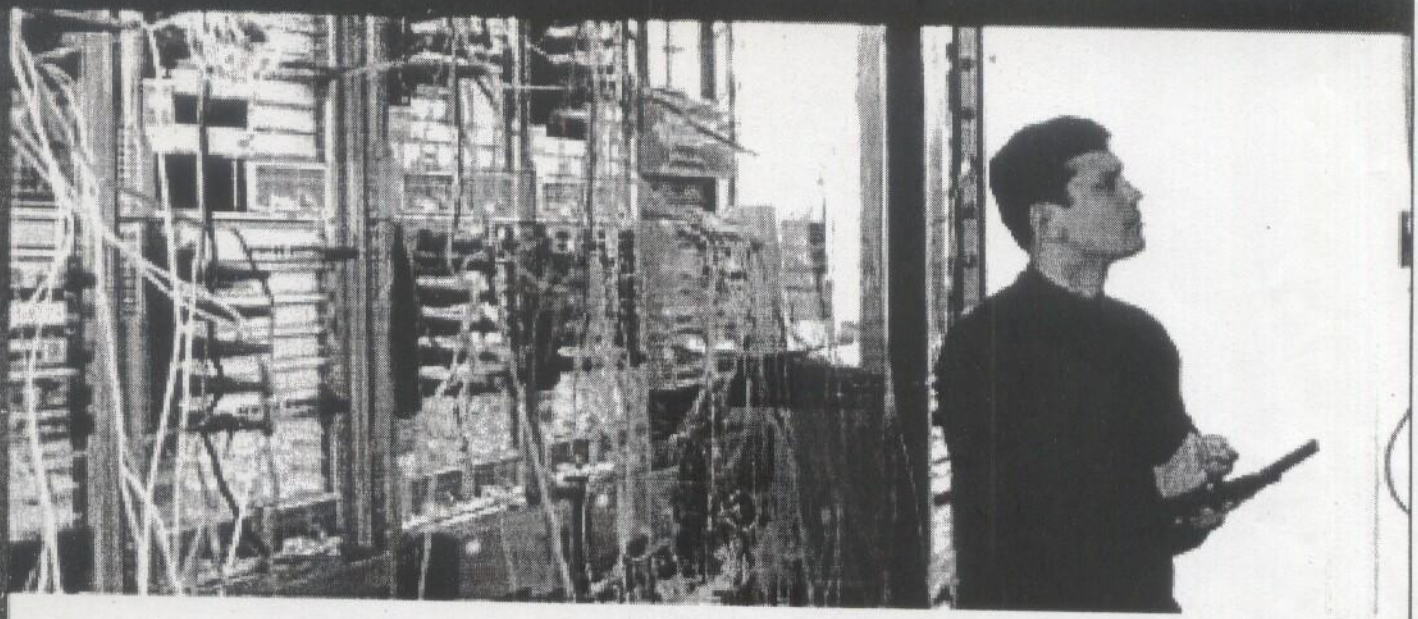


CCNP ROUTE

Prepared by
ENG: Ahmed Abdallah

EIGRP

→ why you would choose to use eigrp ?

1- back up Routes [using Dual algorithm]

2- Rapid convergence

3- simple configuration

4- flexability in summarization

5- unequal cost load balance

6- combines best of distance vector & link state

7- support multiple network protocol [IP, IPX, APPLE TALK]

EIGRP tables & terminology

a Router Running EIGRP maintains 3 tables

1. neighbor table : [#sh IP eigRP neighbor]

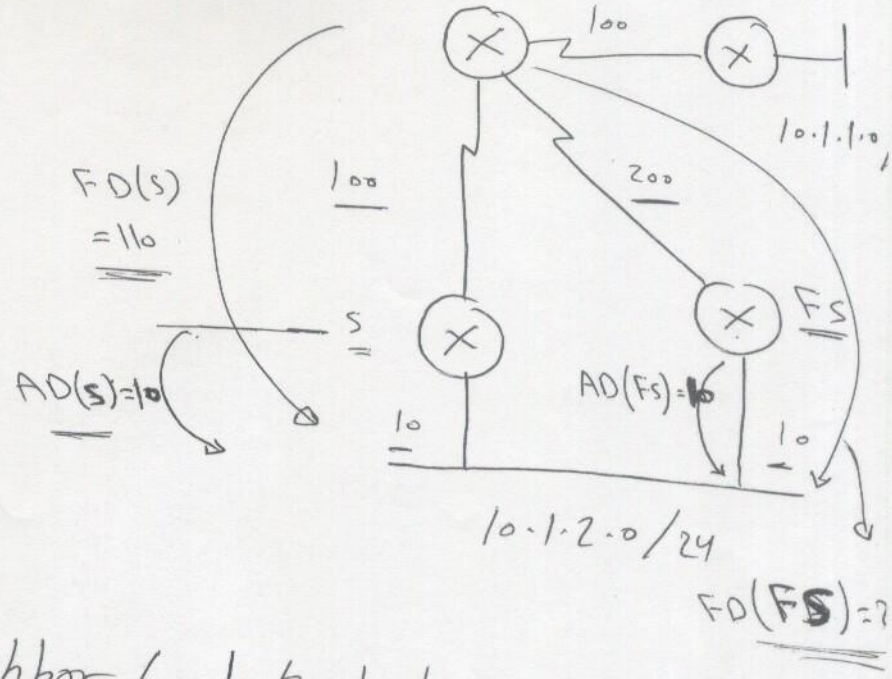
contain neighbor Routers which is direct connected with you

2. topology table : [#sh IP eigrp topology]

contain 2 Routes
- successor Route [best Routes]
- Feasible successor Route [back up Routes]

3. Routing table : [#sh IP Route]

contain best Routes [successor Routes]



successor (S) : neighbor lead to best Route ~~which~~ which is stored in Routing table

Feasible successor (FS) : neighbor lead to backup Route which is stored in topology table only

Feasible distance (FD): metric between src & dst

Advertised distance (AD) : metric between src neighbor & dst

S or FS

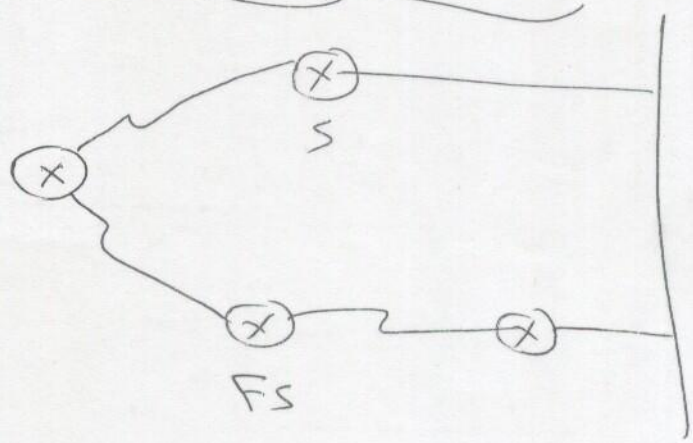
ملحوظة: ذكر على المثال أعلى الصفحة

hint : to be considered a Feasible successor, The AD must be less than The FD of The successor

$$\boxed{AD(Fs) < FD(s)}$$

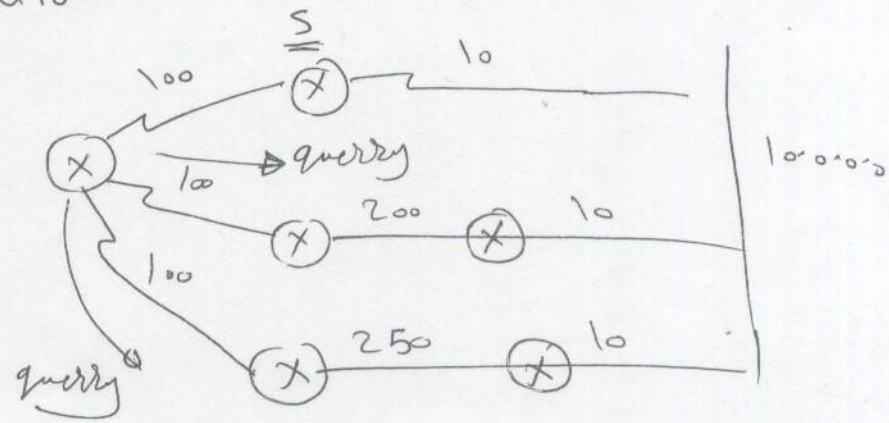
← وذلك حتى نتجنب حدوث أي Loop

hint



① if successor down The Fs becomes a successor

② if There is no a Feasible successor The source Router will send a query Msg to find a way to reach destination

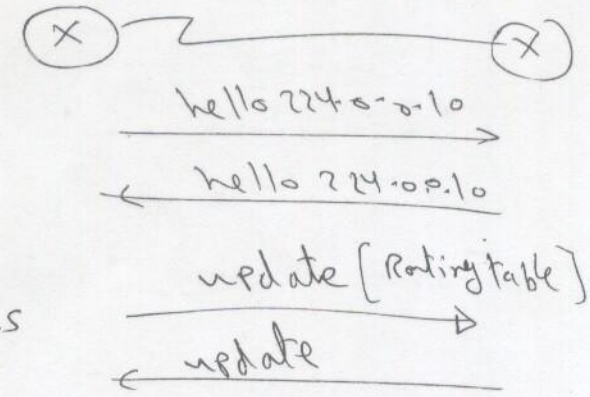


③ يظهر لك في topology table أحد الكلمتين

- Active Route : very Bad
- Passive Route : very good

```
# sh IP eigRP toplogy
P 11.0.0.0/8
P 12.0.0.0/8
```

eigrp Friendly neighborhood



- hello : Forms relationship
- update : send updates
- query : asks about Routes
- reply : respond to a query
- Ack : acknowledges the update, query, and reply

EIGRP metric Calculations

→ EIGRP metric depends on Bw & delay

$$metric = 256 * \left[k_1 * Bw'' + \frac{k_2 Bw''}{256 - load} + k_3 * delay + \frac{k_5}{reliability + k_4} \right]$$

where $Bw'' = \frac{10^7}{Bw}$ (Bw → kbps), delay → μsec (microseconds)

⇒ The default value's of k factors is:

k_1 (Bw) = 1

k_2 (load) = 0

k_3 (delay) = 1

k_4 (reliability) = 0

k_5 (reliability) = 0

لو عاوز تشوف قيمهم ⟸ #sh IP protocol

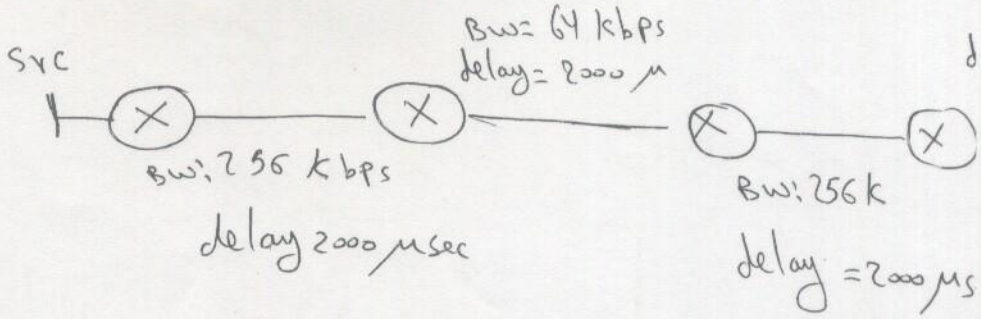
بعد التعويض بقيم k في المعادلة

$$metric = 256 * [\text{slowest } Bw'' + \text{all link delay}]$$

$Bw'' = \frac{10^7}{Bw}$ ← kbps

all link delay → microseconds

example : calculate the metric of this path



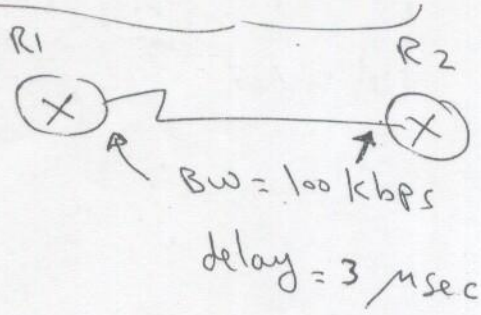
metric = 256 * [slowest Bw + all link delay]

10^7/BW (kbps) μsec

$$= 256 * \left[\frac{10^7}{64} + 2000 + 2000 + 2000 \right]$$

metric = 41536000

hint



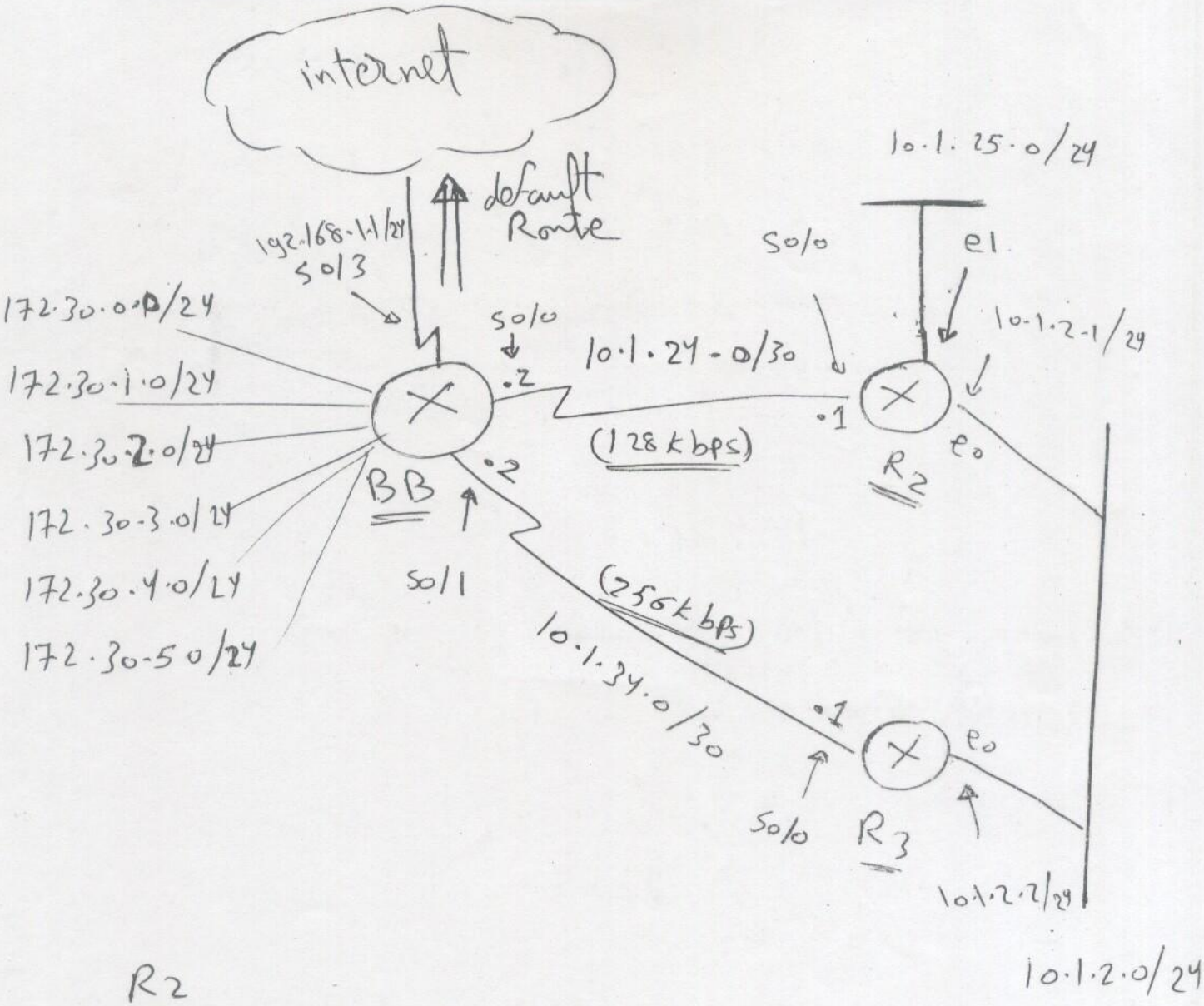
- you can change Bw value by command

  if) # bandwidth 100 ← kbps

- you can change delay value by command

  if) # delay 3 ← μsec

Configuring EIGRP



R2

```
R2(config) # router eigrp 1
  -router) # network 10.1.2.0 0.0.0.255
  -router) # network 10.1.24.0 0.0.0.3
  -router) # no auto-summary
  -router) # network 10.1.25.0 0.0.0.255
```

R3

```
R3(config) # router eigrp 1
(config-Router) # network 10.1.2.0 0.0.0.255
        router ) # network 10.1.34.0 0.0.0.3
        router ) # no auto-summary
```

BB [back bone Router]

```
BB(config) # router eigRP 1
        router) # network 10.1.0.0 0.0.255.255
```

حوف كل الشبكات اللي حولها والتي تبدأ 10.1.0.0

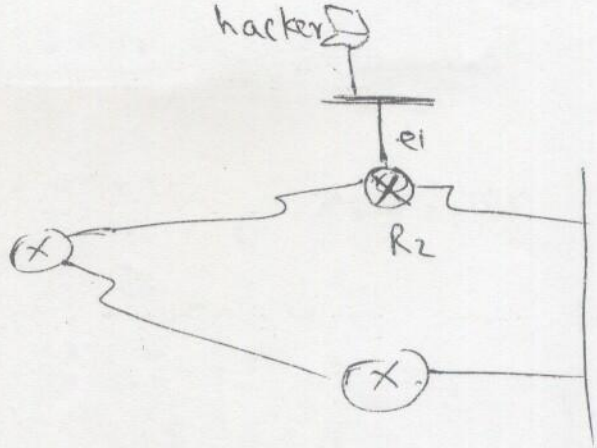
```
        router ) # network 172.30.0.0 0.0.255.255
                exit

BB (config) # IP route 0.0.0.0 0.0.0.0 S0/3
```

لكل ال

default route

وبجعل كلاً من Router 2 ، Router 3 يشوفوا ذلك default Route

```
BB (config) # router eigrp 1
        router) # redistribute static
```



في حالة وجود هاكر في الشبكة فإنه يستطيع أن يرسل eigrp hello

إلى R2 وبالتالي سوف يرسل R2 إلى ذلك الأخير Routing table

بتاعه باعتبار أن ذلك الأخير هو Router آخر وبالتالي سيعرف

ذلك الأخير على الشكل العام للشبكة وعلى الـ subnets التي

تحتوي تلك الشبكة. ولتأمين هذه الجزئية كان لزاماً

عليك أن تجعل المنافذ الـ ethernet التي توجد في الروتر

والتي يوجد فيها PC's أن تكون [passive interface]

أي لا ترسل hello

```
R2 (config) # router eigRP 1
router) # passive-interface e1
```

→ Configuring summarization

we should use summary address if possible like networks →

172.30.0.0
172.30.1.0
172.30.2.0
⋮
172.30.5.0

on BB Router

because The smaller your Routing table is The faster your Router

---

لحل (summary address) للشبكات

إعمل التالي

172.30.0.0/24
172.30.1.0/24
⋮
172.30.5.0/24

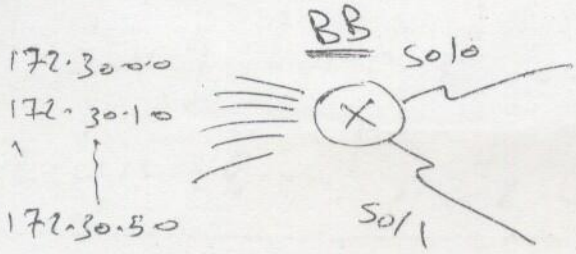
172.30. 0000	0000.0
172.30. 0000	0001.0
172.30. 0000	0010.0
172.30. 0000	0011.0
172.30. 0000	0100.0
172.30. 0000	0101.0
172.30. 0000	0000.0

This is The summary address

⇓

⇒ 172.30.0.0/21

common bits



BB(config) # int S0/0

if) # ip summary-address eigrp 1

→ 172.30.0.0 255.255.248.

int S0/1

if) #IP summary-address eigrp 1 172.30.0.0 255.255.248.

أرسل ال summary address من S0/0 ل S0/1

حتى تصل إلى الروتر الأخرى

configuring load balancing over un equal metric paths

BB(config)# router eigrp 1

router) # variance 2

ثم قم بعمل

(BB # clear ip eigrp neighbors)

لإعادة تكوين ال Routing table من جديد

ثم قم بعمل

BB # show IP route

D	10.1.2.0 →	[135412/90]
		[354151/90]

سوف يظهر لك مساريين للشبكة 10.1.2.0

بالرغم من أن ال metric يتساوى مختلف

Troubleshooting

#sh IP route → show Routing table

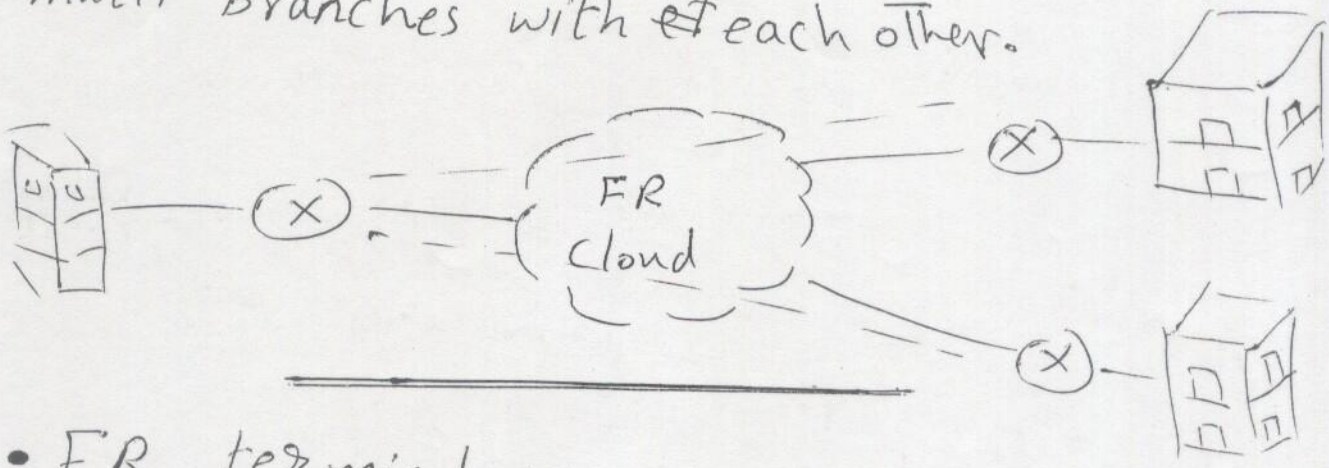
#sh IP eigrp neighbor → show neighbor table

#sh IP eigrp topology → show topology table

#sh IP Protocols → to show active Running Protocols

Frame relay

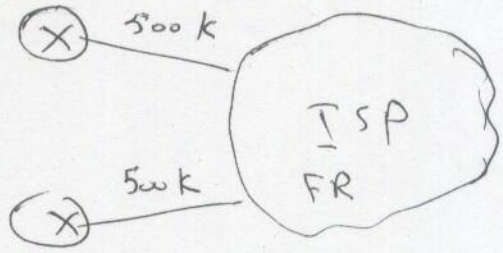
- FR is a wan technology used to Join multi branches with ~~et~~ each other.



- FR terminology

- [CIR] committed information rate.

