighbor PE 2|3|4 update-source lo 0
(Config-router) # address-family L2VPN VPLS
(Config-router-af) # neighbor PE 2|3|4 activate
(Config-router-af) # neighbor PE 2|3|4 next-hop-self

Session 25
What is traffic engineering?

It is manipulate traffic to fit network resources.







TE Implementation:

1. Static Routing.
2. Policy map.
3. Adjust IGP metric.
4. Using MPLS.

Session 25 Part 2
MPLS TE

TE using MPLS is formed using traffic engineering tunnels.

- What is TE Tunnel?

  TE Tunnel is a path that contains Head End, Tail End & Mid Points.
  (Head End = Tunnel source, Tail End = Tunnel dst)

- To Create TE Tunnel we need:
  - OSPF | ISIS with TE extensions.
  - Calculation method of best path using CSPF = Constrained Shortest Path First. (PCalc ≡ Path Calc)
  - RSVP with MPLS TE extension.

- Configuration on Head End:

```
(Config)# interface Tunnel 0
(Config-if)# ip unnumbered loopback 0
(Config-if)# tunnel destination ___Tail End___
(Config-if)# tunnel mode mpls traffic-eng
(Config-if)# tunnel mpls traffic-eng bandwidth _____ kbps
(Config-if)# tunnel mpls traffic-eng path-option __*__
                              {dynamic | explicit} name __Anwar__
(Config-if)# tunnel mpls traffic-eng auto route announce

(Config)# ip path-option explicit name __Anwar__
(Config-exp-path)# next-address ___PE 2___
(Config-exp-path)# next-address ___P1___
(Config-exp-path)# next-address ___P2___

(Config-if)# tunnel mpls traffic-eng path-option 1 explicit name Anwar
(Config-if)# tunnel mpls traffic-eng path-option 2 dynamic
```

Session 25 Part 3
MPLS TE Operation

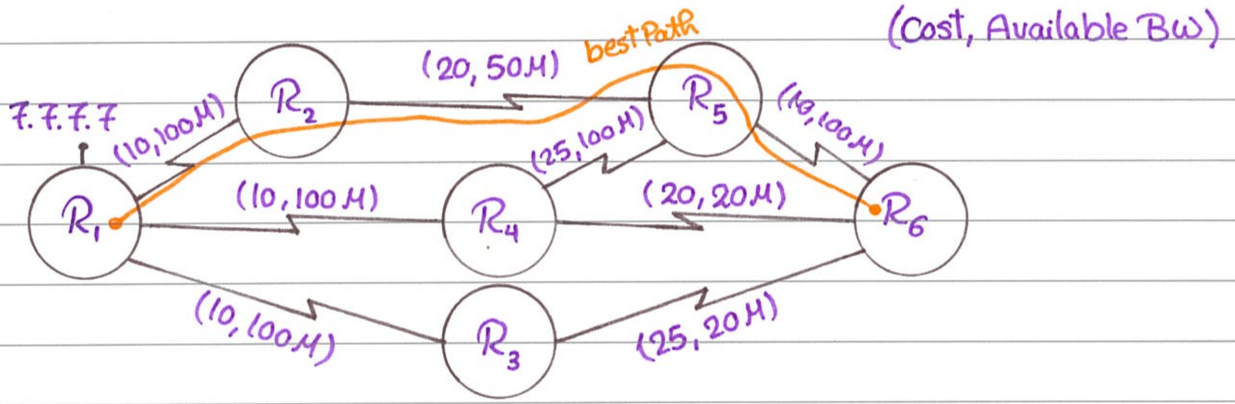
Phase 1: Topology Discovery

using OSPF or ISIS with TE extension

Advertise (max BW, reserved BW & available BW)

using opaque LSAs (Type 9, 10, 11)

link local, area local, Intra AS



(Config) # router ospf 1

(Config-router) # mpls traffic-eng router-id lo0

(Config-router) # mpls traffic-eng area 0

⇒ Build TE LSDB

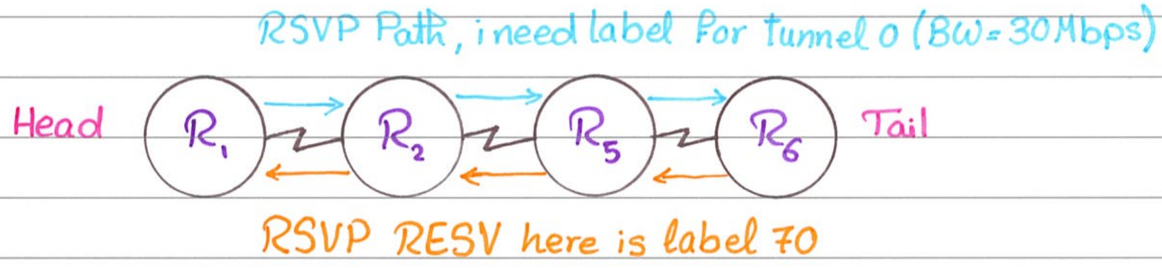
Phase 2: Choosing Constraint best path

using CSPF(PCalc):

- Available BW.
- Least Cost.
- More Available BW.
- Least hop Count.

⇒ Best Path from Head End to Tail End.

Phase 3: Build LSP (label switch path)
use RSVP ≡ Resource Reservation Protocal



⇒ every router:

(Config)# ip cef
(Config)# mpls traffic-eng
(Config-if)# mpls ip
(Config-if)# ip rsvp bandwidth [____]

⇒ R_1:

(Config)# ip route ________ ________ Tu0
OR PBR
OR autoroute announce → on all routers

⇒ in this scenario:
use only one label ≡ TE label

another scenario:
use 3 labels ≡ TE label, LDP (next PE), & MP-BGP (vrf).