BW That ISP gave you

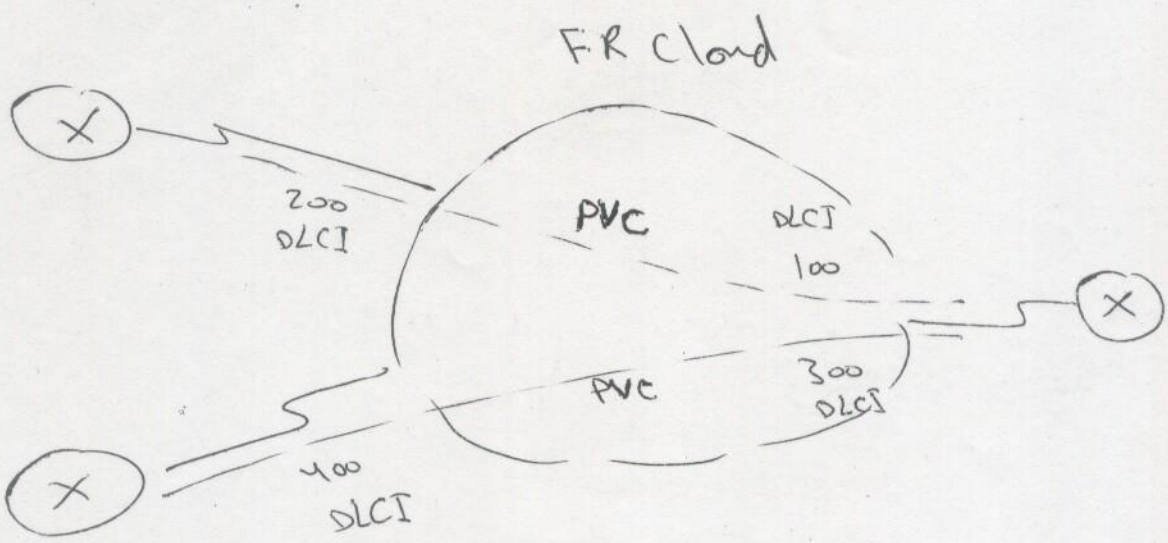


- LMI : local management interface

→ language between your Router & ISP

- **DLCI** [data link control identifier]

→ L2 addressing used with **FR**
→ it is like mac-address

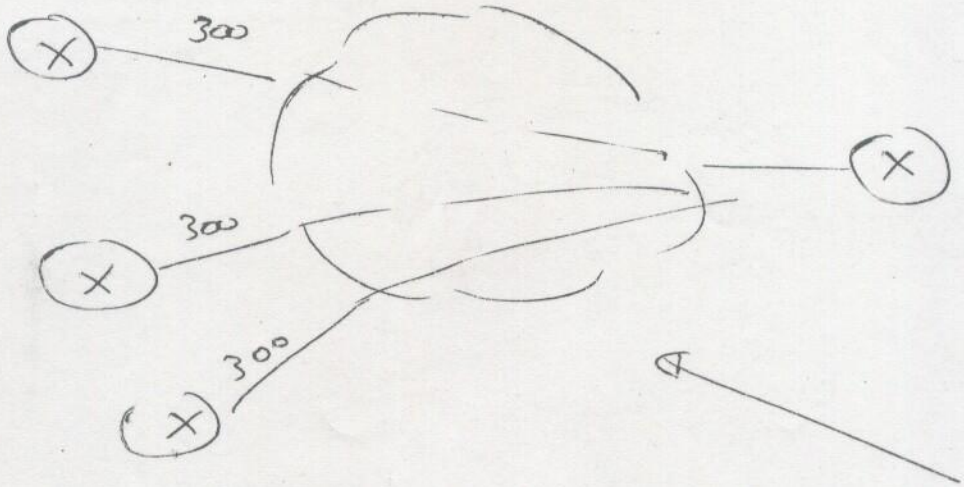


- لربط الأفرع ببعض عن طريق **FR cloud** فإننا نستخدم

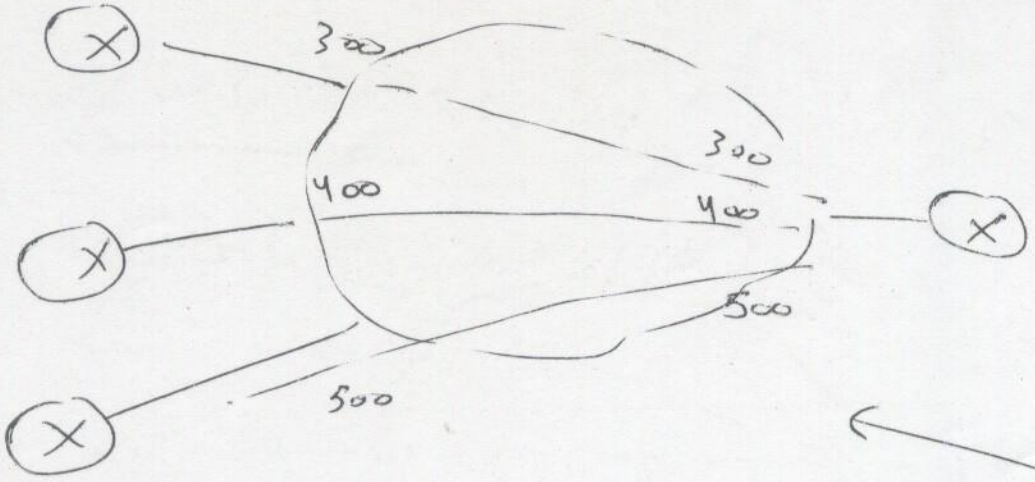
قنوات للربط تسمى PVC [permit virtual circuit] ويوضح

لكل قناة (DLCI Number) كما بالشكل

→ DLCI is locally significant



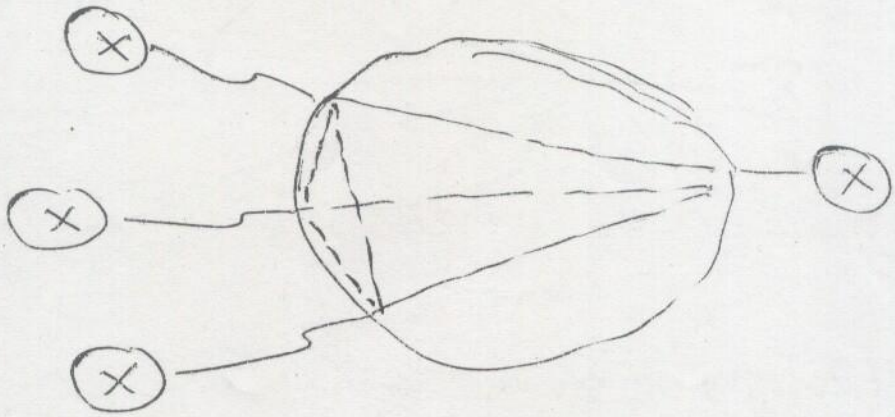
تصميم خاطئ



تصميم صحيح

FR PVC design

1 Full mesh

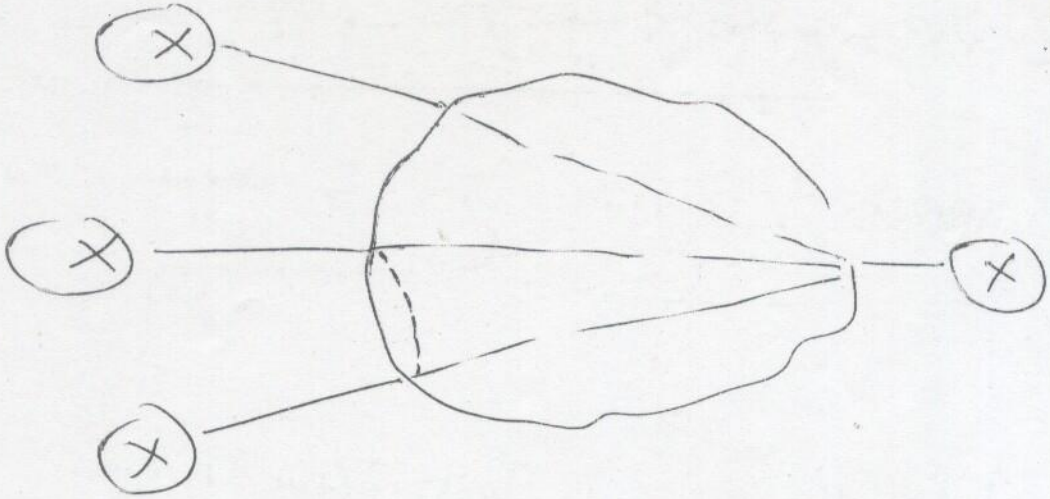


يعتبر أفضل design ولكن تكلفة باهظة الثمن نظراً

لكثرة الـ PVC's المستخدمة

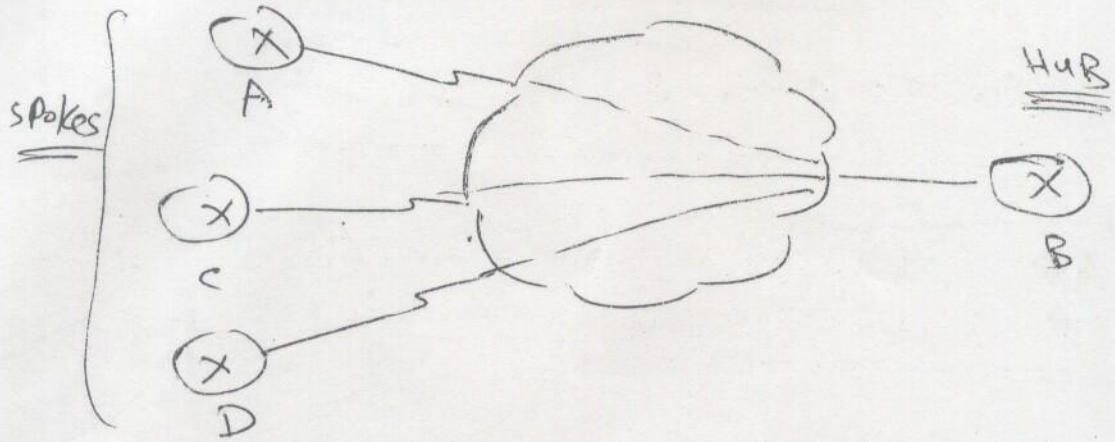
---

2 Partial mesh:



- critical places should be connected

3 HUB and spokes



- تعتبر أوضاعهم إلى أرضهم

- مشكلة لو الـ Center ~~ح~~ وقع (HUB) B فإن جميع

الأفرع تفقد إتصالهم ببعض

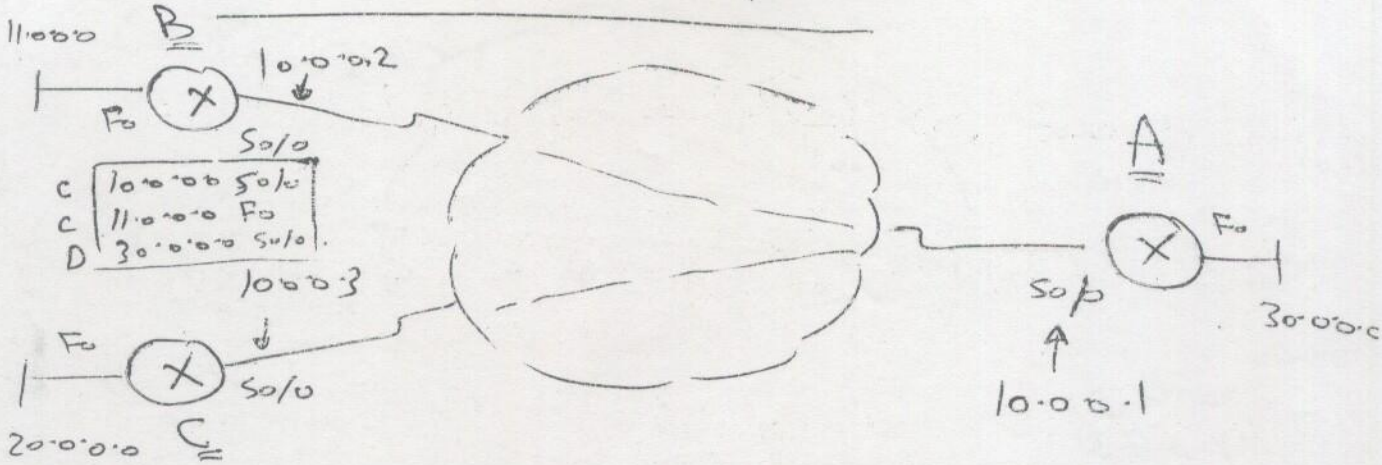
- ومشكلة أيضاً التأخير (delay) : لو A أراد أن يرسل

لـ D فإنه يذهب من A ← B ← D

⇒ we have 2 FR network designs

- Point to-multipoint
- Point to Point

1 Point to multi point



C	20.0.0.0	Fo
C	10.0.0.0	S0/0
D	30.0.0.0	S0/0

C	10.0.0.0	S0/0
C	30.0.0.0	Fo
D	11.0.0.0	S0/0
D	20.0.0.0	S0/0

- يرى A كل الشبكات على الروتر B و C

- أما B فلم يرى الشبكة 20.0.0.0 والتي توجد على الروتر C

- أما C فلم يرى الشبكة 11.0.0.0 والتي توجد على الروتر B

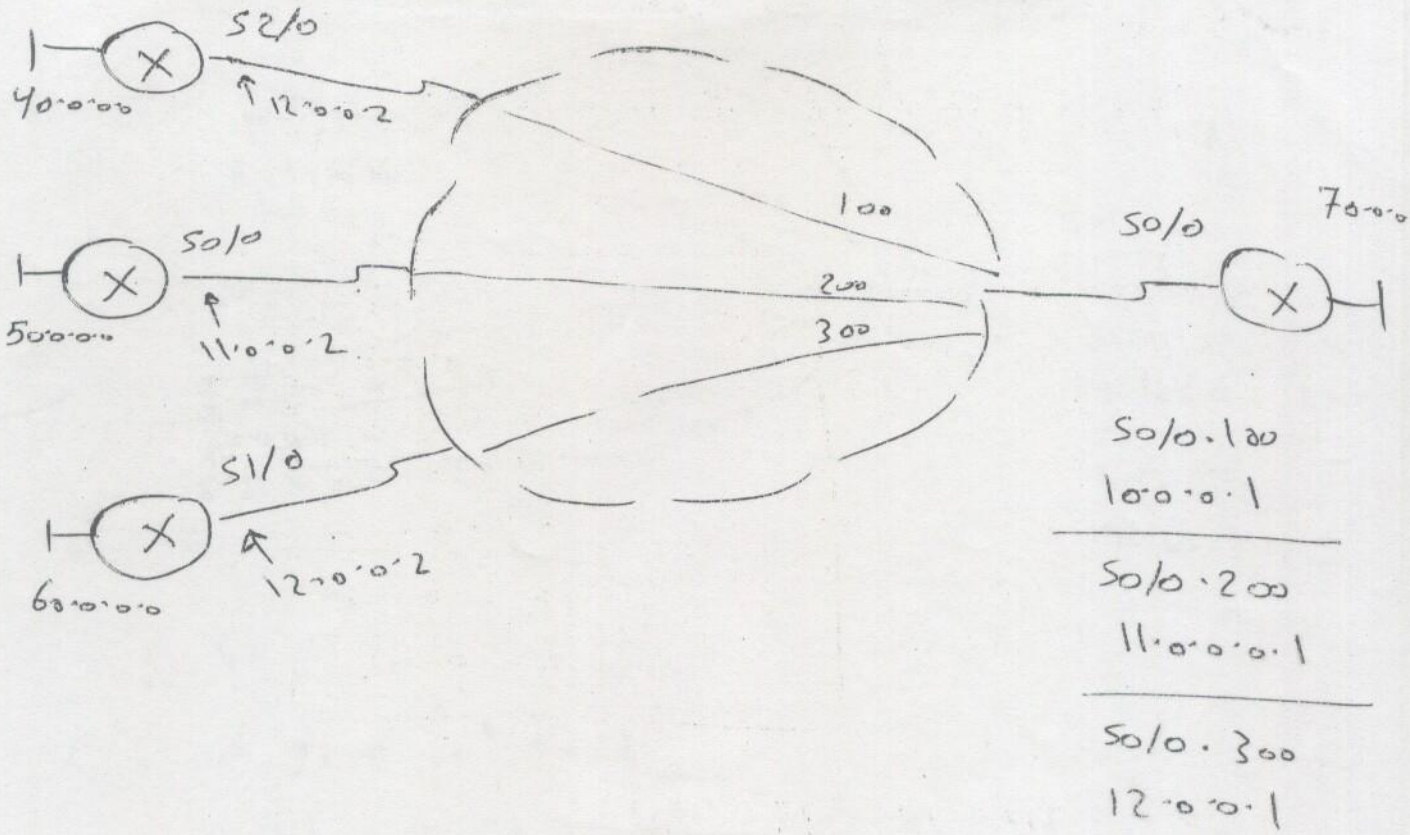
وذلك يرجع إلى split horizon والذي يكون مفعلا"

بشكل تلقائي على الروتر A والذي لم يسمح للروتر B

بأن يتعلم الشبكات التي عند C والعكس

← وللتغلب على تلك المشكلة تم عمل Point to Point

2 point to point

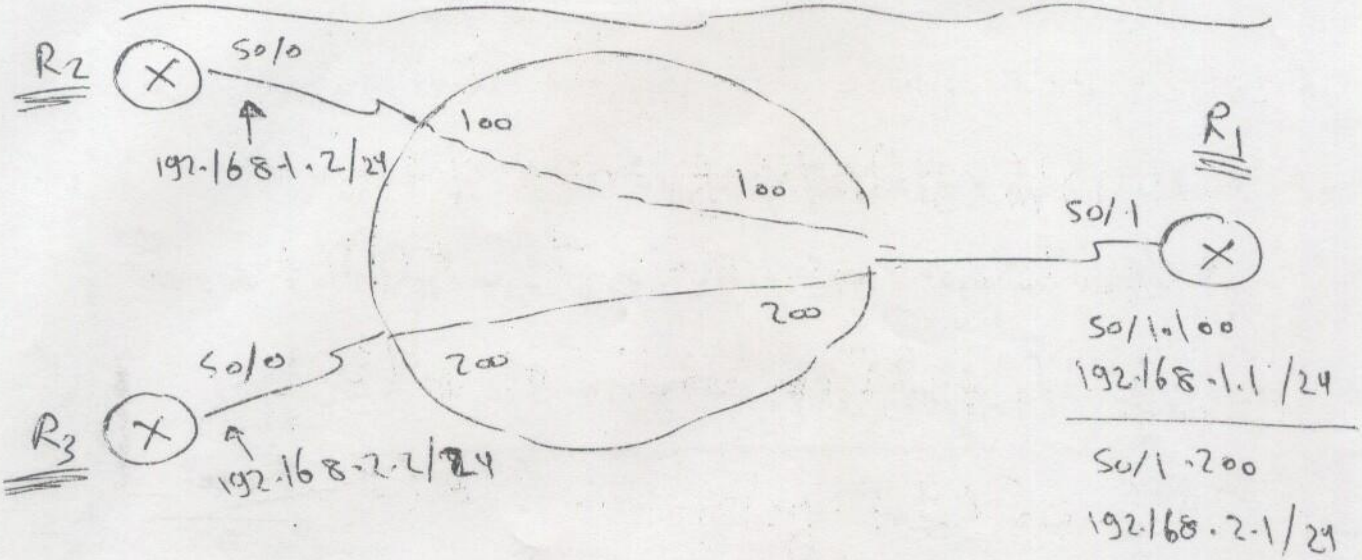


← بعد عمل هذا التصميم ستجد أن كل روتر يرى كل الشبكات الأخرى عن كل الروتر أى أن (Routing table) سيحتوى على

10.0.0.0
11.0.0.0
12.0.0.0
40.0.0.0
50.0.0.0
60.0.0.0
70.0.0.0

وذلك لكل الروتر

① example For point to point cofiguration



R1

```
R1(cofig) # int S0/1
    if) # encapsulation Frame relay
    if) # int S0/1.100 point_to_point
sub-if) # ip address 192.168.1.1 255.255.255.0
sub-if) # frame-relay interface-dLCI 100
sub-if ) # int S0/1.200 point_to_point
sub-if) # IP address 192.168.2.1 255.255.255.0
sub-if ) # frame-relay interface dLCI 200
```

R2

```
R2(config)# int s0/0
    if)# IP address 192.168.1.2 255.255.255.0
    if)# encapsulation Frame-relay
    if)# frame-relay interface-dLCI 100
```

R3

```
R3(config)# int s0/0
    if)# IP address 192.168.2.2 255.255.255.0
    if)# encapsulation Frame-relay
    if)# frame-relay interface-dLCI 200
```

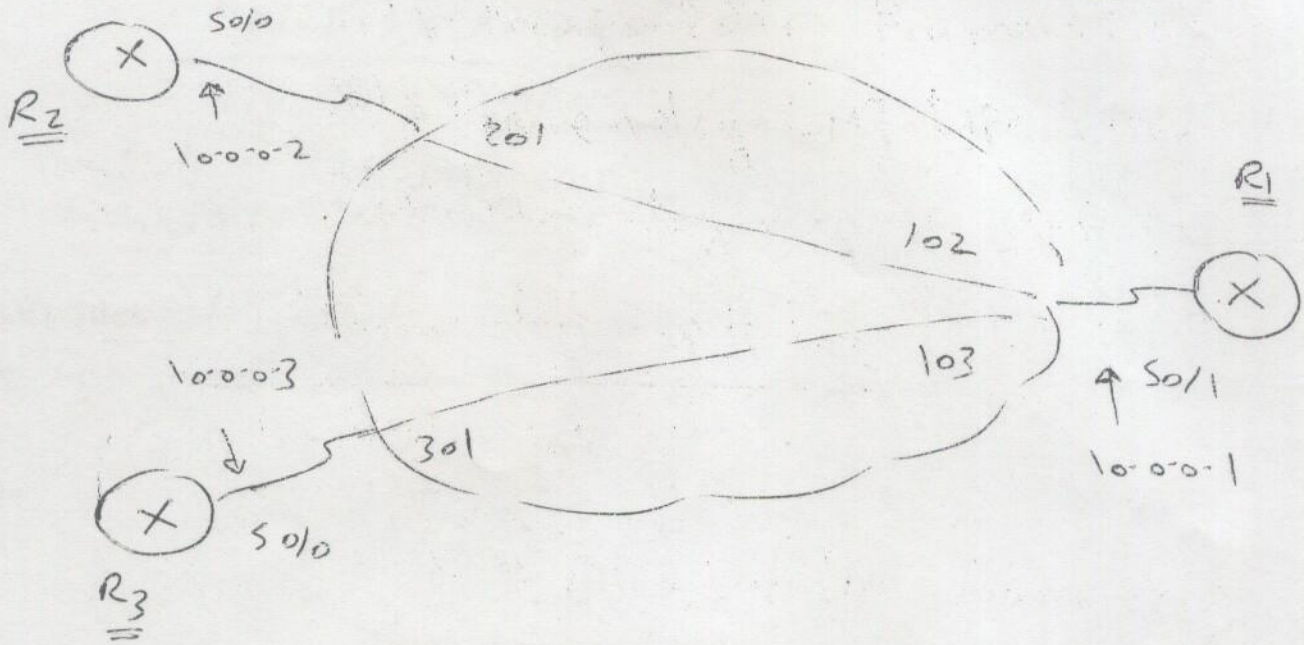
ثم . قم بعمل Routing لكل من R1 ، R2 ، R3

باستخدام RIP أو EIGRP

حتى أن كل Router قد رأى

كل الشبكات

② example For multi-Point configuration



R1

R1 (config) # int S0/1

if) # ip address 10.0.0.1 255.0.0.0

if) # encapsulation frame-relay

if) # frame-relay LMI-type cisco

if) # frame-rlay map ip 10.0.0.2 102 broad

if) # frame-rlay map ip 10.0.0.3 103 broadcast

R2 (config) # int S0/0

if) # IP add 10.0.0.2 255.0.0.0

if) # encapsulation frame-relay

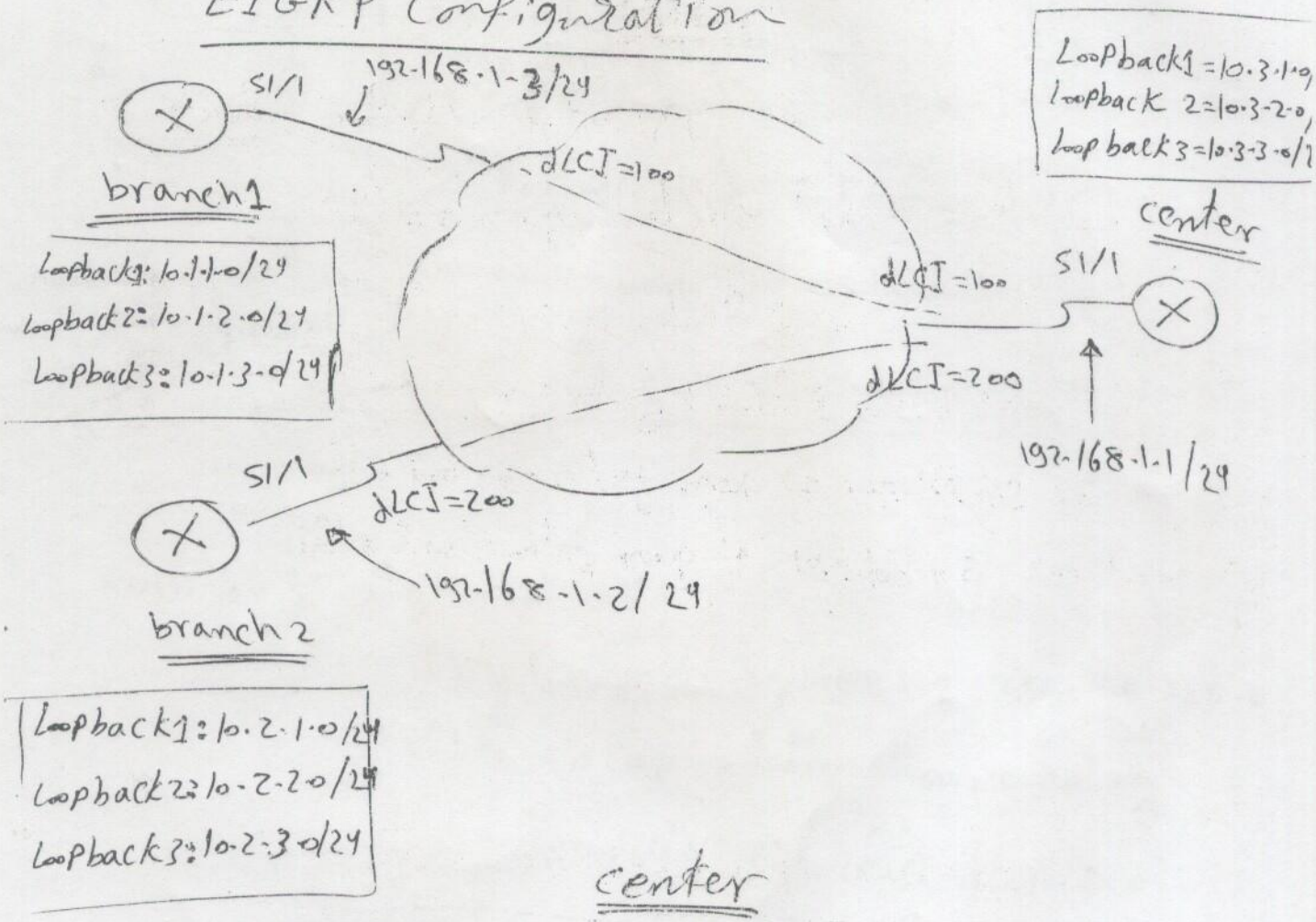
if) # frame-relay LMI-type cisco

if) # frame-relay map ip 10.0.0.1 201 broadcast

if) # frame-relay map ip 10.0.0.3 201 broadcast

كرر نفس الكلام مع R3

③ Example for multi-point with EIGRP Configuration



center

```
center(config)# int S1/1
    if)#encapsulation frame-relay
    if)#frame-relay interface dLCI 100
    if)# frame relay interface dLCI 200
    if)# frame-relay map ip 192.168.1.3 100 broadcast
    if)# frame-relay map ip 192.168.1.2 200 broadcast
```

branch 1

```
branch1(Config)# int s1/1
    if)# ip address 192.168.1.3 255.255.255.0
    if)# encapsulation frame-relay
    if)# frame-relay interface-dLCI 100
    if)# frame-relay map ip 192.168.1.1 100 broadcast
    if)# frame-relay map ip 192.168.1.2 100 broadcast
```

branch 2

```
branch2(Config)# int s1/1
    if)# ip address 192.168.1.2 255.255.255.0
    if)# encapsulation frame-relay
    if)# frame-relay interface-dLCI 200
    if)# frame-relay map ip 192.168.1.1 200 broadca
    if)# frame-relay map ip 192.168.1.3 200 broadca
```

Routing Configuration

```
center(Config)# router eigrp 1
    router)# no auto-summary
    router)# network 10.3.0.0 0.0.255.255
    router)# network 192.168.1.0
```

```
branch1 (config)# router eigrp 1
        router)# no auto-summary
        router)# network 192.168.1.0
        router)# network 10.1.0.0 0.0.255.255
```

```
branch2 (config)# router eigrp 1
        router)# no auto-summary
              )# network 192.168.1.0
              )# network 10.2.0.0 0.0.255.255
```

وبعد عمل ذلك سوف يمر أن branch1 لا يرى الشبكات التي

في branch2 والعكس وذلك نتيجة لل split horizon

الموجود في center وإذا أردت إيقافه عليك

بالأمر التالي

```
center(config)# no ip split-horizon eigrp 1
```

Configuring summarization

Center (Config) # int s1/1

if) # IP summary-address eigrp1 10.3.0.0 255.255.252

branch1 (Config) # int s1/1

if) # IP summary-address eigrp1 10.1.0.0 255.255.252.0

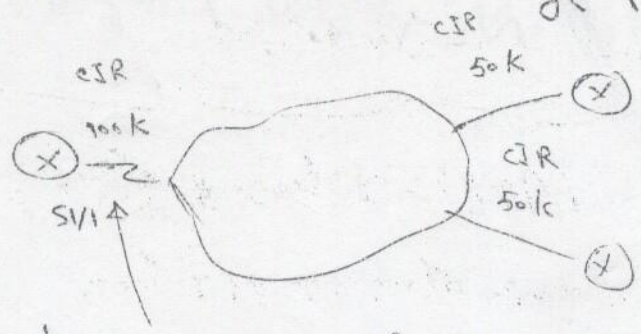
branch2 (Configg) # int s1/1

if) # ip summary-address eigrp 1 10.2.0.0 255.255.252.0

The band width percent

- by default eigrp is set to use only up to 50% of bandwidth of an to exchange routing information

ex



eigrp updates use 50% of BW [50 x bps] if we want to use more than 50% use the command

int S1/1
if) bandwidth 100
if) # IP bandwidth-percent eigrp 1 75

سوف تستخدم الـ eigrp updates من الـ BW 75%

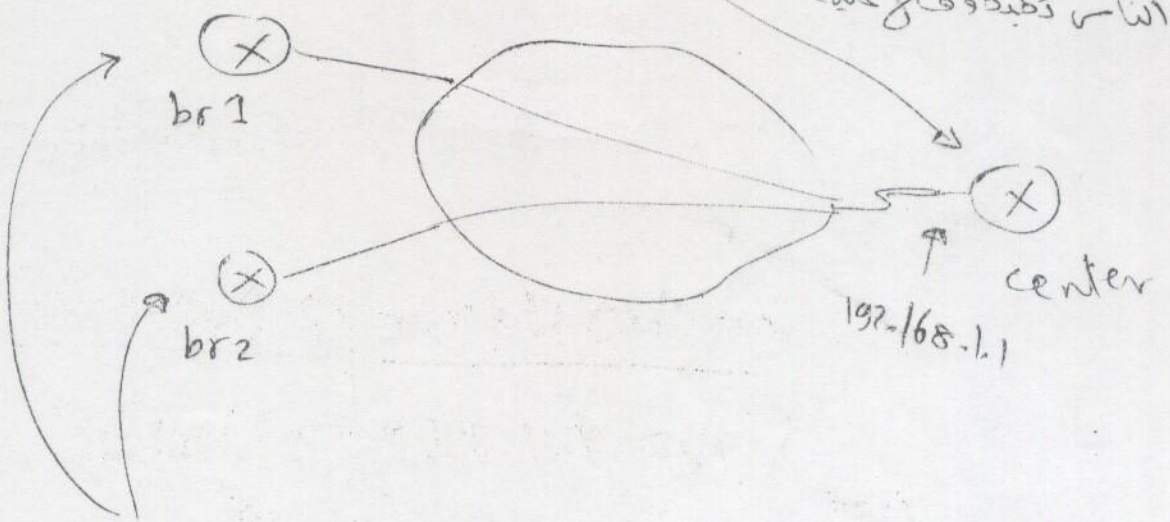
NTP [network time protocol]

أريد أن أجعل (Center Router) هو master time أو server time

① إضبط الوقت عليه

center # clock set 04:20:00 15 sep 2011

c(onfig) # ntp master ← حتى يكون هو server وكل الناس تظبط وقتها عليه



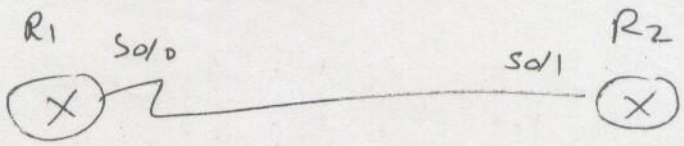
(config) # ntp server 192.168.1.1

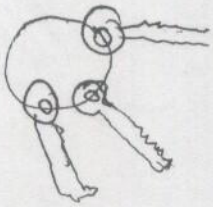
Authentication using key chain

سلسلة مفاتيح

- Eigrp authentication helps prevent Denial of service attack [DOS]. which prevents attackers from forming neighbor relationship

ex





R1 (Config) # key chain carkeys

- key chain) # Key 1

keychain - key) # key-string ford

int S0/0

if) # IP authentication mode eigrp 1 md

if) # ip authentication key-chain eigrp 1 carkeys

R2 (Config) # Key chain mykeys

- key chain) # key 1

- key) # key-string ford

- key) # int S0/1

if) # ip authentication mode eigrp 1 md5

if) # IP authentication key-chain eigrp 1 mykeys

hints

① The key chain name and which is used on two Routers don't have to match

② The key string & key No. on each of two potential neighbors must match

③ check using The command

(# sh key chain)

⇒ key chain can be joined with time

key 1 : [cisco 1] ٢ بعد منتصف الليل

- accept from midnight 1/1/2011 → midnight 1/2/2011
- sent from " " → " "

key 2 : [cisco 2]

- accept from midnight 1/2/2011 → enternity ← إلى مالا نهاية
- sent from " " → " "

R1 (config)# key chain mykeys

أولاً

key chain)# key 1

key)# string cisco1

key)# accept-lifetime 00:00:00 1 jan 2011 → 00:00:00 1 feb 2011

key)# send-lifetime 00:00:00 1 jan 2011 00:00:00 1 feb 2011

key chain)# key 2

key)# string cisco2

key)# accept-lifetime 00:00:00 1 feb 2011 infinite

key)# send-lifetime 00:00:00 1 feb 2011 infinite

ثانياً قم بتفعيلها

(config)# int s0/0

if)# ip authentication mode eigrp 1 md5

if)# IP authentication key-chain eigrp 1 mykeys

R2 قم بتنفيذ نفس الخطوات على

EIGRP route Filtering

- route filtering : allows an engineer to filter which routes are advertised in an EIGRP updates

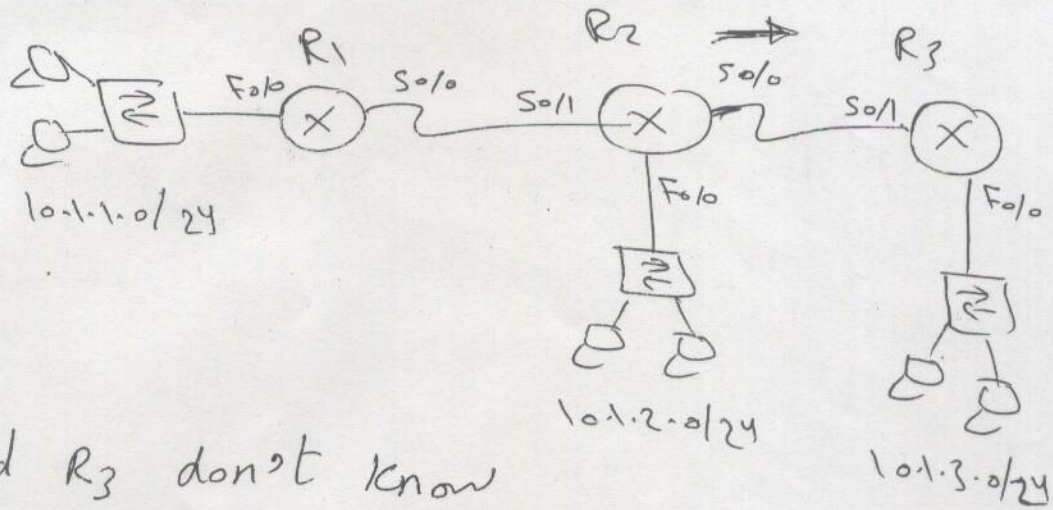
- reasons
  - → branch offices only need to communicate with head quarters, not with each other
  - → smaller Routing table
  - → security

⇒ EIGRP use Distribute list to filter Routes

Distribute list use

- ACL
- Prefix list
- Route MAP

① example for ACL



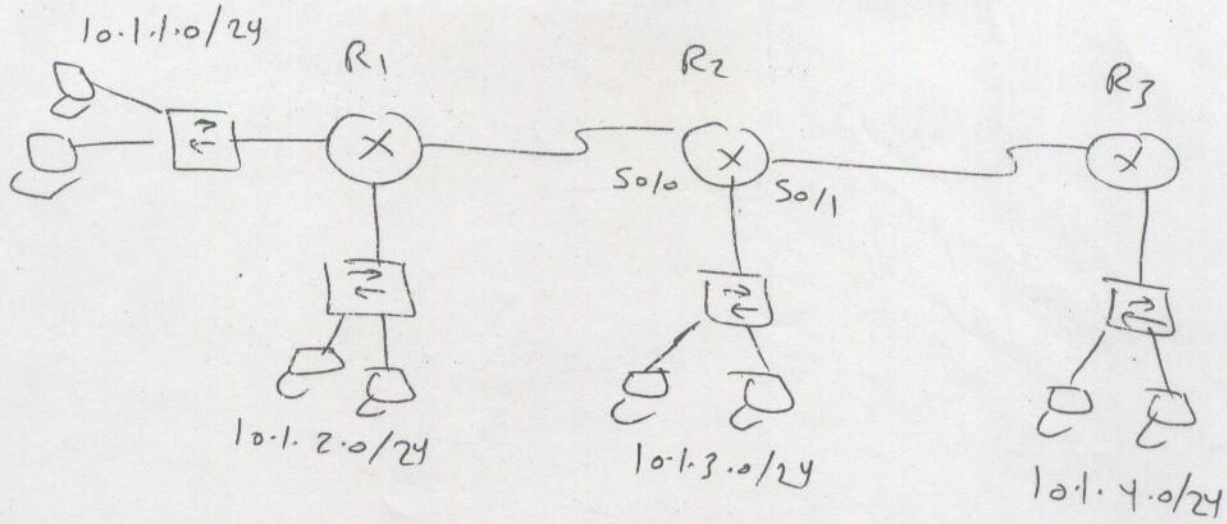
→ we need R_3 don't know any Routes about network 10.1.1.0/24

Solution

we will Put The distribute list at The out of s0/0 of R_2

```
R2 (config) # access-list 2 deny 10.1.1.0 0.0.0.255
(config) # access-list 2 permit any
(config) # router eigrp 1
router) # distribute-list 2 out s0/0
```

② example for prefix list



→ we need R_3 didn't know any routes about networks 10.1.1.0/24 and 10.1.2.0/24

R_2 (config) # IP prefix-list ---- seq 5 deny

→ 10.1.1.0/24 ge 24 Le 24

The subnet number → 24 ← subnetmask

R_2 (config) # IP prefix-list aa — seq 10 deny

→ 10.1.2.0/24 ge 24 Le 24

R_2 (config) # IP prefix-list aa — seq 15 permit

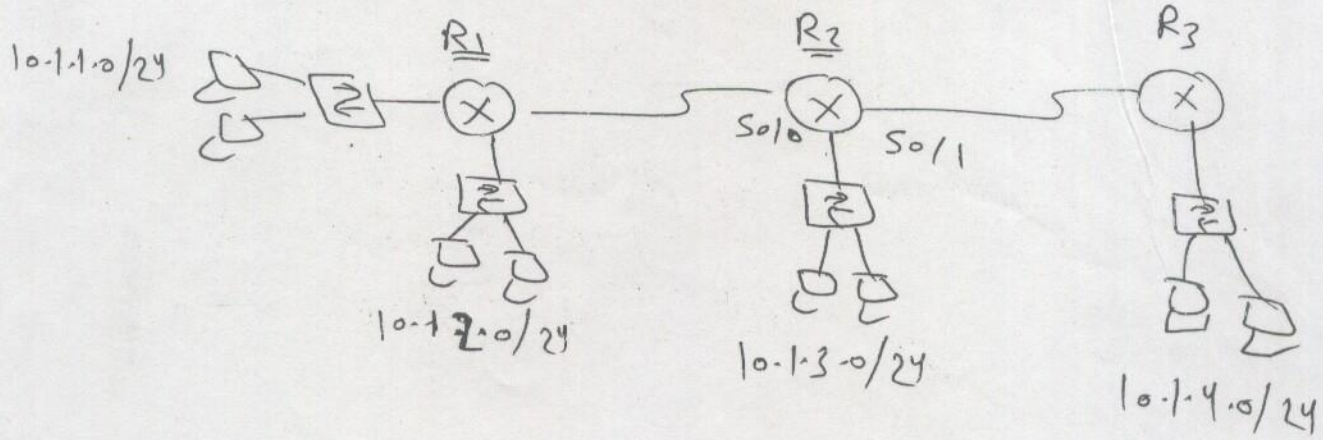
→ 0.0.0.0/0 Le 30

(config) # router eigrp 1

router) # distribute-list prefix aa out S0/1

③ example for route map

عملت فلتر بال ACL أو prefix list



→ we need R_3 didn't know any Routes about network 10.1.1.0/24 and network 10.1.2.0/24

R2 (config) # access-list 1 deny 10.1.1.0 0.0.0.255
R2 (config) # access-list 1 deny 10.1.2.0 0.0.0.255
R2 (config) # access-list 1 permit any

(config) # route-map aa permit 10
(route map) # match ip address 1
(config) # router eigrp 1
(router) # distribute-list route-map aa

ACL رقم

→ out S0/1

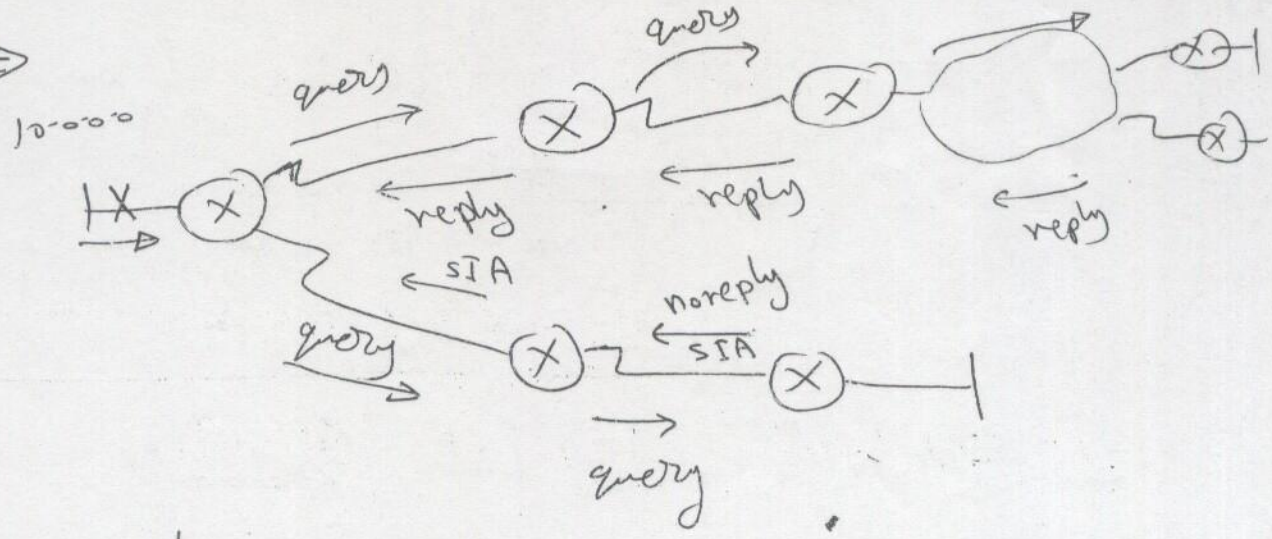
Stuck-in-Active [SIA]

⇒ SIA msg results when a router can't answer a query because:

① The router is too busy to answer the query

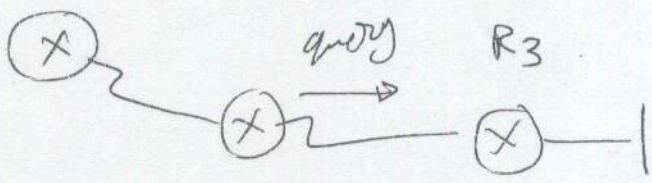
② bad circuit between the routers (Packet loss)
↳ unidirectional links: a link on which traffic can only flow in one direction due to a failure

⇒



Solution: ① summarization

② stub Routers

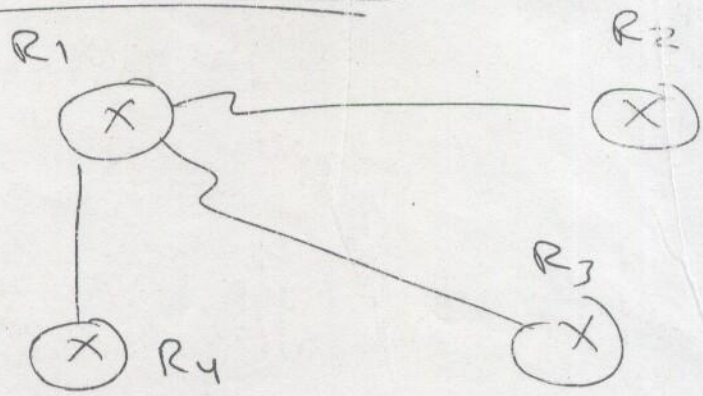


R3 (config)# router eigrp

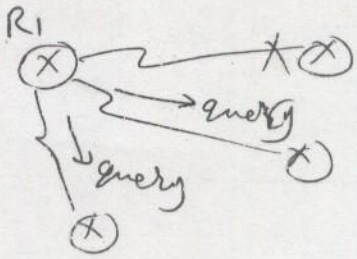
router) # eigrp stub connected

لما stub و بس أعلم فقط عن الشبكات direct connected فقط

Good bye Msg



- in old IOS if R_2 down or reloaded
- R_1 will know That R_2 is down by holding down timer on R_1 and will send query

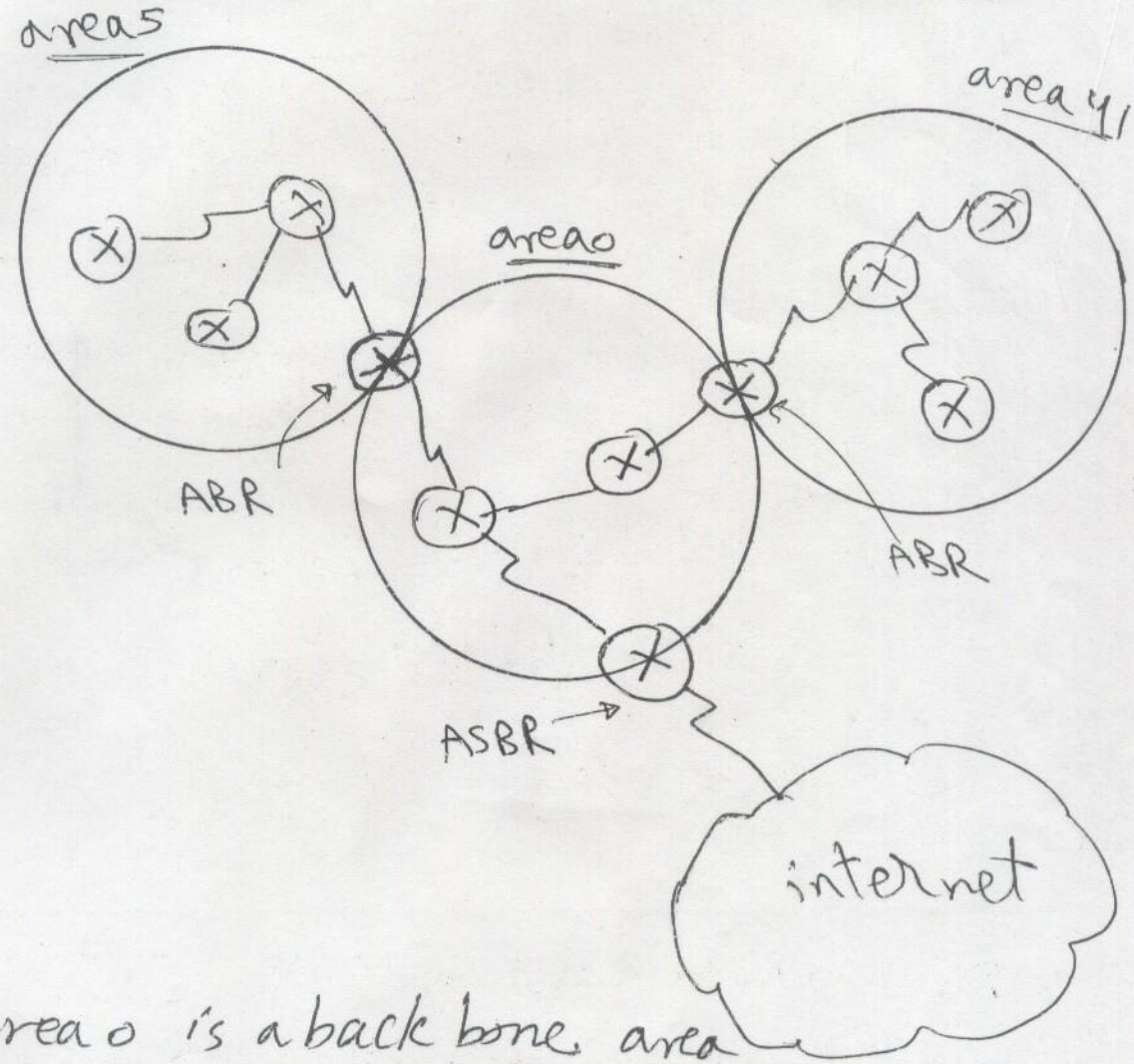


- in IOS 12.3(2)T ~~vi~~ version after R_2 reloaded he will send Final hello msg with k values =255 [known as goodbye msg]
- when R_1 receive hello with k values =255 k values mismatch happen
- so R_1 know That R_2 is down and he will not form neighbor relationship instead of sending queries and congest BW of links

OSPF "open shortest Path first"

- link state routing protocol
- admin distance = 110
- metric = $\frac{10^8}{BW}$ [metric $\propto \frac{1}{BW}$]
- send hello to maintain neighbor relationship
- maintain 3 tables
  - → neighbor table
  - → topology table
  - → Routing table
- use Dijekstra shortest Path first [SPF] algorithm
- send triggered update to announce network chang
- send periodic updates [Ls refresh ment] on long interval [30 min]

OSPF area design & terms



- area 0 is a back bone area
- all other areas must connect to area 0
- all routers in an area have the same topology table

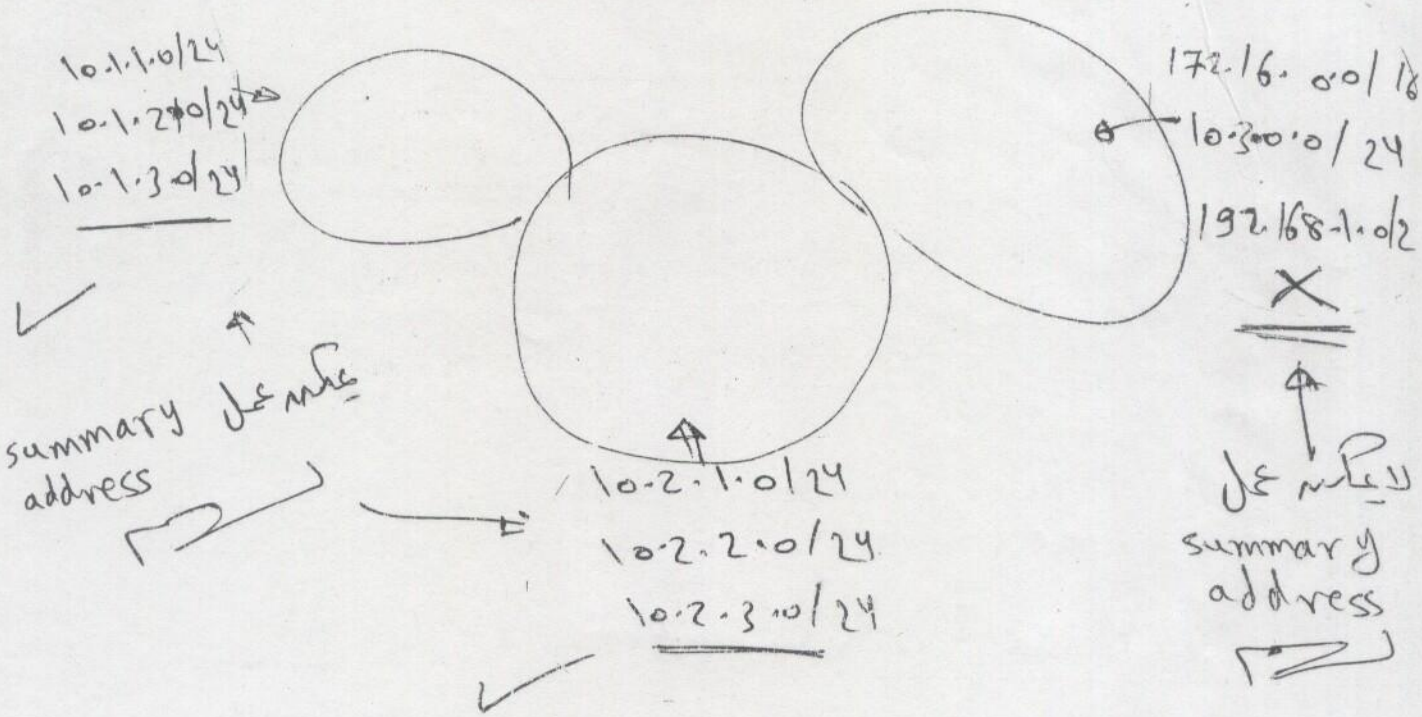
Goal: localize update within an area

أي أن كل area تحتوي على summary الخاص بال area's الأخرى

Requires: hierarchical design

لكي نعرف كيف لاحظ الصفحة التالية

- لابد أن يكون توزيعاً للـ IPs في كل area يكون بشكل جيد و متناسق حتى نستطيع أن نعمل لها summary



[1] ABR : [Area border router]

is a router that has one interface / area

[2] ASBR [autonomous system boundary route

- Router connect you outside of your OSPF autonomous system

ملحوظة: ٢- ⊛ ABR & ASBR هما الروتر اللي بيعمل (summary address) عليهم حتى يرسلوا ذلك (summary address) إلى area's الأخرى

⊛ أما باقي الروتر فلا يتم عمل (summary address) عليهم

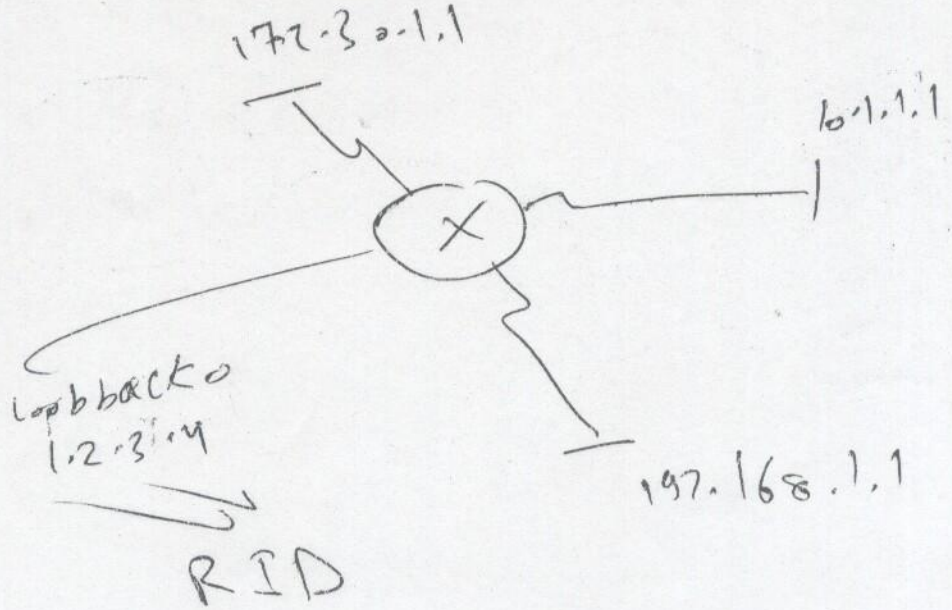
OSPF neighbor relationship

- relationship forms between Routers in same area

1 The router will determine its own Router ID

* The router ID is simply The router's name in The ospf process

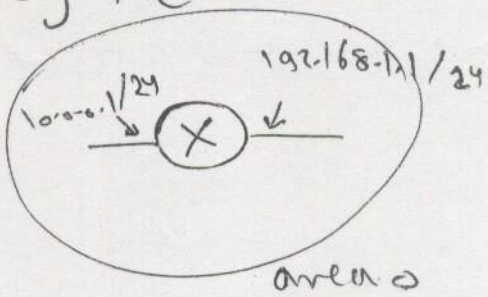
* Router ID
  - → hightest Loop back IP address if no loop back
  - → highest Physical IP address



* router ID can be hard coded using router ID command

```
(config)# router ospf 1
        router)# router-id 1.2.3.4
```

2 add interfaces to link data base [dictated by The network command]



الطريقة الأولى

(A)
```
(config)# router ospf 1
        router)# network 10.0.0.0 0.0.0.255 area 0
        router)# network 192.168.1.0 0.0.0.255 area 0
```

(B)
```
(config)# router ospf 1
        router)# network 10.0.0.1 0.0.0.0 area 0
        router)# network 192.168.1.1 0.0.0.0 area 0
```

الطريقة الثانية

3 send hello message on chosen interfaces

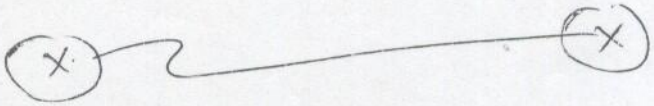
hello msg's are sends → every 10 sec on B.cast (ethernet interfa)
and P-2-P networks (serial interface)

→ every 30 sec on NBMA networks (like frame relay)

dead interval = 4 * hello

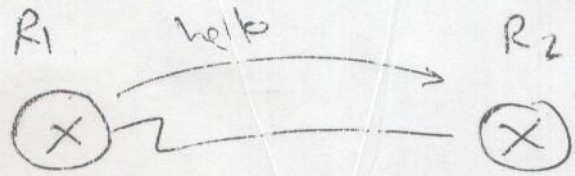
⇒ hello msg contain all sorts of information

- Router ID
- hello & dead timers*
- neighbors
- network mask*
- router ID
- router priority
- DR/BDR IP address
- authentication password



* → أي لابد أن تكون نفس القيمة على الروترين

4 Receive hello

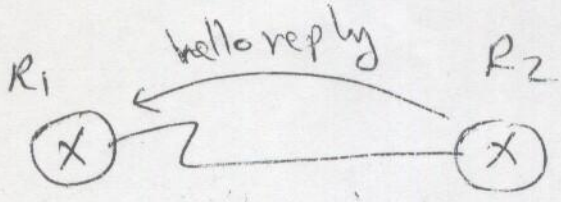


- R_2 receive hello from R_1
- ∴ R_2 is in <u>init state</u>

→ after R_2 receives hello from R_1 he checks

- check hello/dead intervals
- check network mask
- check area
- check authentication password

5 send reply hello



- when R_2 checks The hello sends from R_1 he reply hello to R_1

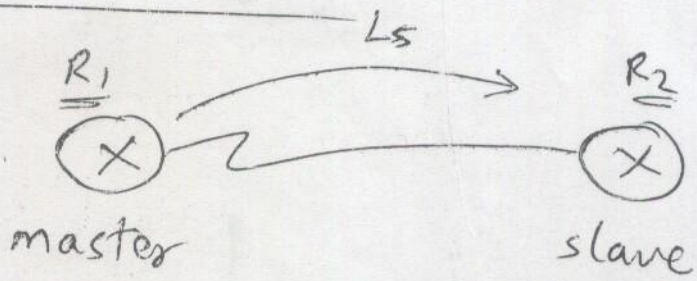
∴ R_2 is in <u>2way state</u>

- R_2 asked R_1 {am I listed as a neighbor in your hello packet?}

  [if yes, reset dead timers]

  [if no, add as a new neighbor]

6 master slave relationship



- determind by "priority" & "Router ID"
- master sends data base descreption packet [DBD]

DBD: cliff notes of link state data Base [LSDB]
summary

7 DBD's are acknowledged & reviewed

* "loading state" *

* slave requists details [link state requists (LSR)]

* master sends updates [Link state update (LSU)]

* master requists details [LSR]

* slave sends updates [LSU]

8 neighbors are syncronized

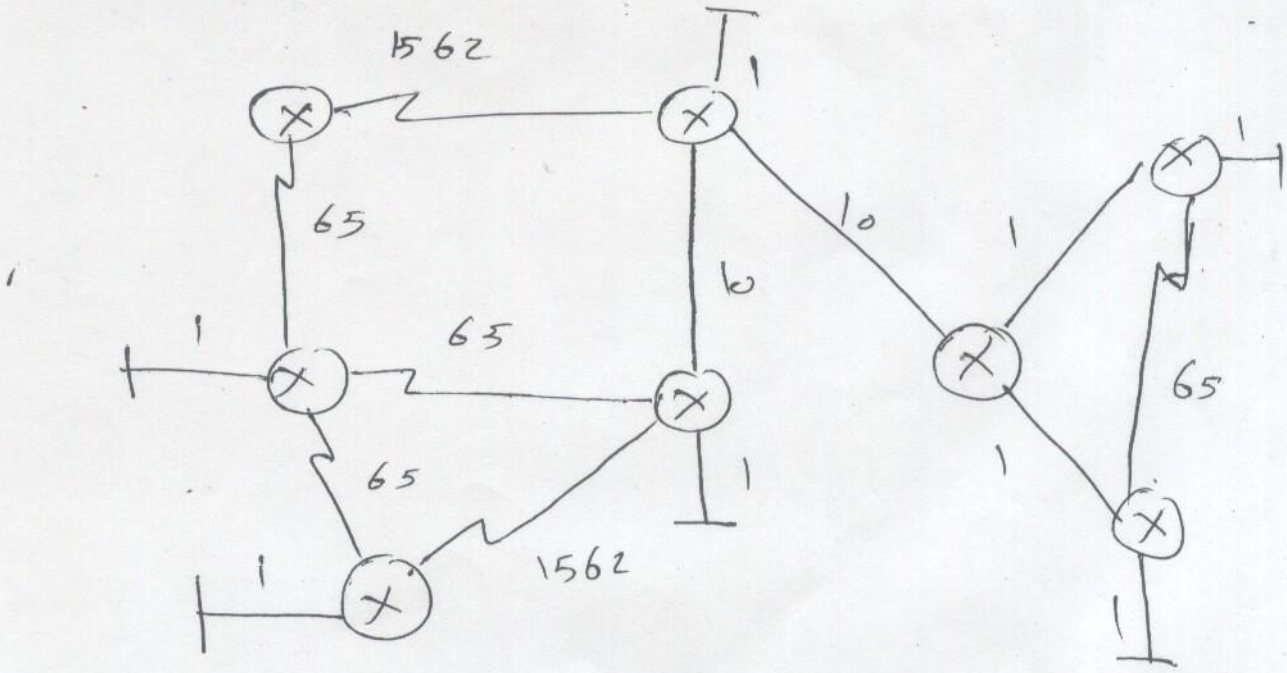
* "Full state" *

OSPF Costs

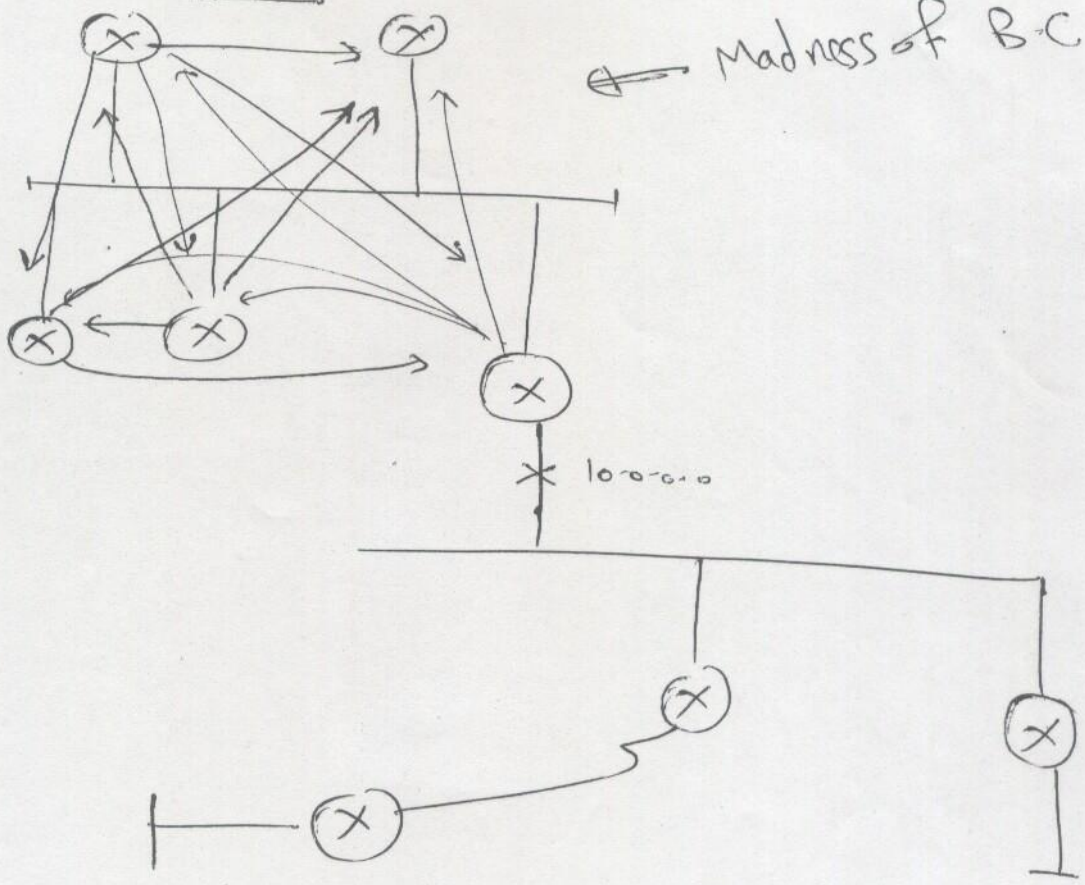
$$\text{cost} = \frac{10^8}{BW} = \frac{100}{BW\,(\text{Mbps})}$$

Common Costs

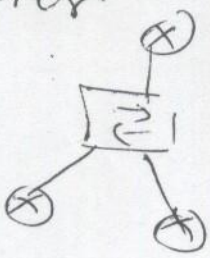
56k	= 1785
64K	= 1562
T_1 [1.544]	= 65
E_1 [2.048]	= 48
ethernet (10M)	= 10
fastethernet	= 1



DR & BDR

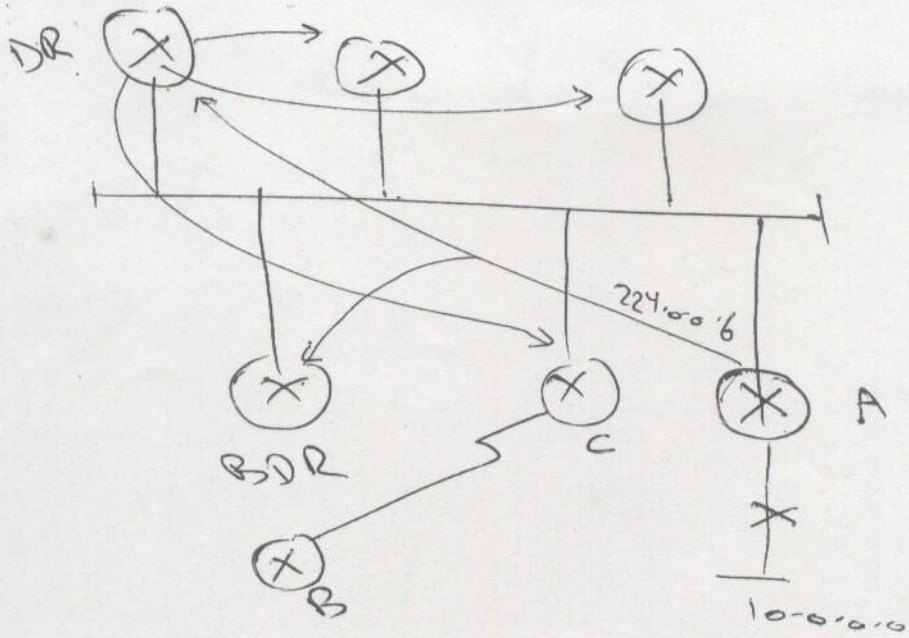


if network 10.0.0.0 down The Router which are connected on shared link will happen between Them a madness of "Broadcast"



- to solve This problem ~~we~~ There must be a DR [designated Router] &

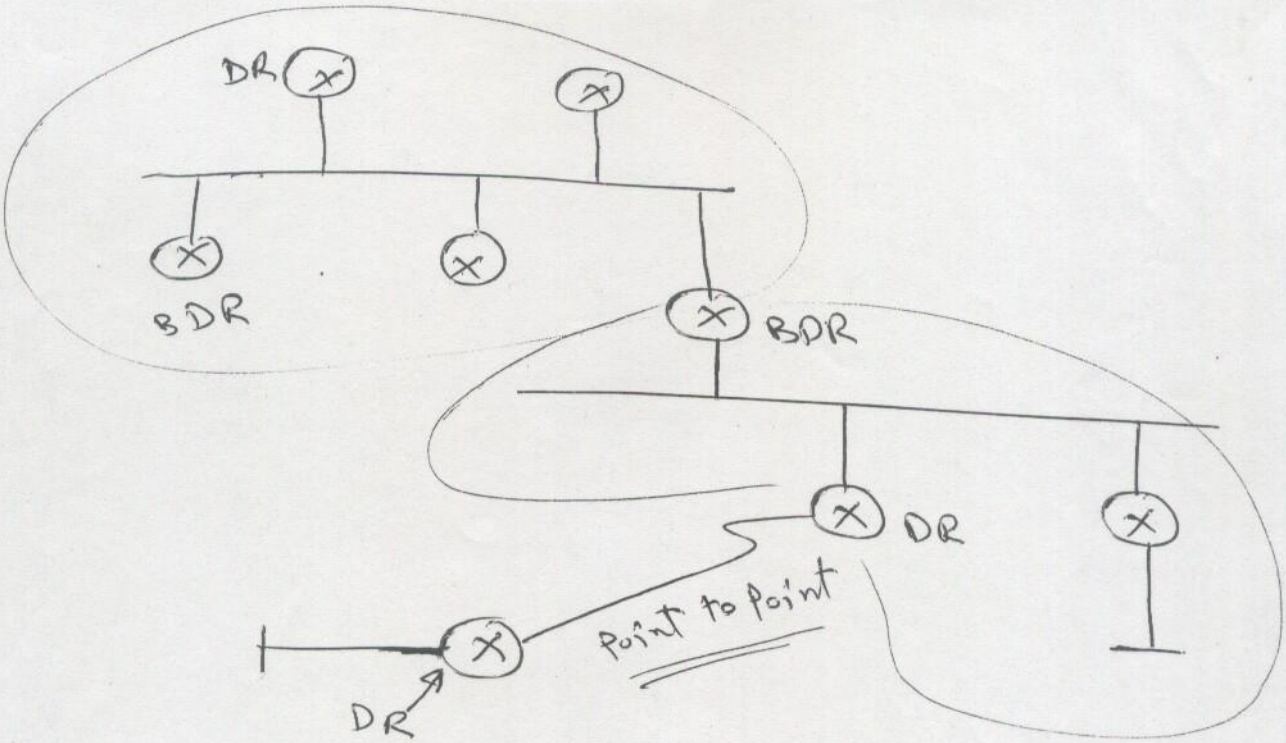
BDR [backup DR]



- Router A will inform DR and BDR That N.W 10.0.0.0 is down on (224.0.0.6)
- DR will inform all routers in shared link That N.W 10.0.0.0 down on 224.0.0.5

- Router C now will know That N.W 10.0.0.0 is down so he will inform Router B as a (Point to point) That N.W 10.0.0.0 is down on 224.0.0.5

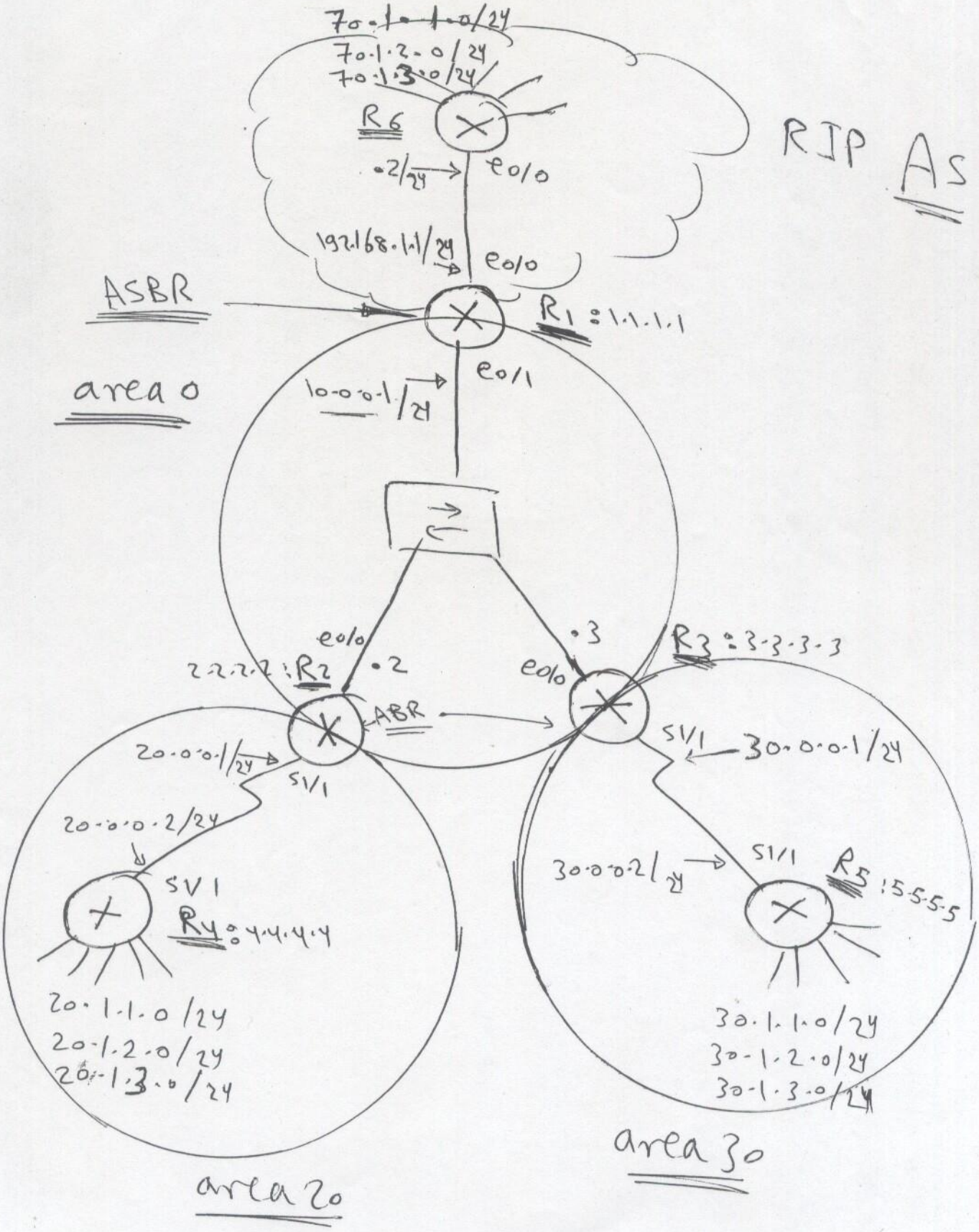
- hint : There are a DR per shared segme



DR : ① Router with highest priority
② Router with highest Router ID

BDR : ① Router with second highest priority
② Router with second highest Router II

configuring OSPF multi Area



R6 (config) # router rip
(router) # version 2
(router) # no auto-summary
(router) # network 70.0.0.0
(router) # network 192.168.1.0

R1 (config) # router rip
(router) # version 2
(router) # no auto-summary
(router) # network 192.168.1.0
(config) # router ospf 1
(router) # network 10.0.0.1 0.0.0.0 area 0
(router) # router-id 1.1.1.1

R2 (config) # router ospf 1
(router) # router-id 2.2.2.2
(router) # network 10.0.0.2 0.0.0.0 area 0
(router) # network 20.0.0.1 0.0.0.0 area 20

R4 (config) # router ospf 1
(router) # router-id 4.4.4.4
(router) # network 20.0.0.2 0.0.0.0 area 2
(router) # network 20.1.0.0 0.0.255.255 area 20

R3 (Config)# router ospf 1
router)# network 10.0.0.3 0.0.0.0 area 0
router)# network 30.0.0.1 0.0.0.0 area 30
router)# router-id 3.3.3.3

R5 (Config)# router ospf 1
-router)# router-id 5.5.5.5
-router)# network 30.0.0.2 0.0.0.0 area 30
-router)# network 30.1.0.0 0.0.255.255 area 3

R5 # show IP route

O IA	10.0.0.0
O IA	20.0.0.0
O IA	20.1.1.0
↑ inter area	⋮

R6 لا يرى الشبكات في (ospf domain)

وكذلك الروتر الموجودة في (ospf domain) لا ترى الشبكات (70.1.1.0, 70.1.2.0, 70.1.3.0)

والحل في redistribution

R1 (config) # router rip

router) # redistribute ospf 1 metric 5

(config) # router ospf 1

router) # redistribute rip subnets

R4 # show IP route

O IA	30.0.0.0
O IA	30.1.1.0
O E2	70.1.1.0
O E2	70.1.2.0
O E2	70.1.3.0

external type 2 LSA → "تقوم لا صحا"

⇐ وماذا عن summarization

⇒ we know That The smaller your Routing table The faster your Router.

- كل روتر يجب أن يرى كل الشبكات والتي تقع في نفس الـ area

- أما بالنسبة لباقي الشبكات التي توجد في area's الأخرى فيكفيه أن يعرف عنها summary فقط

- لذلك إذا أردت أن تقوم بعمل summary فإنك توضح

على (ABR Router) أو على (ASBR Router)

ABR

R2 (Config) # router ospf 1

summary address

router) # area 20 range 20.1.0.0 255.255.0.0

ABR

R3 (Config) # router ospf 1

router) # area 30 range 30.1.0.0 255.255.0.0

ASBR

R1 (Config) # router ospf 1

router) # summary-address 70.1.0.0 255.255.0.0

⇒ in area 0 R_3 is The DR [designated router]

because he is The highest RID

⇒ we want R_1 to be The DR

R_1 (config) # int e0/1

R_1 (config - if) # IP ospf Priority 100

R_1 (config - if) # exit

R_1 # clear ip ospf process → to start ospf process again.

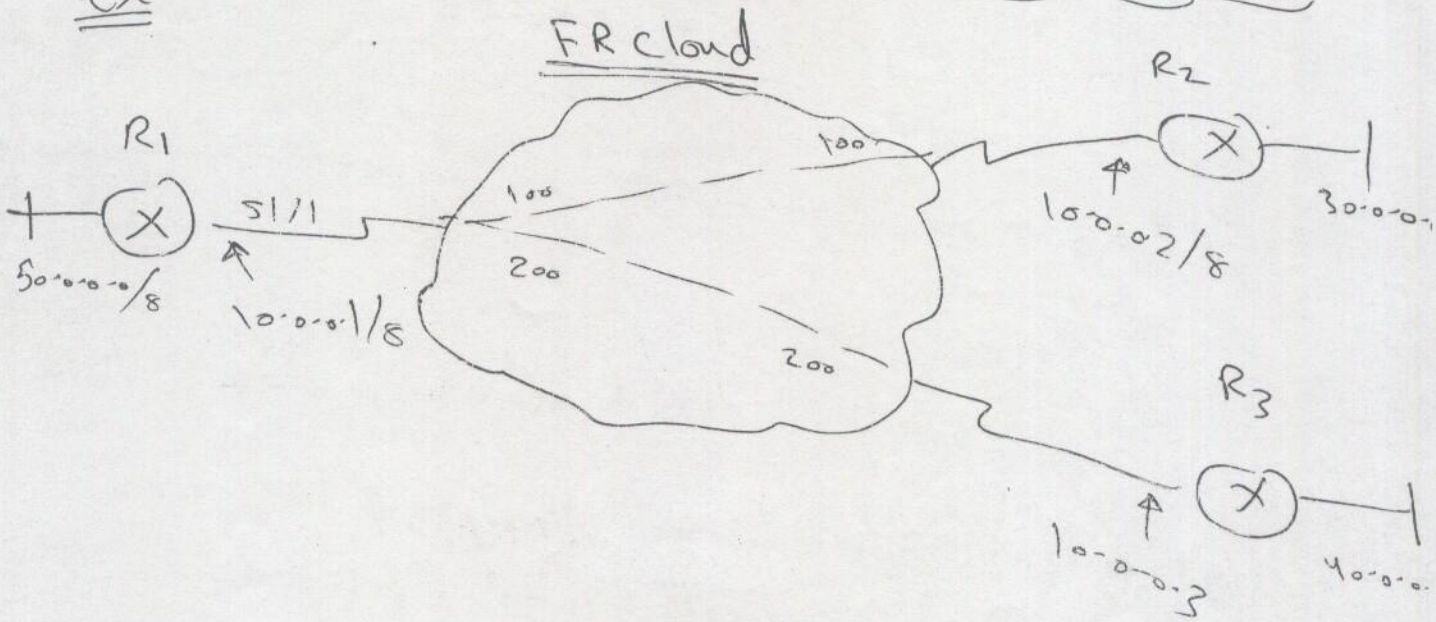
R_1 # sh IP ospf interface e0/1

RID: 1.1.1.1
state DR

OSPF over NBMA [Non B.C multi access] (FR)

① OSPF over point to multi-point mode.

ex



← مش محتاج تعمل FR - MAP

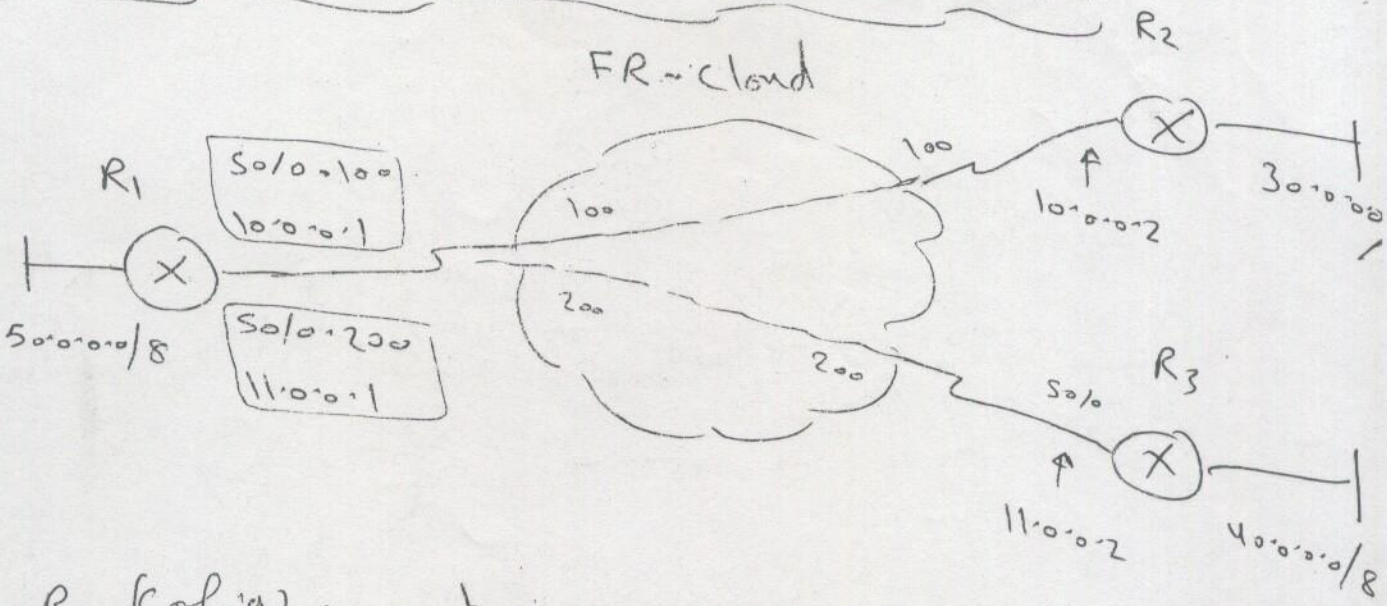
R1(Config) # router OSPF 1
router) # network 50.0.0.0 0.255.255.255 area 0
router) # network 10.0.0.1 0.0.0.0 area 0
~~router~~ int S1/1 if) # IP OSPF network point_to_multipo

وكذلك على R2 و R3

(link state Protocols) لا تكون فعالة مع split horizon (طبوغرافية)

أي أن R2 يرى الشبكة 40.0.0.0 وكذلك R3 يرى شبكة 30.0.0.0

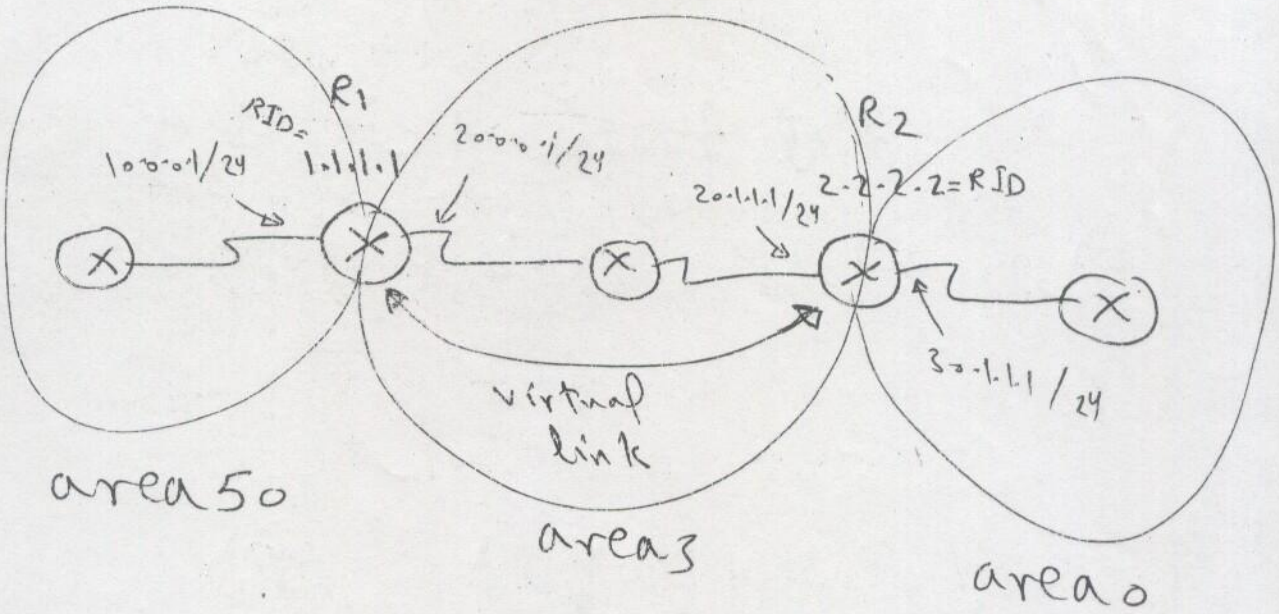
② OSPF over Point-to-Point mode




```
R1 (config) # router ospf 1
  router) # network 50.0.0.0 0.255.255.255 area 0
  router ) # network 10.0.0.1 0.0.0.0 area 0
  router ) # network 11.0.0.1 0.0.0.0 area 0
  router ) # int s0/0.100 point-to-point
    sub-if) # IP ospf network point-to-point
    if ) # int s0/0.200 point-to-point
    if) # IP ospf network point-to-point
```

R3 & R2 كرر نفس الخطوات كالأعلى

OSPF virtual links




```
R1(config)# router ospf 1
    router)# network 10.0.0.1 0.0.0.0 area 5
    router)# network 20.0.0.1 0.0.0.0 area 3
    router)# router-id 1.1.1.1
    router)# area 3 virtual-link 2.2.2.2
```

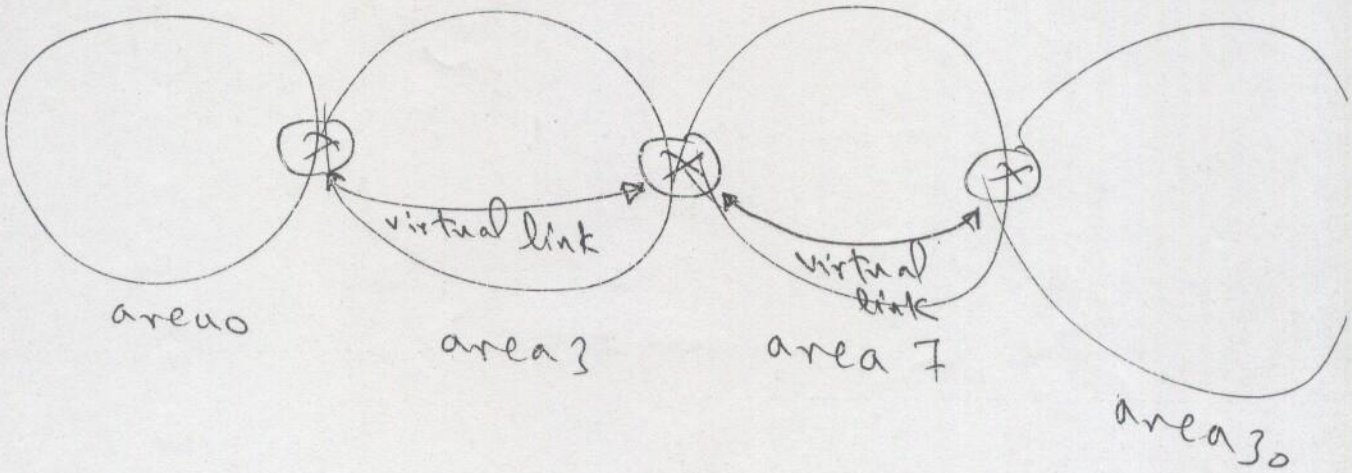
Router ID
للروتر المقابل ع الطرف الآخر
من الـ virtual link

```
R2(config)# router ospf 1
    router)# network 30.1.1.1 0.0.0.0 area 0
    router)# network 20.1.1.1 0.0.0.0 area 3
    router)# router-id 2.2.2.2
    router)# area 3 virtual-link 1.1.1.1
```

Troubleshooting

```
# sh IP ospf neighbors
# sh IP route
# sh IP ospf virtual link
```

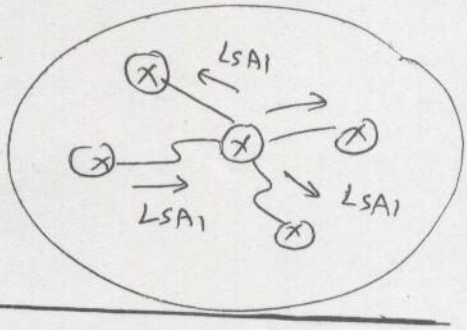
hint : يمكن عمل virtual link وانه نتوسع به على النحو الآتي :



OSPF LSA types

1 LSA type 1 [Router LSA] "router link"

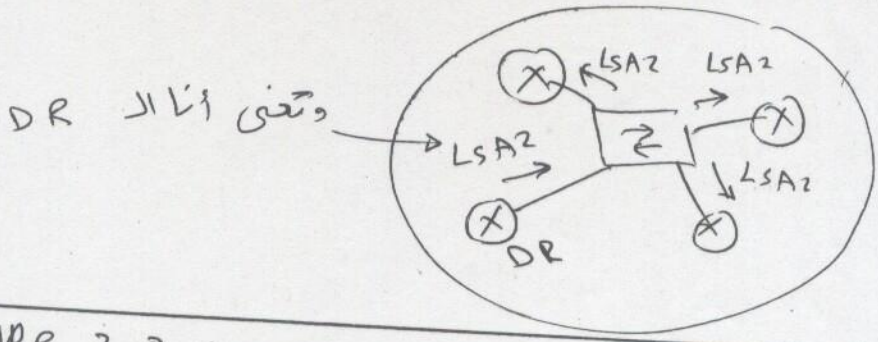
→ flooded within the area to all other Routers



2 LSA type 2 [Network LSA] "Net link"

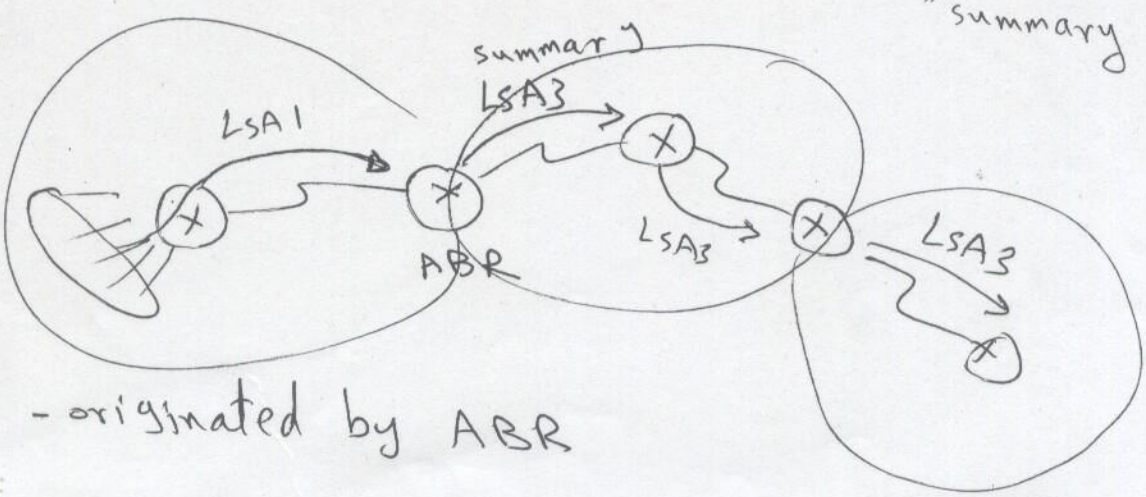
→ generated by the DR on shared link

→ flooded only within the originating area



3 LSA type 3 : summary LSA [ABR summary route]

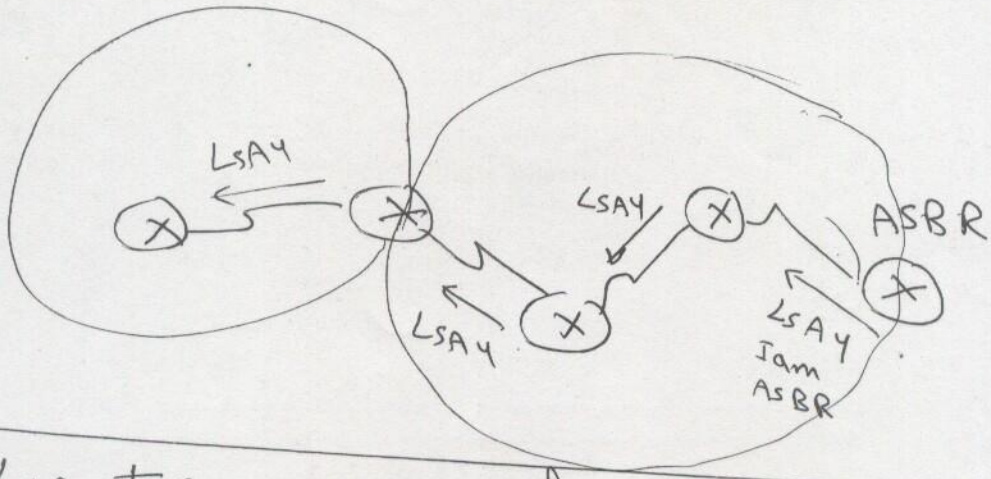
"summary net"



- originated by ABR

4 LSA type 4 : summary LSA [ASBR location] "summary ASB"

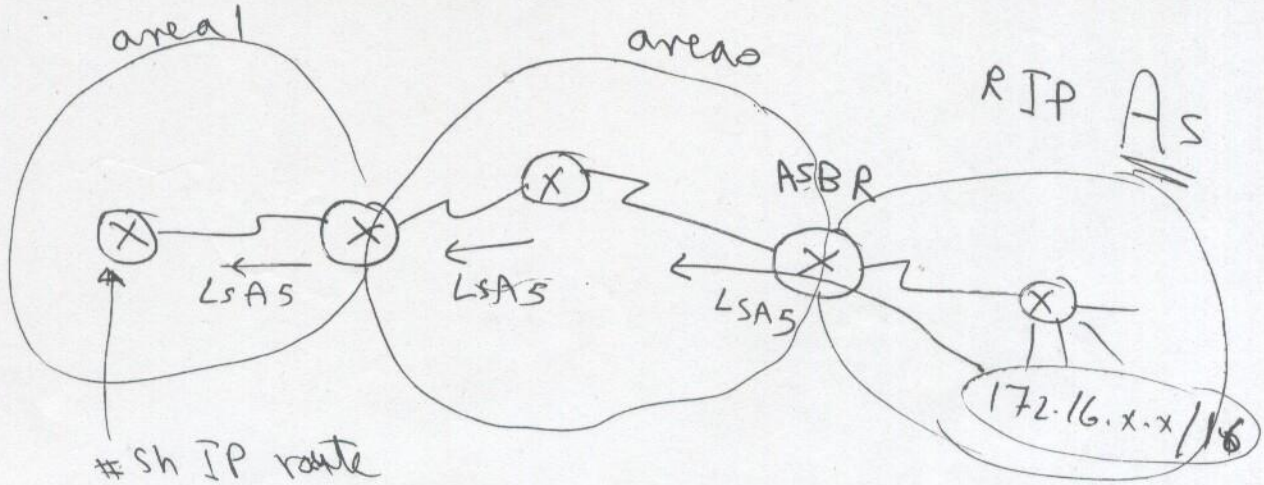
→ advertise the location of ASBR [send ASBR IP address]



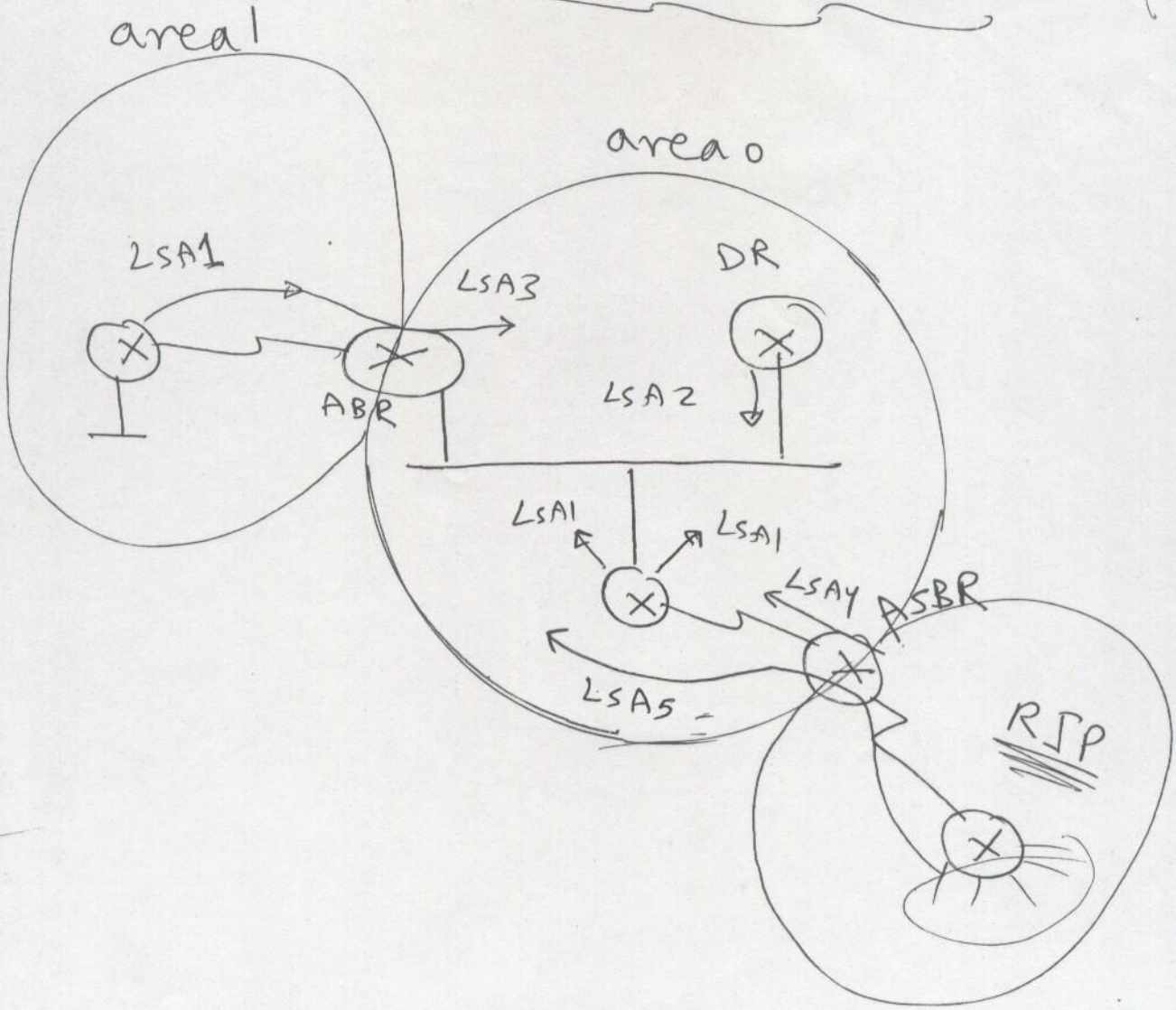
5 LSA type 5 : external LSA [ASBR summary routes]
: [OE1, OE2]

→ generate by ASBR & Flood to all Autonomous system

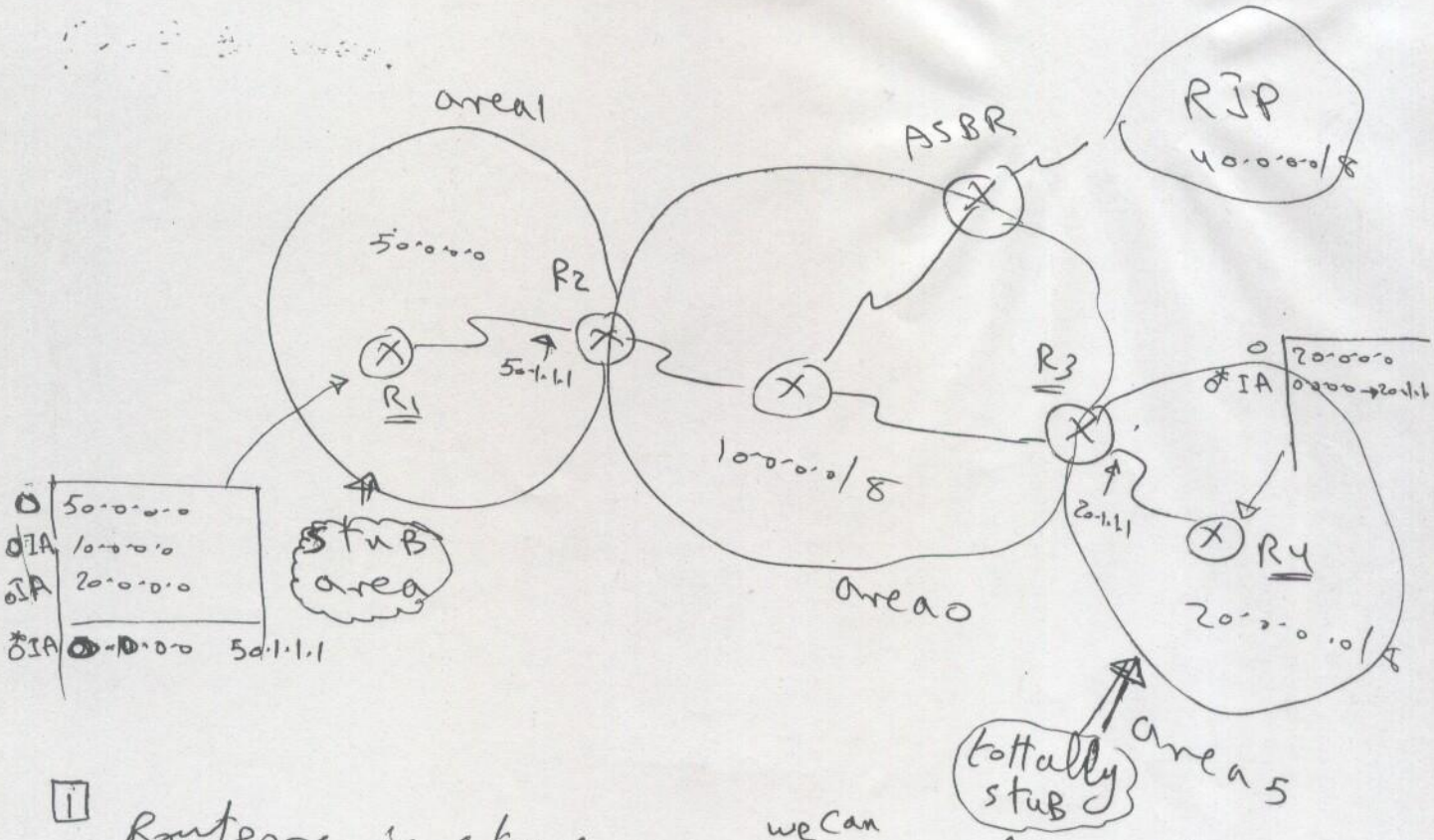
→ it describes routes to destination networks in an external routes



LSA ملخص


area1
area0
LSA1
LSA3
DR
ABR
LSA2
LSA1
LSA1
LSA4
ASBR
LSA5
RIP

* stub & totally stuby Areas *



1 <u>Routers in stub area</u>: we can see only Routes in our area and other area's and default route but we can't see external routes.

أي أن R1 يستطيع أن يرى كل الشبكات التي في areas & area0 & area1 ولكنه لا يستطيع أن يرى الشبكات الخارجية والتي توجد في (RIP domain) ولكنه يرى (default route) في جدول R2

O	50.0.0.0
OIA	10.0.0.0
OIA	20.0.0.0
*IA	0.0.0.0 → 50.1.1.1

<u>stub area</u>: blocks type 5 LSA from entering

stub area configuration

R2 (config) # router ospf 1
ABR router) # area 1 stub

يكتب هذا الأمر على كل الروتر الموجودة في area 1

R1 (config) # router ospf 1
router) # area 1 stub

[2] → Routers in totally stubby areas: we can see only routes in our area and default routes, No external routes & No inter area routes

أي أن R4 لن يرى إلا البيانات التي في areas ولن يستطيع أن يرى البيانات في ال area's الأخرى ولن يستطيع أن يرى البيانات الخارجية، وكذلك فقط سيرى

O 20.0.0.0
O* IA 0.0.0.0 20.1.1.1

R3 في إتجاه (default route)

totally stubby area: Blocks type 3, 4 & 5 LSA from entering

totally stubby area configuration

R3(config)# router ospf 1

ABR router)# area 5 stub no-summary

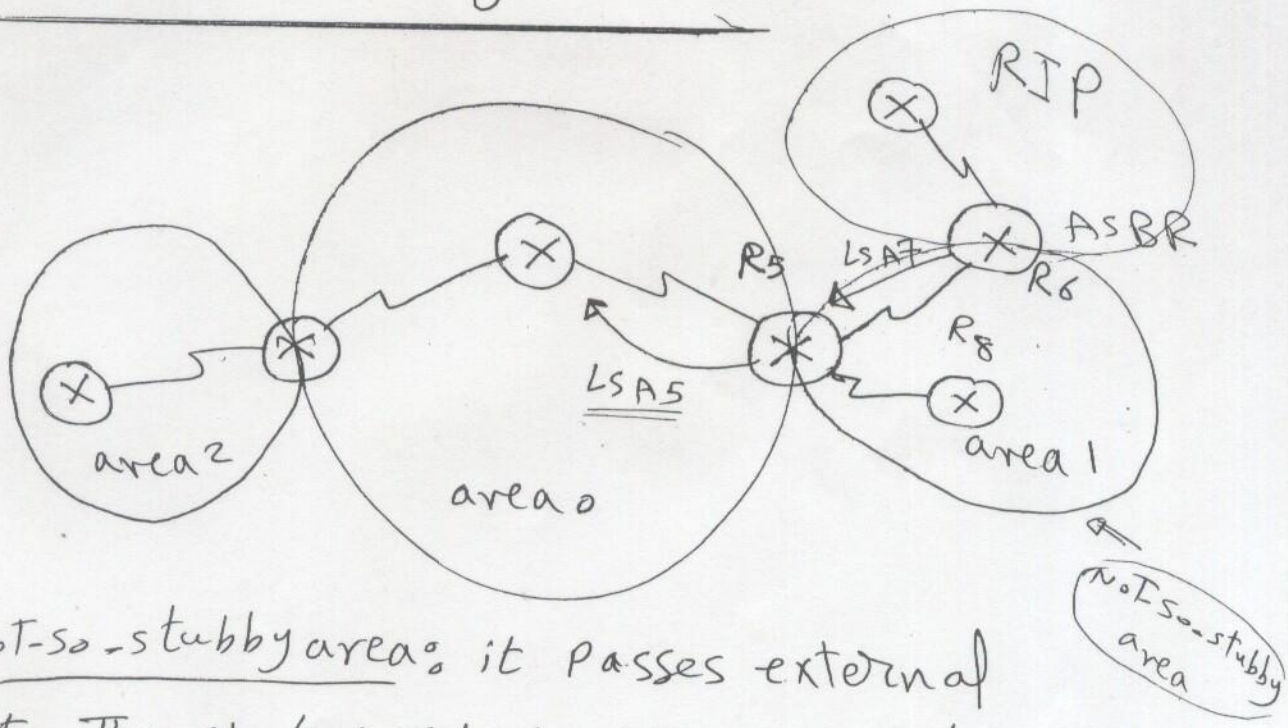
يعني totally stubby

يكتب على ABR فقط

Ry(config)# router ospf 1

router)# area 5 stub → ثم إكتب هذا الأمر على كل الروتر الموجودة في area5

* NOT-SO-STUBBY area *



NOT-SO-stubby area: it passes external routes through type 7 LSA, these convert back to type 5 once they reach the back bone

أي أن area معزولة عن العالم الداخلي ولكن ليست معزولة عن العالم الخارجي لأن الـ ASBR يقع فيها

NSSA configuration

R6 (config) # router ospf 1

ASBR router) # area 1 nssa ← يكتب هذا الأمر على الراوتر الي فيه nssa عدا ال ABR

R8 (config) # router ospf

router) # area 1 nssa

R5 (config) # router ospf 1

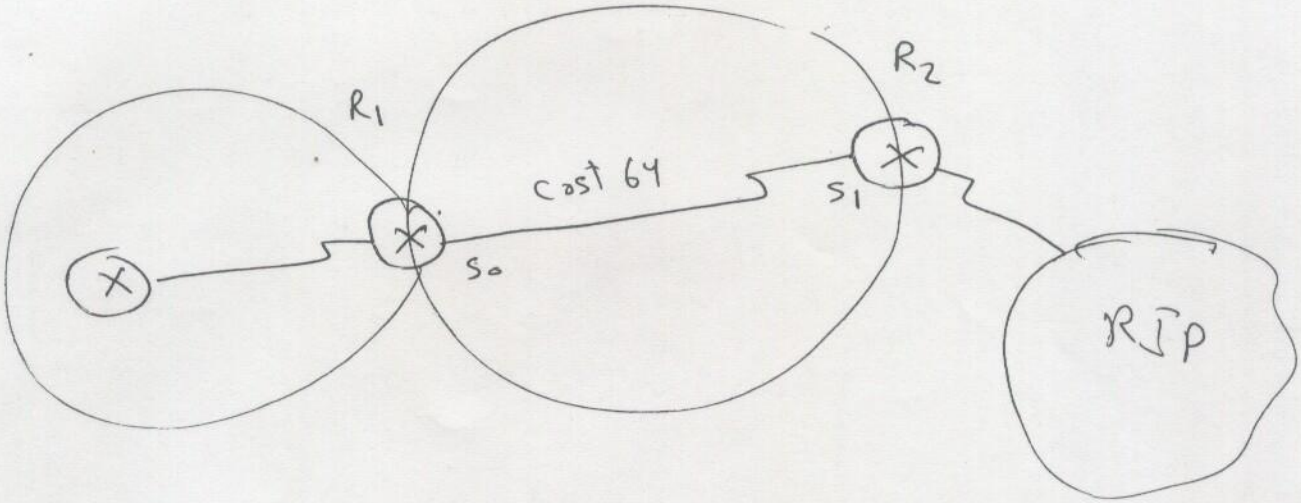
ABR router) # area 1 nssa no-summary

Trouble shoot

sh IP route

sh IP ospf data base

Adjusting OSPF cost



to adjust The cost between R_1 & R_2

to b = 64

```
R1 (Cofig) # int s0
        if) # IP OSPF cost 64
```

```
R2 (Cofig) # int s1
        if) # IP OSPF cost 64
```

وممكن تضبطي أيضاً عن طريق ال BW $\left[cost = \frac{100}{BW} \right]$ Mbps

وممكن عن طريق ال Cost أو ضل

وهذا جدول يحتوي على قيم cost الشهيرة

$$Cost = \frac{10^8}{BW} = \frac{100}{BW(Mbps)}$$

56 K	= 1785
64 K	= 1562
T1 [1.544 M]	= 65
E1 [2.048 M]	= 48
ethernet [10 M]	= 10
Fast ethernet	= 1

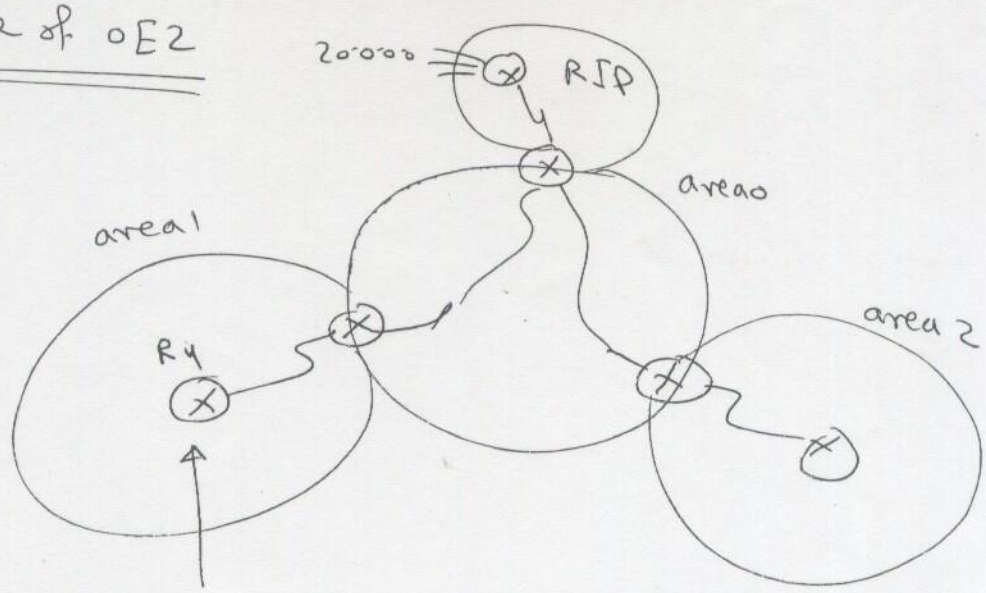
OSPF external route types

- OSPF supports two classifications of external routes

Ⓐ **E2 (default)**: cost of route remains the same as it passes through the autonomous system

Ⓑ **E1**: cost of route increments as it passes through the autonomous system

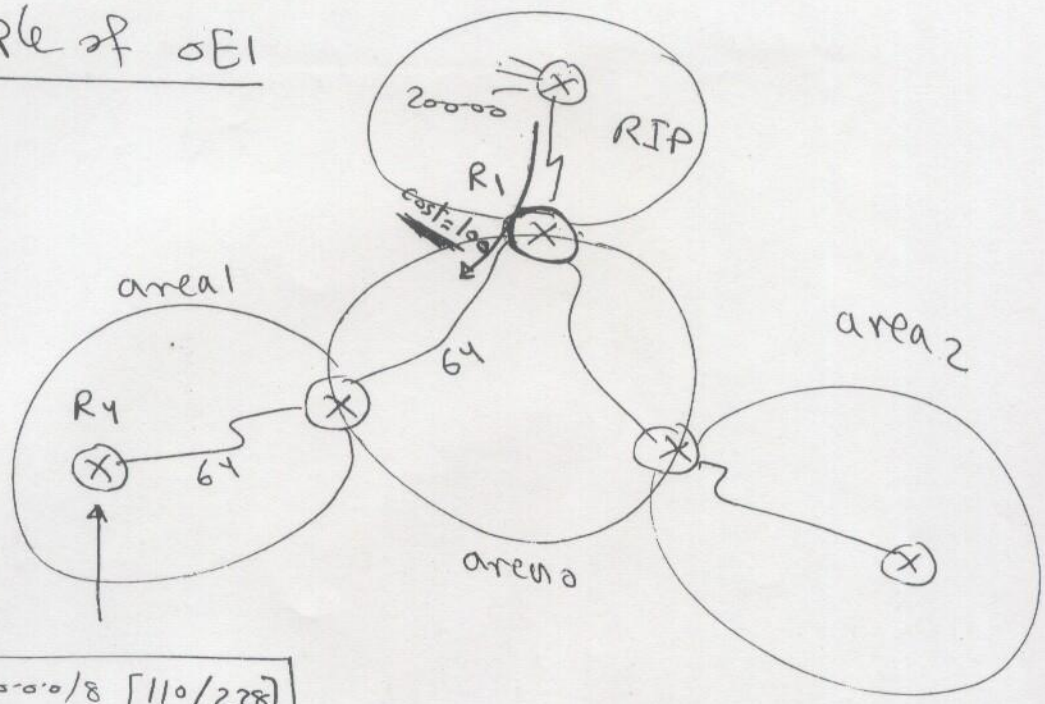
example of OE2



OE2 | 20.0.0.0 [110/20] |

→ The default metric of external route is OE2 and = 20

#example of OE1



OE1 [200.0.0.0/8 [110/228]] → cost = 100 + 64 + 64 = 228

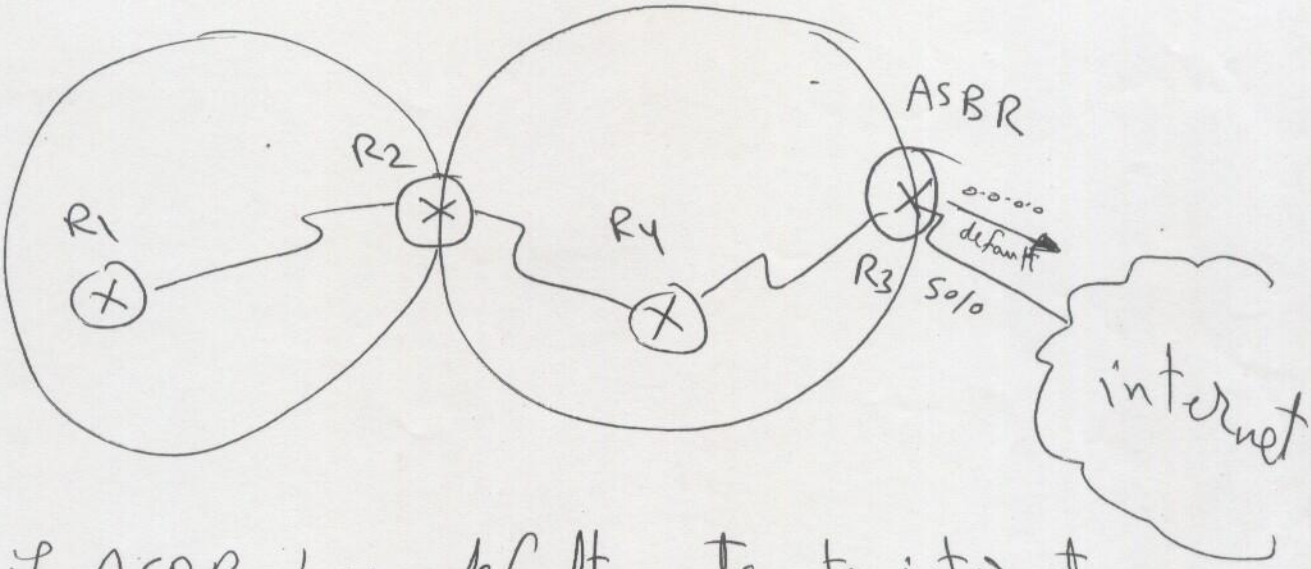
R1 (config) # router ospf 1

↑ ASBR

router) # redistribute rip subnets metric 100

→ metric-type 1

Default information originate



- if ASBR has a default route to internet and we want to propagate This default route to all routers in our area's

```
R3 (config) # IP route 0.0.0.0 0.0.0.0 S0/0
(config) # router ospF 1
        router) # default-information originate
```

ASBR

→ if you didn't want t write default route command

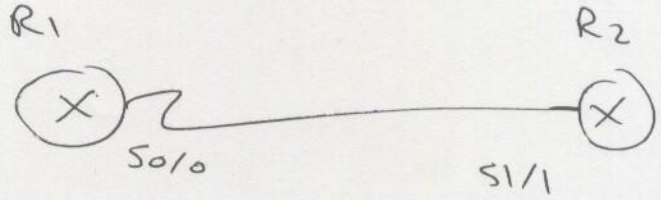
```
R3 (config) # router ospF 1
        router) # default-information originate always
```

ASBR

R1 # sh IP route

* -

OSPF authentication



1 easy way athentication

```
R1 (config) # int s0/0
        if) # IP ospf authentication
        if) # IP ospf authentication-key ----a1
```

ثم نفذ نفس الأمر بيم السابقيم على R2 على S1/1

2 message digest authentication

```
R1 (config) # int s0/0
        if) # ip ospf authentication message-digest
        if) # ip ospf message-digest-key 1 md5 ----a1
```

ثم كرر نفس الأمر بيم السابقين على R2 على الفتحة S1/1

OSPF Route Filtering

- OSPF advertise LSA's not routes
- inside an area, all routers must know all LSAs or Routing Loops could occur
- so, OSPF does not allow The Filtering of LSAs inside an area

⇒ Filtering using Distribute-list

- ACL
- Prefix-list
- route MAP

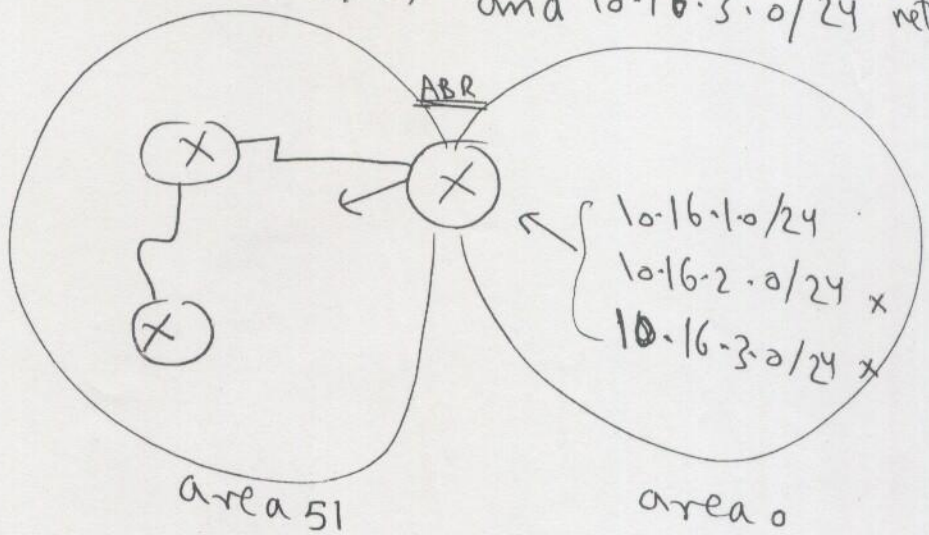
→ same logic as we did eigrp

→ only in direction works For Filtering

⇒ "The Best way to filter routes in OSPF is "Filterlist"

hint: "Filter routes between Networks by ABR"

example: prevent area 51 users from access 10.16.2.0/24 and 10.16.3.0/24 networks



ABR (config)# IP prefix-list ahmed deny 10.16.2.0/24
(config)# IP prefix-list ahmed deny 10.16.3.0/24
(config)# IP prefix-list ahmed permit 0.0.0.0/0 le 32
(config)# router ospf 1
(router)# area 51 filter-list prefix ahmed in

أى إمنع تلك الشبكات من الدخول area 51

in: IOS filters prefixes being created and floaded into the configured area

another solution

ABR (config)# IP prefix-list ahmed deny 10.16.2.0/24

(config)# IP prefix-list ahmed deny 10.16.3.0/24

(config)# IP prefix-list ahmed permit 0.0.0.0/0 Le32

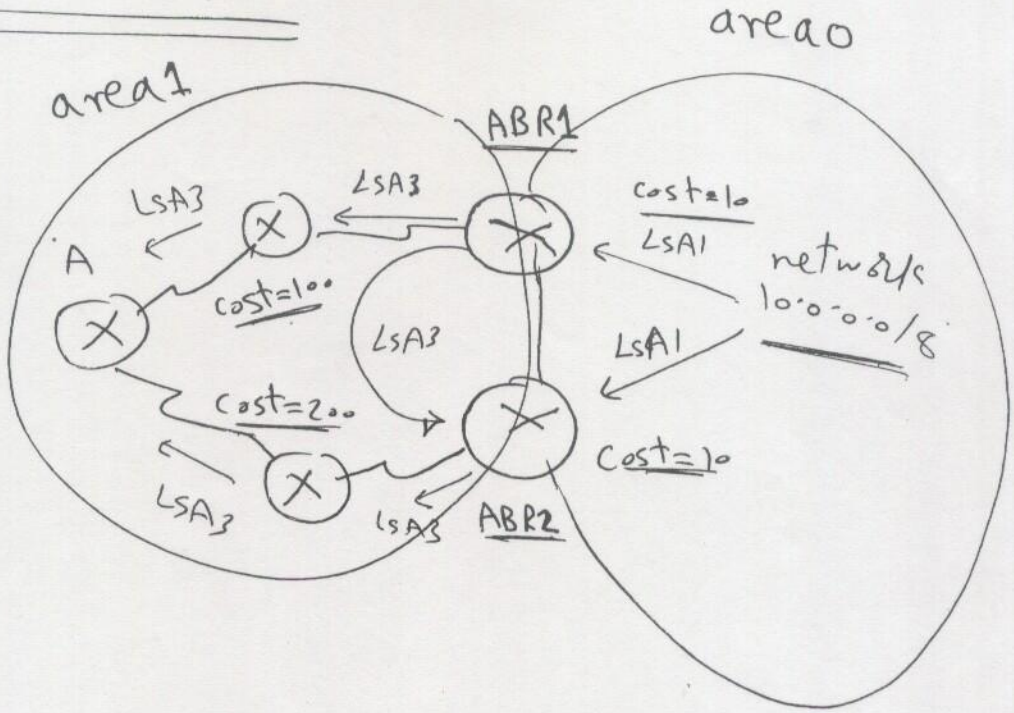
(config)# router ospf 1

router)# area 0 Filter-list prefix ahmed out

امنع تلك الشبكات من الخروج من area 0

out: IOS filters prefixes coming out of the configured area

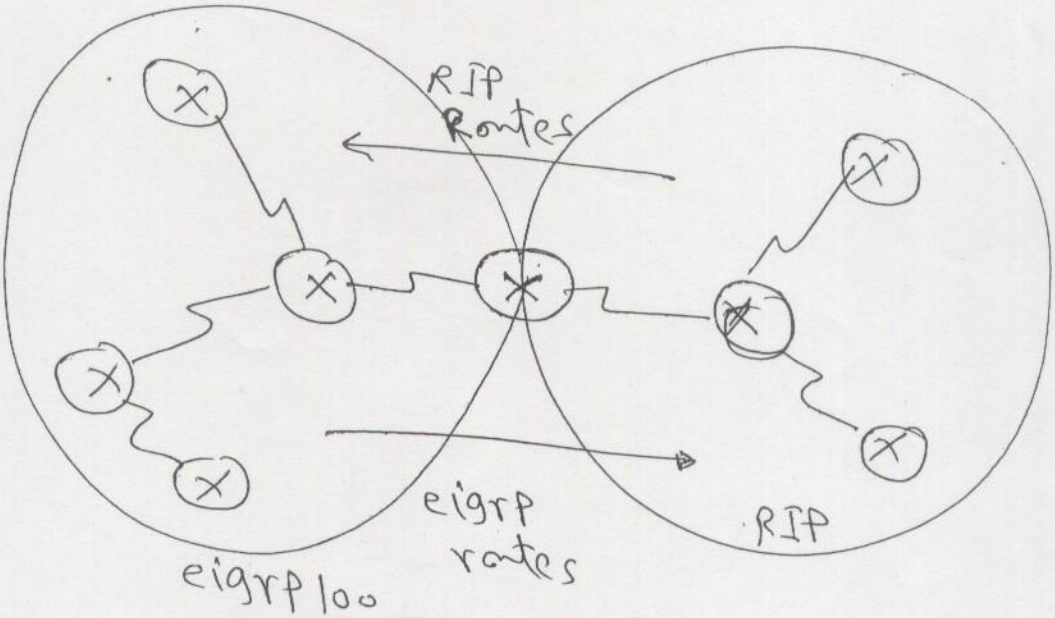
multiple ABR's



- Router A has 2 ways to reach network 10.0.0.0 he will choose the way with lowest metric [The above way]

- Router ABR1 will send type 3 LSA to all routers in area1, so ABR2 will receive another way to network 10.0.0.0
- Router ABR2 will learn LSA3 comes from area0 only and will ignore LSA3 comes from area1

Route Redistribution



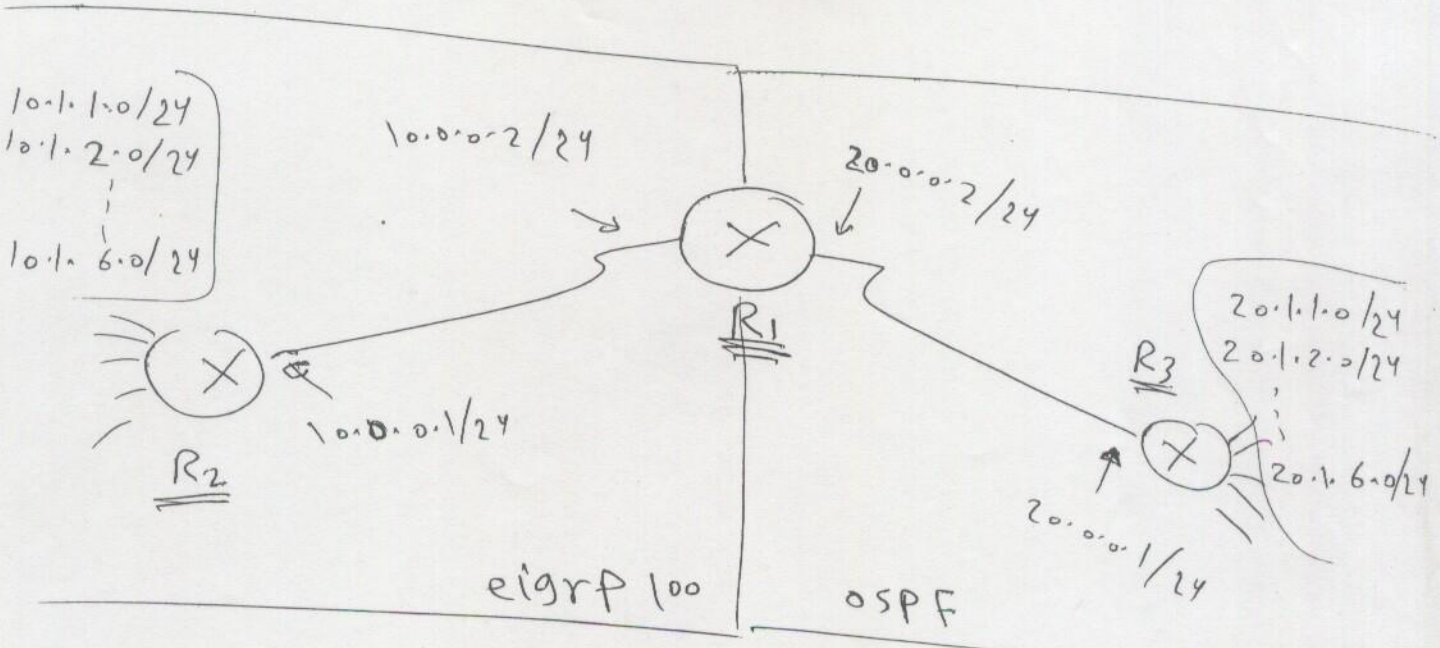
- Route redistribution: The process of exchanging routing information between routing protocols

for example: Routes learned from a RIP process may need to be imported into an eigrp process

→ one-way route redistribution: one protocol receives the The routes from another

→ two-way route redistribution: both protocols receive routes from each other

example



R2(config) # router eigrp 100

router) # network 10.0.0.0

) # no auto-summary

R3(config) # router ospf 1

router) # network 20.0.0.0 0.255.255.255 area 0

R1 (config) # router eigrp 100

router) # network 10.0.0.0 0.0.0.255

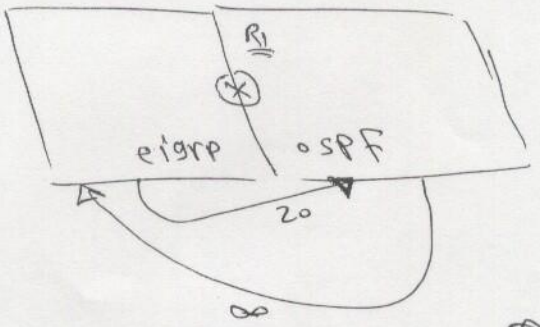
router) # no auto-summary

(config) # router ospf 1

router) # network 20.0.0.2 0.0.0.0 area 0

يستطيع الراوتر R1 أن يرى الشبكات 10.1.x.x بال eigrp والشبكات 20.1.x.x بال OSPF

- by default ospF will see external routes [from eigrp] with metric = 20
- by default eigrp will see external routes with metric = ∞



① redistribute eigrp into ospF

```
R1(cofig)# router ospF 1
  router)# redistribute eigrp 100 subnets
```

- سوف يكون ال metric = 20 وهكذا إنت تغير قيمة ال metric

```
  router)# redistribute eigrp 100 subnets metric 100
```

- وهكذا كمان تضيف ال metric الداخلة [O E1]

```
  )# redistribute eigrp 100 subnets metric 100 metric-type 1
```

---

② redistribute ospF into eigrp

```
R1(cofig)# router eigrp 100
  router)# redistribute ospf 1
```

سوف يتم إرسال ال ospF routes بقيمة metric = ∞ ولكن R2 أي شيء

```
  router)# redistribute ospf 1 metric 1000 33 255 1 1500
```

metric ← ترتيبها هذه هي قيم حتى تكون هناك قيمة لل metric — BW, delay, reliability, load, MTU

فيستطيع R2 أن يرى ospf routes

R2 # sh ip routes

```
DEX    20.0.0.0   [170-22131217]
DEX    20.1.1.0   [170-22173513]
```

admin distance

→ we want R3 ~~see~~ only sees odd numbered loopback networks coming from R2

```
R1 (config) # access-list 1 permit 10.1.1.0 0.0.0.255
R1 (config) # access-list 1 permit 10.1.3.0 0.0.0.255
R1 (config) # access-list permit 10.1.5.0 0.0.0.255
(config) # router ospf 1
    router) # distribute-list 1 out
```

→ implement a route-map filtering in such a way that the eigrp domain doesn't see networks → 20.1.1.0/24, 20.1.2.0/24, 20.1.3.0/24 coming from R_3

```
R1 (config)# IP prefix-list ali deny 20.1.1.0/24
R1 (config)# IP prefix-list ali deny 20.1.2.0/24
R1 (config)# IP prefix-list ali deny 20.1.3.0/24
R1 (config)# IP prefix-list ali permit 0.0.0.0/0 Le 32
R1 (config)# route-map ahmed permit
route-map)# match IP address prefix-list ali
R1 (config)# router eigrp 100
router)# redistribute ospf 1 metric 1000 33 255 1 1500
```

→ route-map ahmed

R2 قف

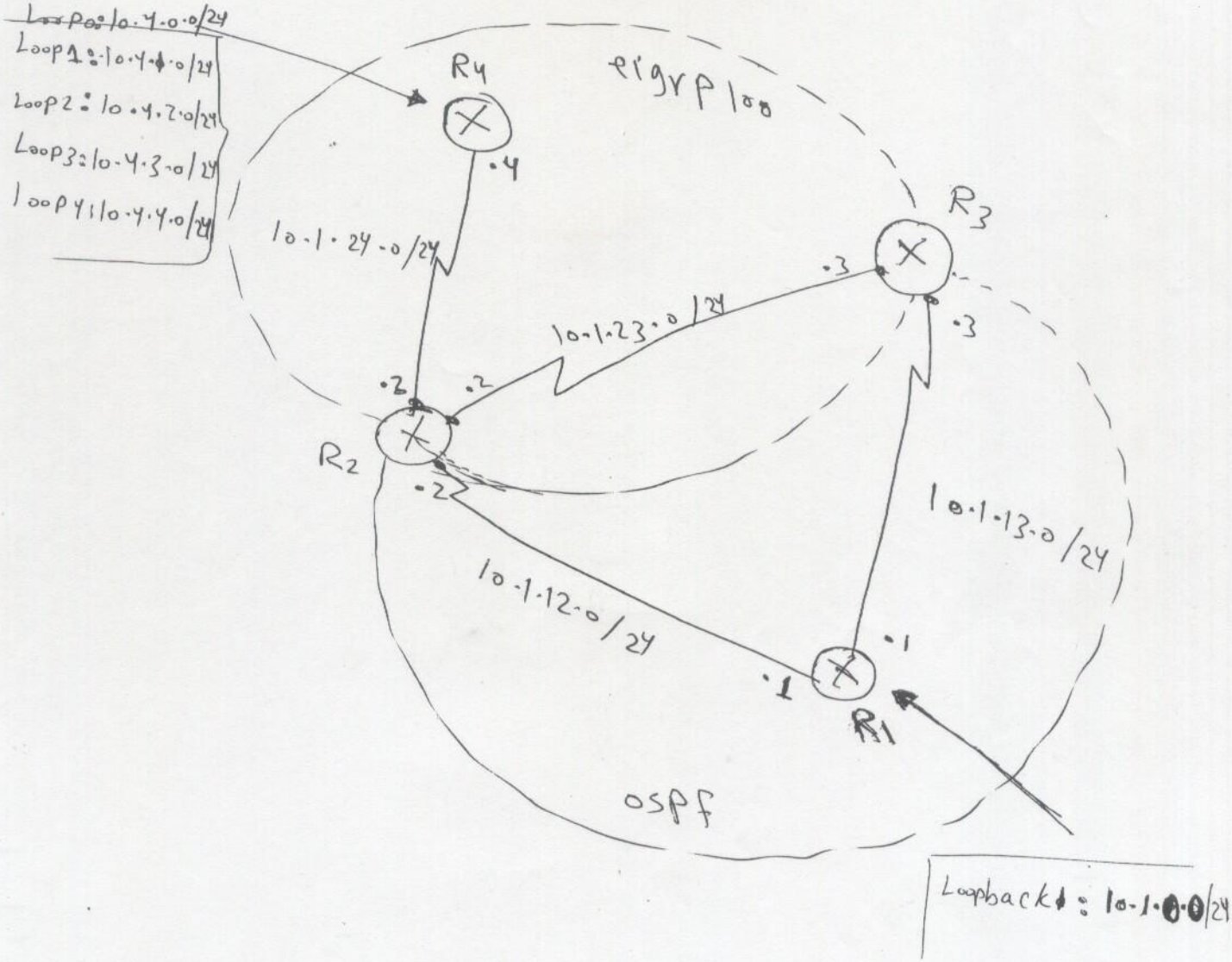
```
R2 # sh IP route
```

← لازم اكتب

20.1.1.0
20.1.2.0
20.1.3.0

X

Advanced Redistribution LAB



objectives

① - configure EIGRP & OSPF for the network shown [use ospf area 0]. advertise all networks on all routers. do not implement any summarization features for eigrp or ospf

- routes should never be advertised in both OSPF and EIGRP routing domains.

R1 (config)# router ospf 1

router) # network 10.0.0.0 0.255.255.255 area 0

R4 (config) # router eigrp 100

router) # network network 10.0.0.0

router) # no auto-summary

R2 (config) # router ospf 1

router) # network 10.1.12.0 0.0.0.255 area 0

router) # router eigrp 100

router) # network 10.1.24.0 0.0.0.255

router) # network 10.1.23.0 0.0.0.255

router) # no auto-summary

R3 (config) # router ospf 1

router) # network 10.1.13.0 0.0.0.255 area 0

router) # router eigrp 100

router) # network 10.1.23.0 0.0.0.255

) # no auto-summary

② enable Full mutual redistribution on R_2 and R_3 between ospF & eigrp. The 10.4.0.0 /24 & 10.4.1.0/24 subnets should have a seed metric of 100 & tag=10 while The 10.4.2.0/24 & 10.4.3.0/24 subnets should have a seed metric of 200 and an ospf tag of 20. all other subnets redistributed into ospF should have a seed metric of 300 and an ospf tag of 30. ospf Routes redistributed into eigrp should have a seed metric of 400 & a tag of 40. finally external ospf routes should not increment Their metric as They pass through The ospf domain

→ ensure The 10.4.4.0/24 network does not reach The ospf Routing domain

hint: eigrp have seed metric of :

BW: 400 & delay: 20 & reliability: 255 & load: 1 & mtu: 1500 & tag of 40

```
R2 (config) #access-list 1 permit 10.4.0.0 0.0.0.255
(config) # access-list 1 permit 10.4.1.0 0.0.0.255
(config) # access-list 2 permit 10.4.2.0 0.0.0.255
(config) # access-list 2 permit 10.4.3.0 0.0.0.255
(config) # access-list 3 permit 10.4.4.0 0.0.0.255
```

```
R2(config) # route-map EIGRP_to_OSPF permit 10
route-map) # match IP address 1
map) # set metric 100
map)# set tag 10
```

```
R2(config) # route-map EIGRP_to_OSPF permit 20
route-map) # match IP address 2
map ) # set metric 200
map) # set tag 20
```

```
R2 (config) # route-map EIGRP_to_OSPF permit 40
route-map) # set metric 300
-map) # set tag 30
```

~~لا يوجد match~~

لا يوجد match

وهنا يعني match everything

```
R2(config) # route-map EIGRP_to_OSPF deny 30
map) # match IP address 3
```

حتى تمنع الشبكة 10.4.4.0

عالم تكرار كرة notebad

```
R2(config)#router ospf 1
    router)#redistribute eigrp 100 subnets route map EIGRP_to_ospf
```

كرر نفس الأوامر السابقة على R_3 ثم قف على R_1

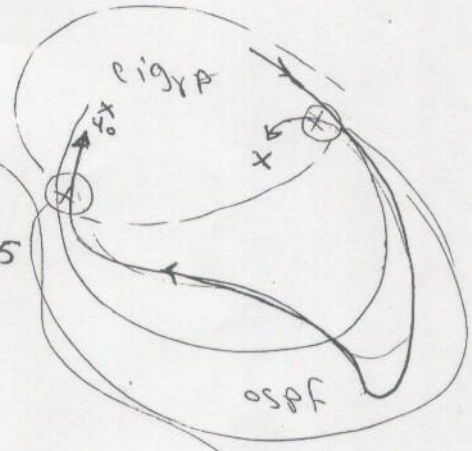
```
R1#sh IP route
```

سوف ترى أنه أصبح يرى الشبكات 10.4.x.x مسارية

```
R2(config)#route-map ospf-to-EIGRP
    map)#set metric 400 20 255 1 1500
    map)#set tag 40
    map)#exit
(config)#router eigrp 100
    router)#redistribute ospf 1 route map ospf-to-EIGRP
```

كرر نفس الخطوات على R_3

③ enable Filtering using The assigned route tags to ensure redistributed routes ~~doe~~ do not cause any Looping issues.



R2 (config) # route-map EIGRP-to-ospf deny 5

route map) # match tag 40

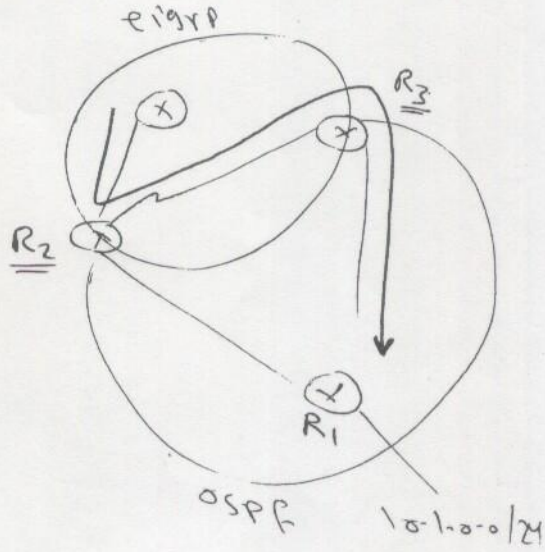
R2 (config) # routemap ospf-to-eigrp deny 5

map) # match tag 10 20 30

↓ default tag if you didn't put a tag

R3 كرر نفس الخطوات على

④ R_3 has The preferred route to reach The 10.1.0.0/24 network. ensure routers prefer This path over The path from R_2



R2(config)# rotereigrp 100

rotter)# distance eigrp 90 105

internal external

ospF=110
eigrp
external =105

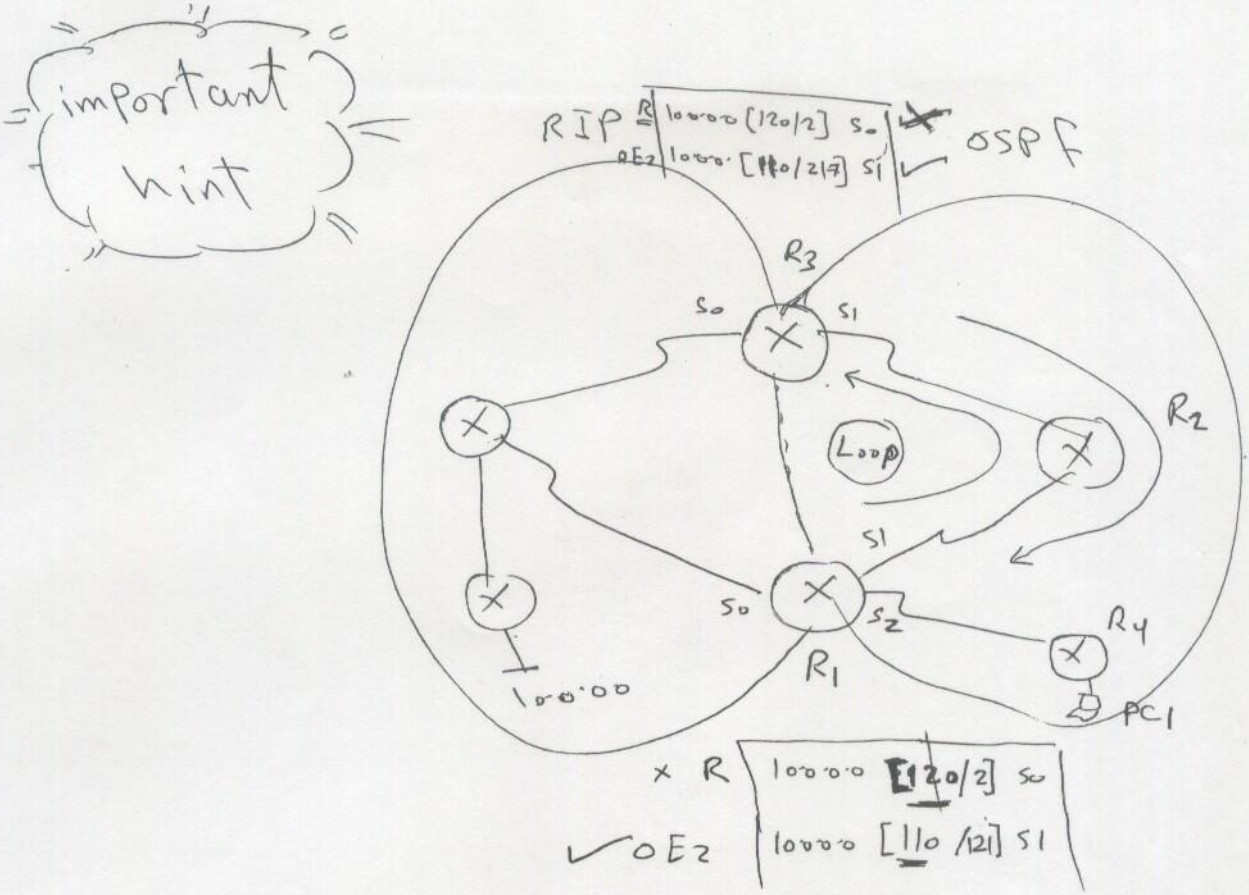
وبالتالي R2 حطيت

extenal admin distance of eigrp from 170 → 105

قمت بتعديل ال

وبالتالي R2 سوف يختار eigrp وبالتالي سوف يرسل

ال data إلى R3 ومن ثم إلى R1



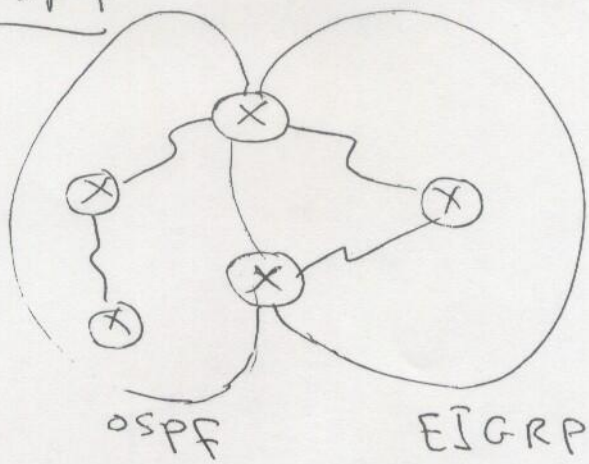
** The Problem : if PC1 want to reach network 10.0.0.0 he will send his traffic to R4 Then R4 will send traffic to R1 , R1 will Look in his Routing table he will find That he can reach to network 10.0.0.0 by 2 Protocols ① RIP with admin distance = 120 & ② ospf with admin distance = 110, so he will choose ospF [lowest admin distance], so R1 will forward traffic to R2 , and R2 will send it to R3 , R3 will look in his Routing table and will choose ospf Routing Protocol , so he will send traffic to R2 to R1 "Loop occurs"

* solution :

internal admin distance	<	external admin distance

لو حققت هذا

① EIGRP & OSPF



internal admin distance	<	external admin distance

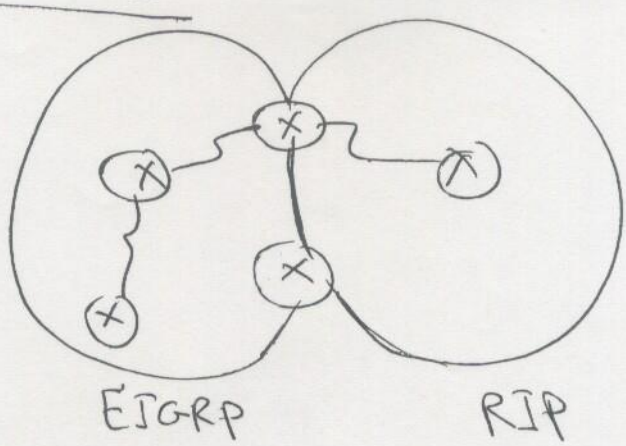
لو تحقق هذا الشرط لا يحدث Loop

∵ ospf internal AD = 110 [<] EIGRP external AD = 170

∵ EIGRP internal AD = 90 [<] ospf external AD = 110

في هذه الحالة لا يحدث Loop

② EIGRP & RIP



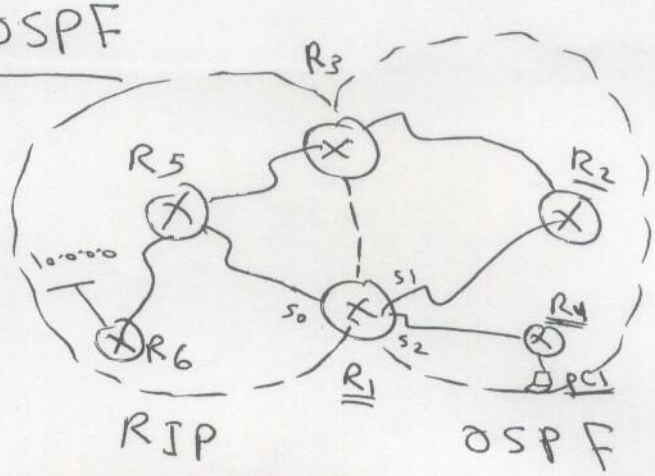
EIGRP internal AD = 90 $\boxed{<}$ RIP external AD = 120

RIP internal AD = 120 $\boxed{<}$ EIGRP external AD = 170

في هذه الحالة لا يحدث Loop

لأن الشرط تحقق

③ RIP & OSPF



ospf internal AD = 110	<	RIP external AD = 120 (good)
RIP internal AD = 120	>	ospf external AD = 110 (bad)

هنا إختل الشرط وبالتالي سوف يحدث Loop

* و للتغلب على هذا الـ Loop يمكن أن نلعب في قيمة الـ admin distance "فمثلا" لو أردنا أن يخرج الـ traffic من

PC1 ⟵ R4 ⟵ R1 ⟵ R5 ⟵ R6 ⟵ 10.0.0.0 "

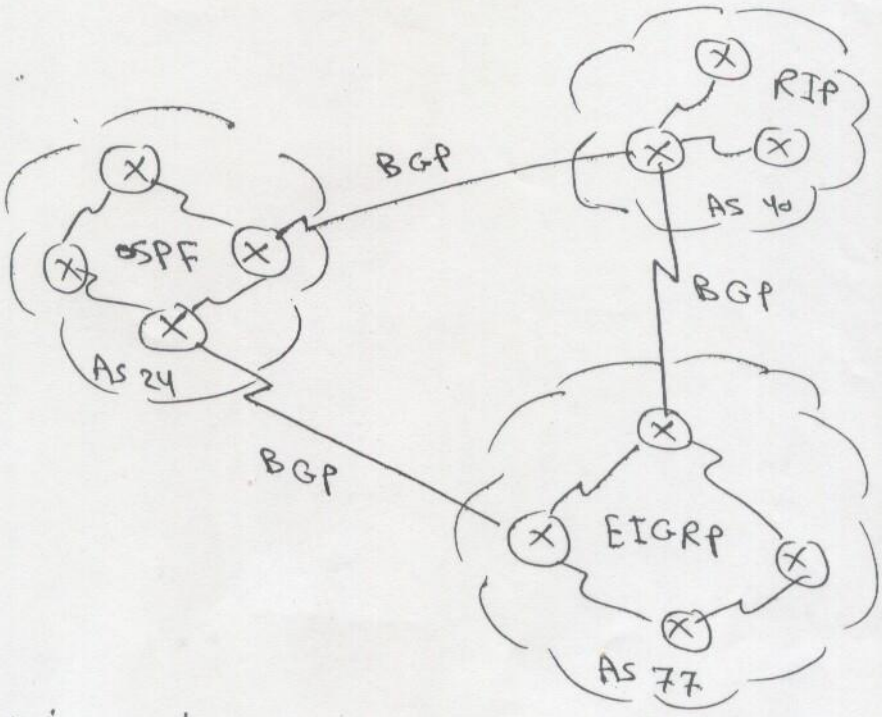
قف على R1

```
R1 (config)# router ospf 1
R1 (config-Router)# distance ospf external 130
```

∴ ospf internal (110) < RIP external (120) (good)
RIP internal (120) < ospF external (130) (good)

وبالتالي لن يحدث Loop

BGP [Border gateway protocol]



- IGP [interior gateway protocol]

- Routing protocol used to exchange routing information within an autonomous system. [RIP, EIGRP, OSPF]

- EGP [Exterior gateway protocol]

- Routing protocol used to exchange routing information between autonomous systems

ex BGP [is a path vector Routing protocol]

- AS [autonomous system]

- a set of Routers under The single technical administration

Autonomous system overview

AS: a group of Routers That share similar routing Policies and operate within a single administrative domain

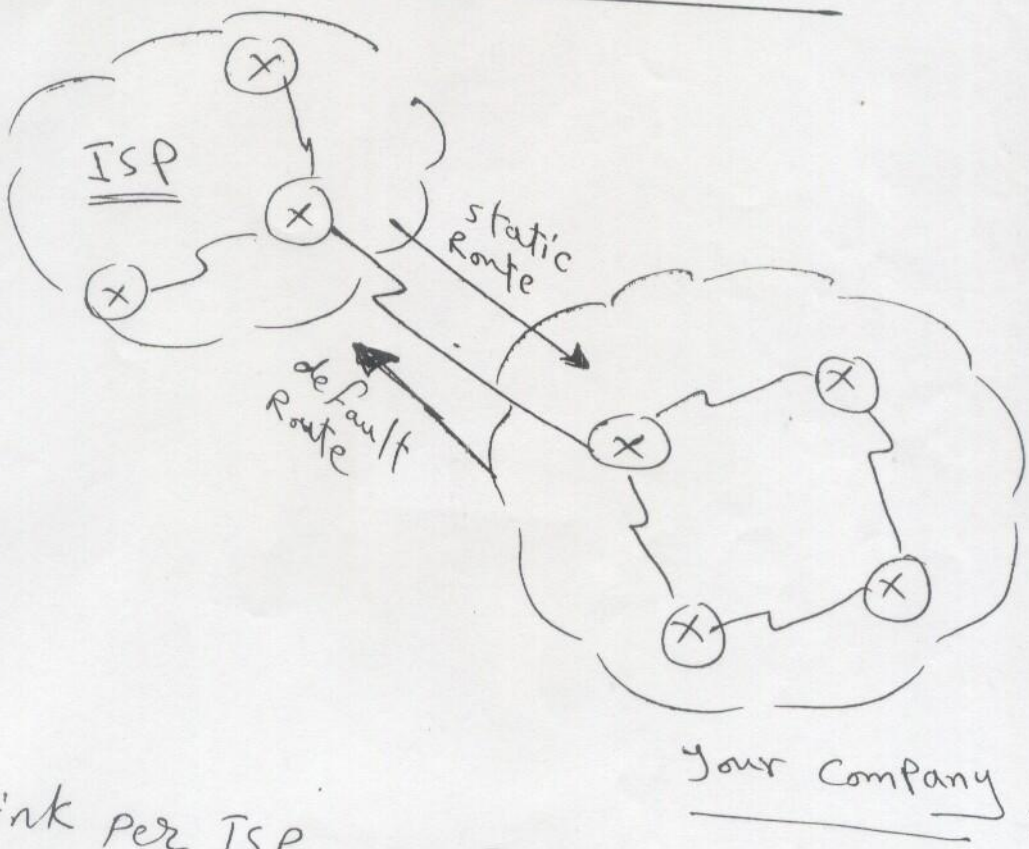
AS numbers

- assigned by service Provider
- between 1 and 65535
- 0 → reserved
- 1 through 64495 → assignable for public use
- 64512 through 65535 → Private use
- 64535 → reserved

hint: because of The finite number of available AS numbers, an organization must present justification of its need before it will be assigned an AS number

Autonomous system types

1 single homed autonomous system

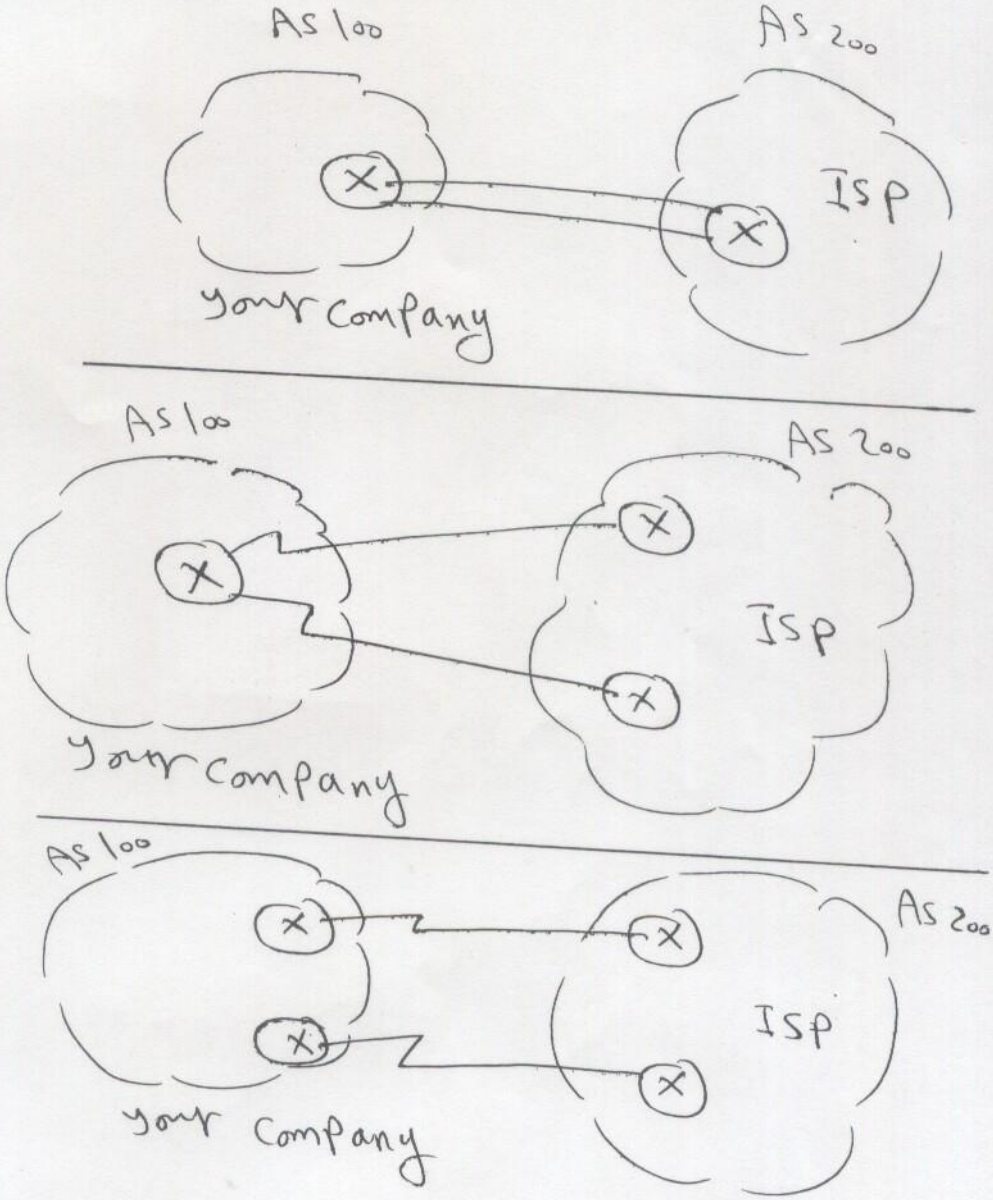


- one link per ISP, one ISP
- only one exit point to outside networks
- often referred to as stub networks
- usually use a default route to handle all traffic destined for non-local networks

hint ① BGP is <u>not</u> normally <u>need</u> in this situation

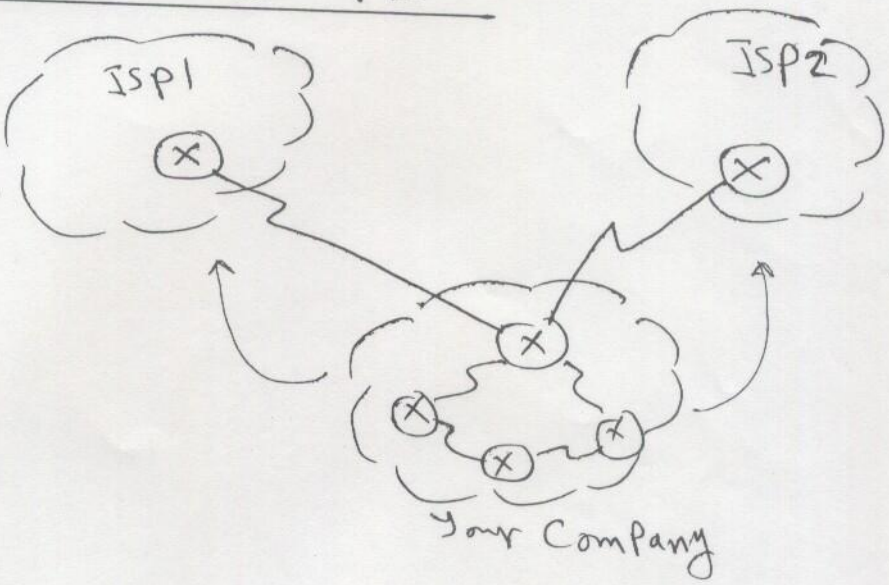
② no need to use public AS number for <u>your Company</u>
just you can use private AS number [illegible]

2 Dual homed AS



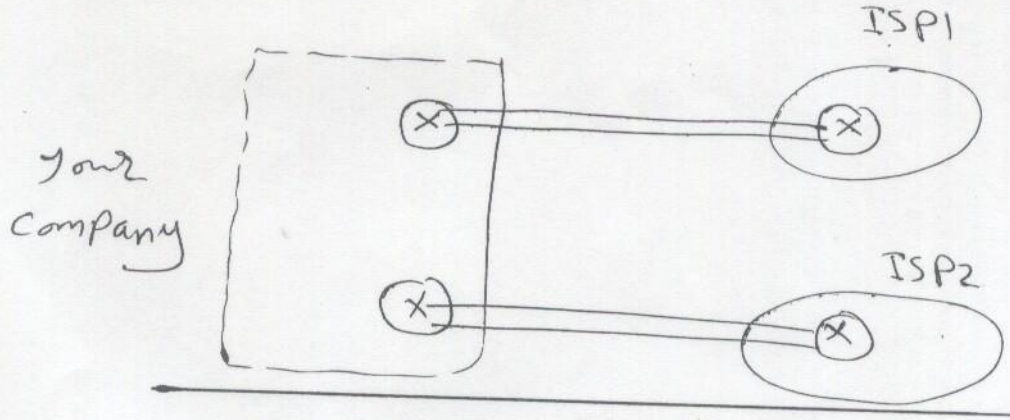
- two or more link per ISP, one ISP
- same options as single-homed
- use both paths with each path acting as a backup

3 single multi-homed As

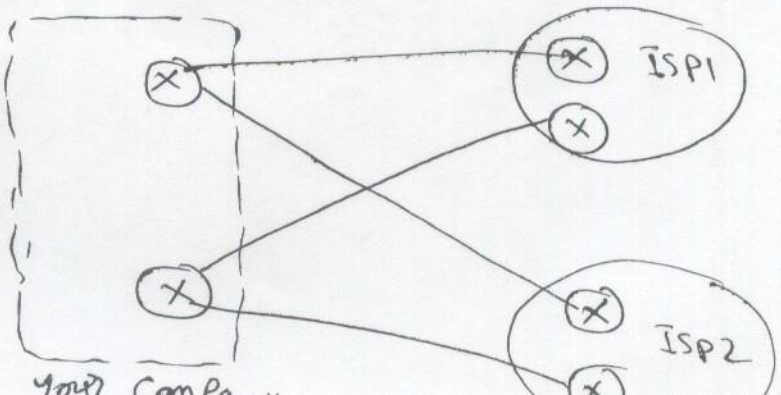


- one link per ISP, two or more ISPs
- typically recommended to run BGP

4 Dual multi-homed

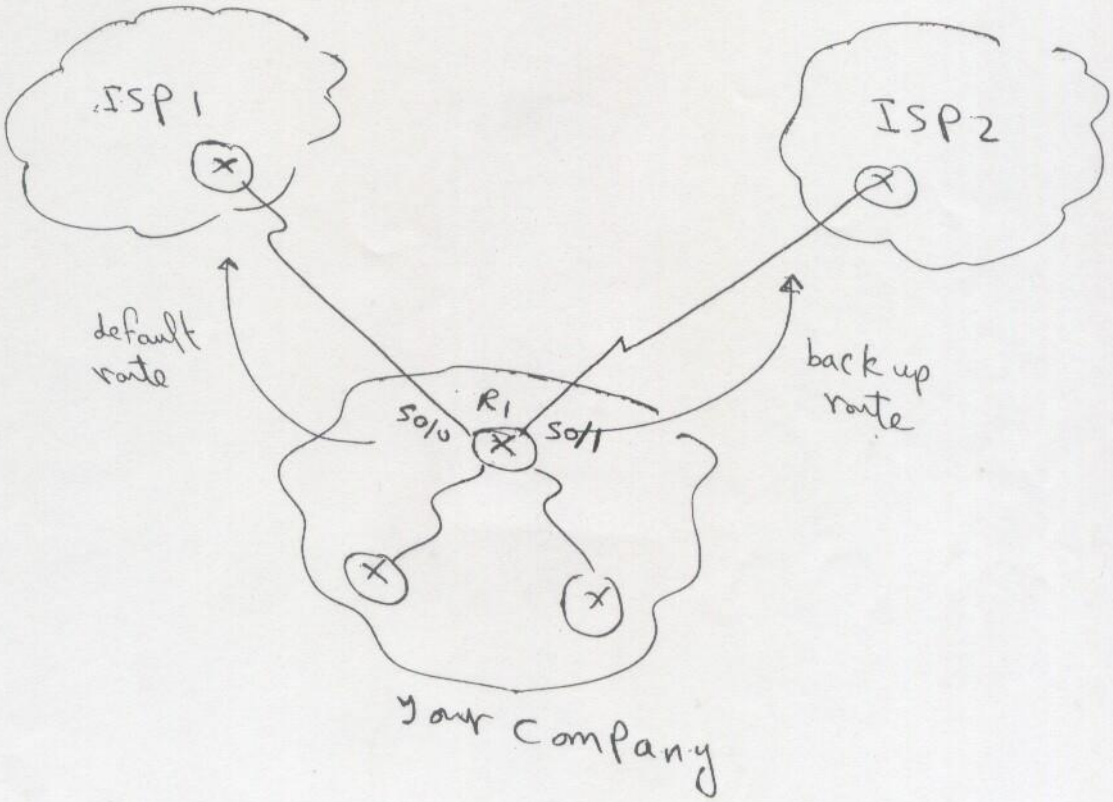


- two or more links per ISP, two or more ISP's



Styles of BGP implementations

style ① [defaultroute]



- your company [As] is connected to two ISP's, you can made one link as a default route, and the other as a back up link

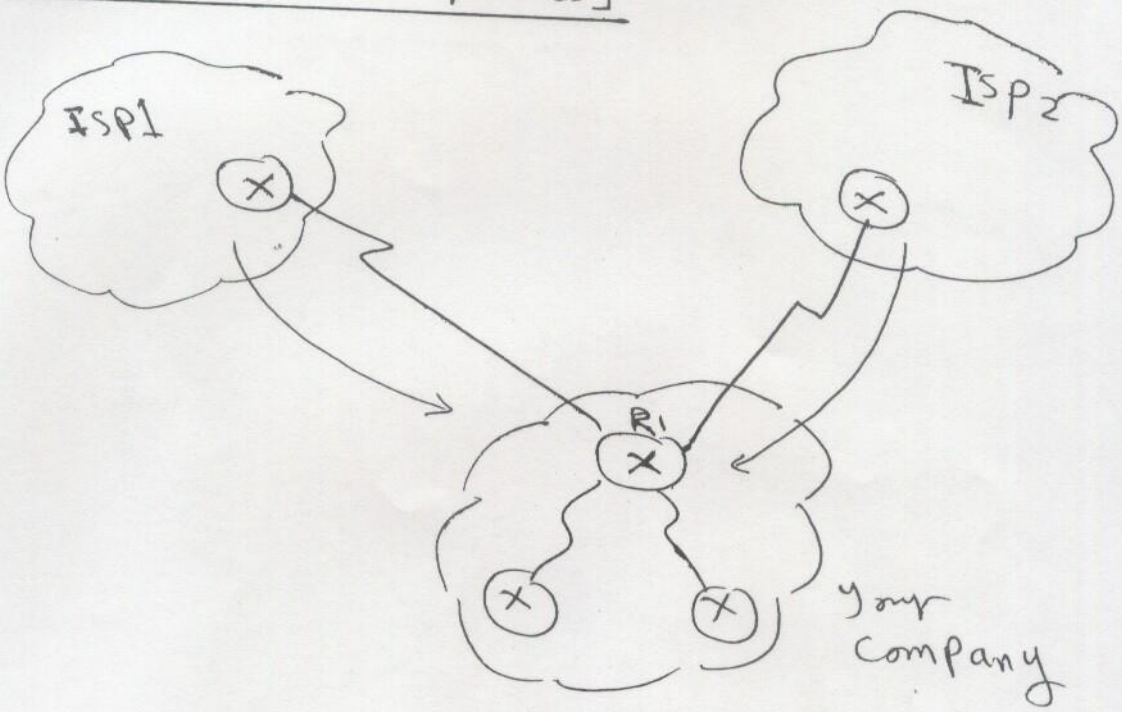
R1(Config)# IP route 0.0.0.0 0.0.0.0 S0/0

R1 (Config)# IP route 0.0.0.0 0.0.0.0 S0/1 5

distance metric of route

والأفضل من ذلك أن تقوم بتشغيل الـ BGP حتى تستطيع
أن تقوم بعمل إرسال للشبكات التي تقع داخل AS الخاص بك
إلى الـ ISP's وأيضاً إذا كان هناك مسار أقصر من الآخر
فتقوم بالإرسال من خلاله.

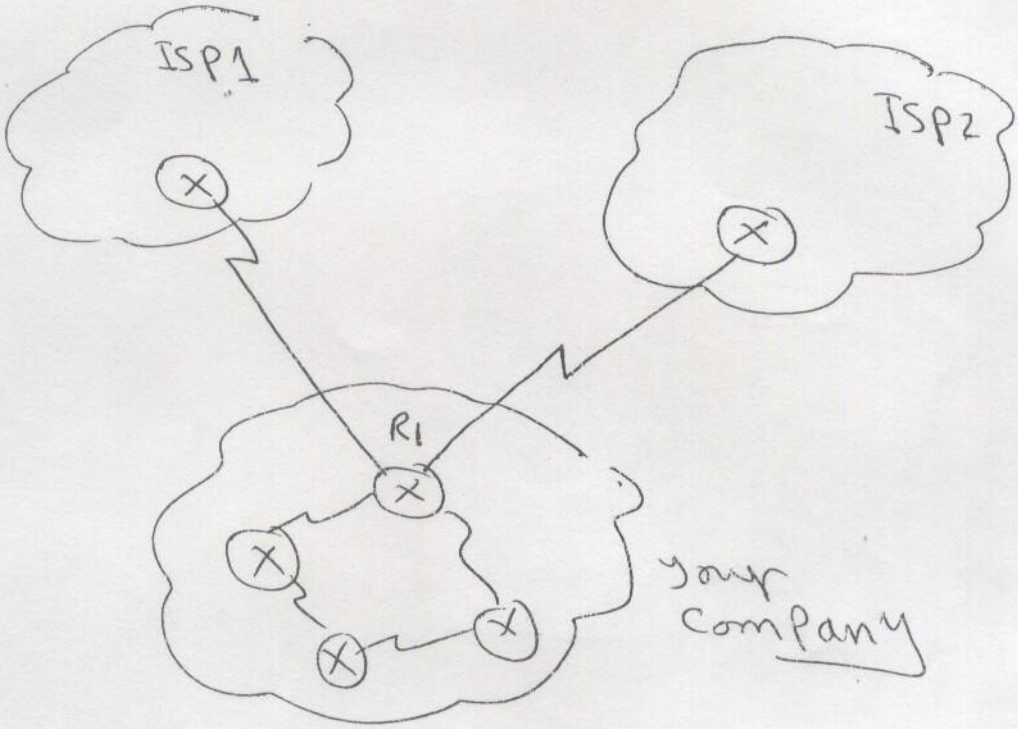
style ② [Full updates]



- R_1 will receive all updates from ISP1 & ISP2
so, R_1 memory will be huge

هذا يعتبر أفضل style ولكن يعيبه ضخامة ال Routing table

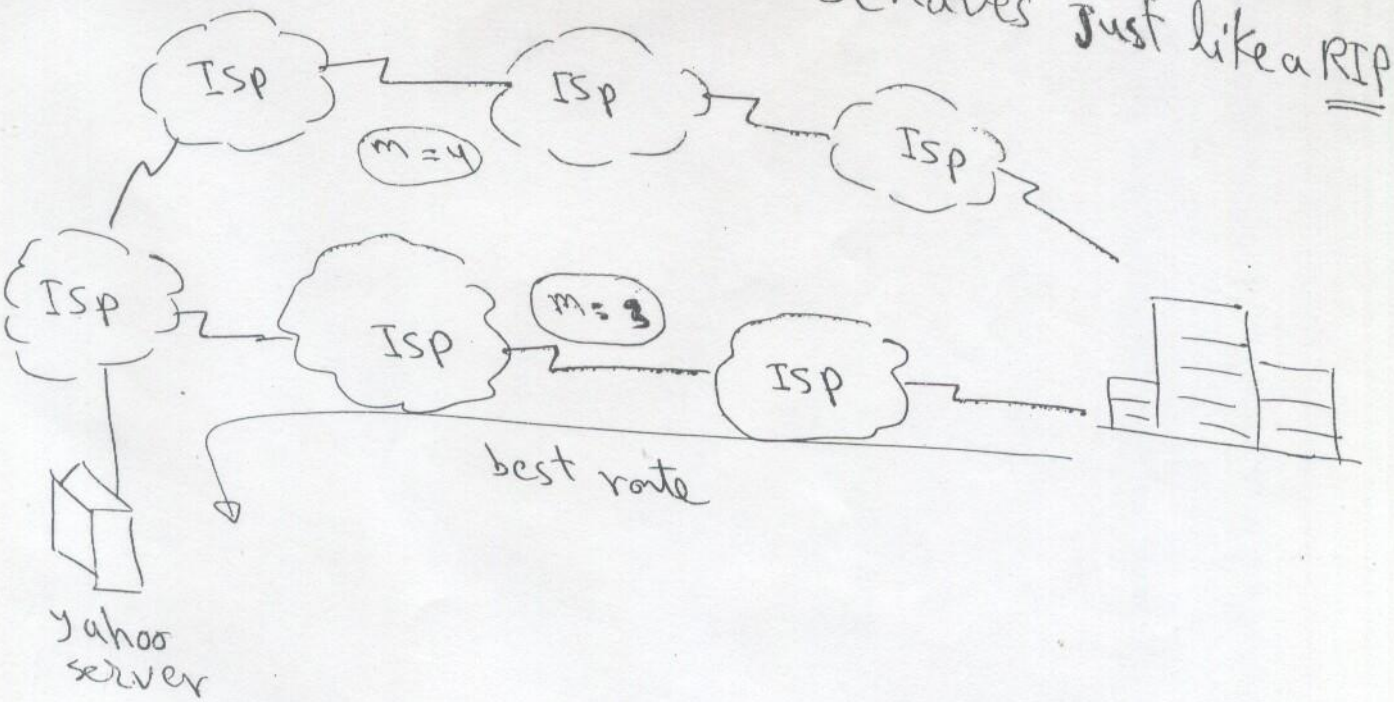
style ③ [partial updates]



- if R1 runs BGP Protocol he will receive all updates from ISP1 & ISP2, so Routing table will be huge
- to over come The hugness of Routing table you can made a route map on R1 to decrease The size of Routing table and to made R1 use The nearest ISP to reach his target

BGP Routing algorithm

- BGP runs on top of tcp [Port 179]
- TCP used for reliability
- updates are incremental & triggered
- metric is the Biggest you have ever seen
- slowest Routing protocol on the planet to converge
- BGP is technically a distance vector protocol, But most call it a "path vector" protocol
- without tuning, BGP behaves just like a RIP



AS in BGP	=	Router in RIP	=	HOP Count

* BGP packets

① open packet : starts The session

② Keep alive packet : make sure That The neighbor still alive

③ update packet : Network reachability exchange

④ notification packet : some Thing bad has happened and session closed

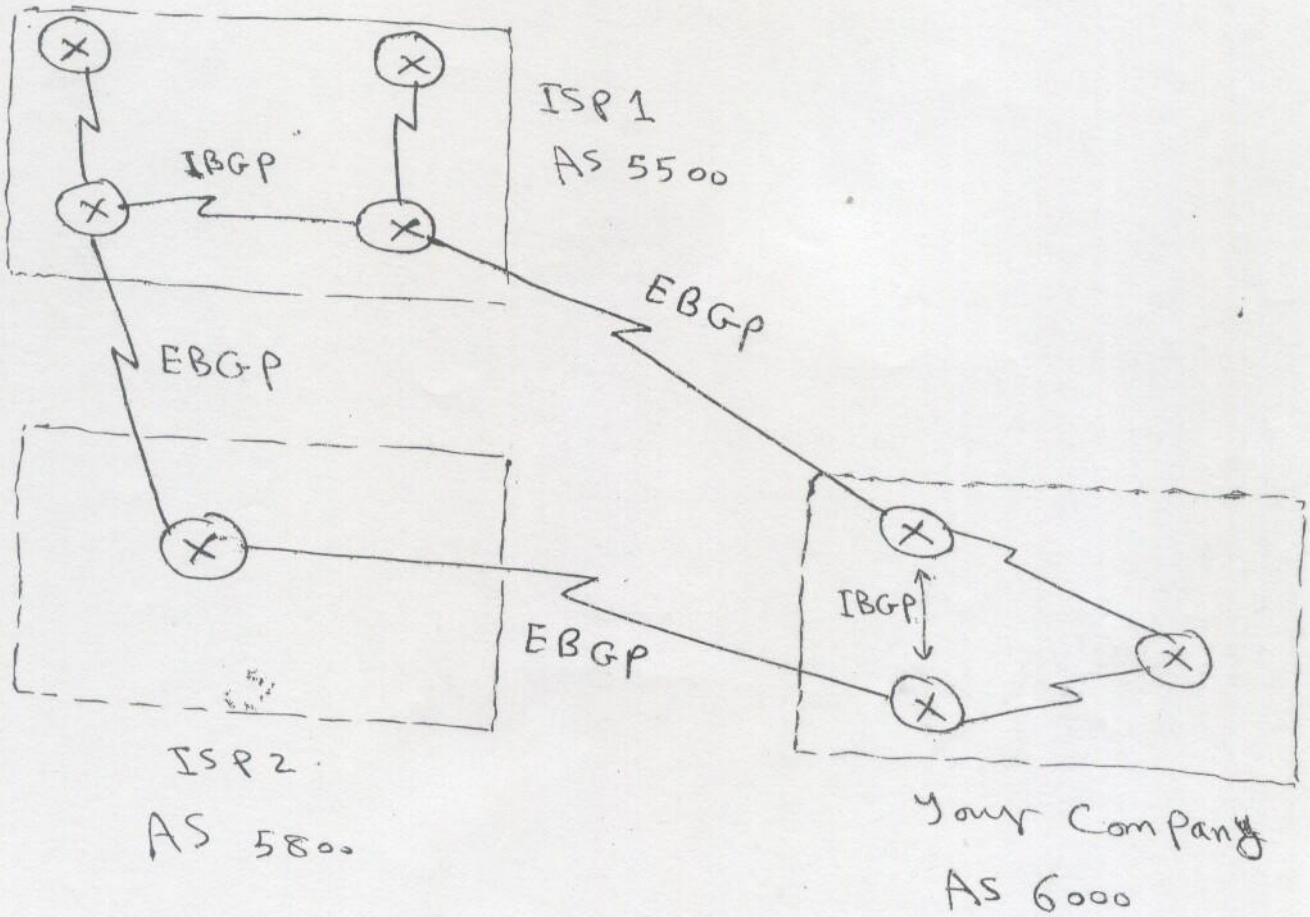
* BGP tables

① neighbor table : The connected BGP friends

② BGP table : list of all BGP routes [can be Big]

③ Routing table : a list of The best routes

understanding IBGP Vs EBGP



IBGP: internal BGP

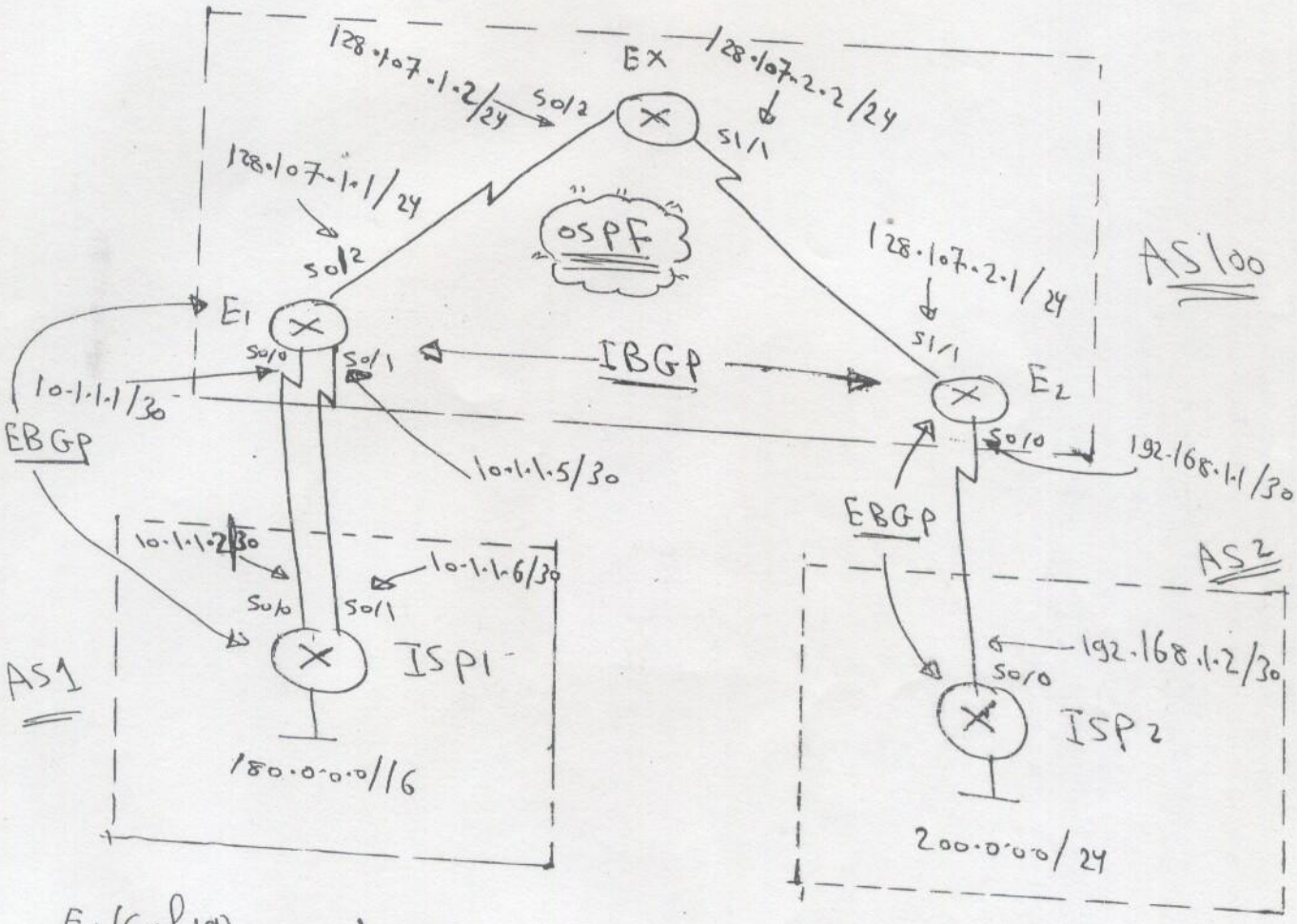
ويكون بين الروتر التي تقع داخل نفس AS

EBGP: external BGP

ويكون بين الروتر التي تقع في AS's مختلفة

BGP configuration

LAB 1



E1(Config) # router bgp 100
router) # neighbor 10.1.1.2 remote-as 1
router) # neighbor 10.1.1.6 remote-as 1
router) # network 128.107.1.0 mask 255.255.255.0
router) # network 128.107.2.0 mask 255.255.255.0

ملحوظة : كل EBGP router لابد وأن يقوم بإذاعة الشبكة الـ public والتي توجد داخل الـ AS والذي يقع فيه هذا الروتر

ISP1 (config) # router bgp 1
router) # neighbor 10.1.1.1 remote-as 100
router) # neighbor 10.1.1.5 remote-as 100
router) # network 180.0.0.0

ISP2 (config) # router bgp 2
router) # neighbor 192.168.1.1 remote-as 100
router) # network 200.0.0.0

E2 (config) # router BGP 100
router) # neighbor 192.168.1.2 remote-as 2
router) # network 128.107.1.0 mask 255.255.255.0
router) # network 128.107.2.0 mask 255.255.255.0

والآن قم بعمل IBGP بين E1 و E2

E1 (config) # router bgp 100
router) # neighbor 128.107.2.1 remote-as 100

E2 (config) # router bgp 100
router) # neighbor 128.107.1.1 remote-as 100

E1 # sh IP bgp

```
*> 128.107.1.0
*> 128.107.2.0
*> 180.0.0.0
*i 200.0.0.0
```

valid

*> valid best Route

hint

*i 200.0.0.0 means:
I know about 200.0.0.0 via IBGP but is not the best path.

* configure next-hop-self between E_1 & E_2

E_1(config) # neighbor 128.107.2.1 next-Hop-self

E_2(config) # neighbor 128.107.1.1 next-hop-self

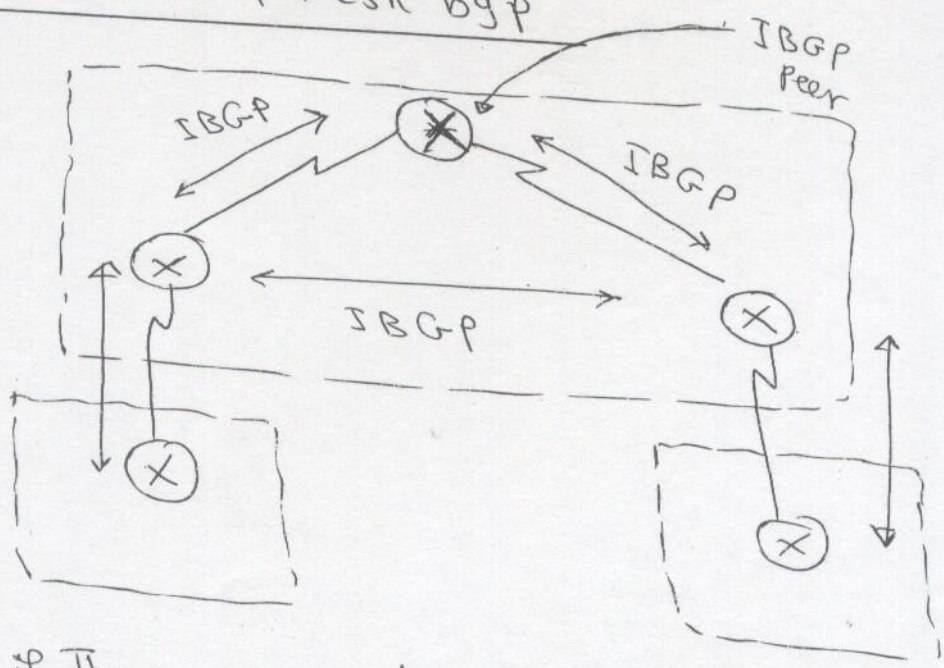
E_1 # sh Ip bgp

*> 200.0.0.0

E_1 # ping 200.0.0.1

.....

* configure Full mesh bgp



hint: if There were routers That were part of ospf domain but not in The path between E_1 & E_2, we would not include Them as an IBGP Peers

أي قمت بعمل IBGP مع الروتر التي ستربط بين E_1 & E_2

E1(Config)# router bgp 100
router)# neighbor 128.107.1.2 remote-as 100
router)# neighbor 128.107.1.2 next-hop-self

E2(Config)# router bgp 100
router)# neighbor 128.107.2.2 remote-as 100
router)# neighbor 128.107.2.2 next-Hop-self

EX (Config)# router bgp 100
router)# neighbor 128.107.1.1 remote-as 100
router)# neighbor 128.107.2.1 remote-as 100

hint: no need to configure next-Hop-self because he is not an EBGP peers

---

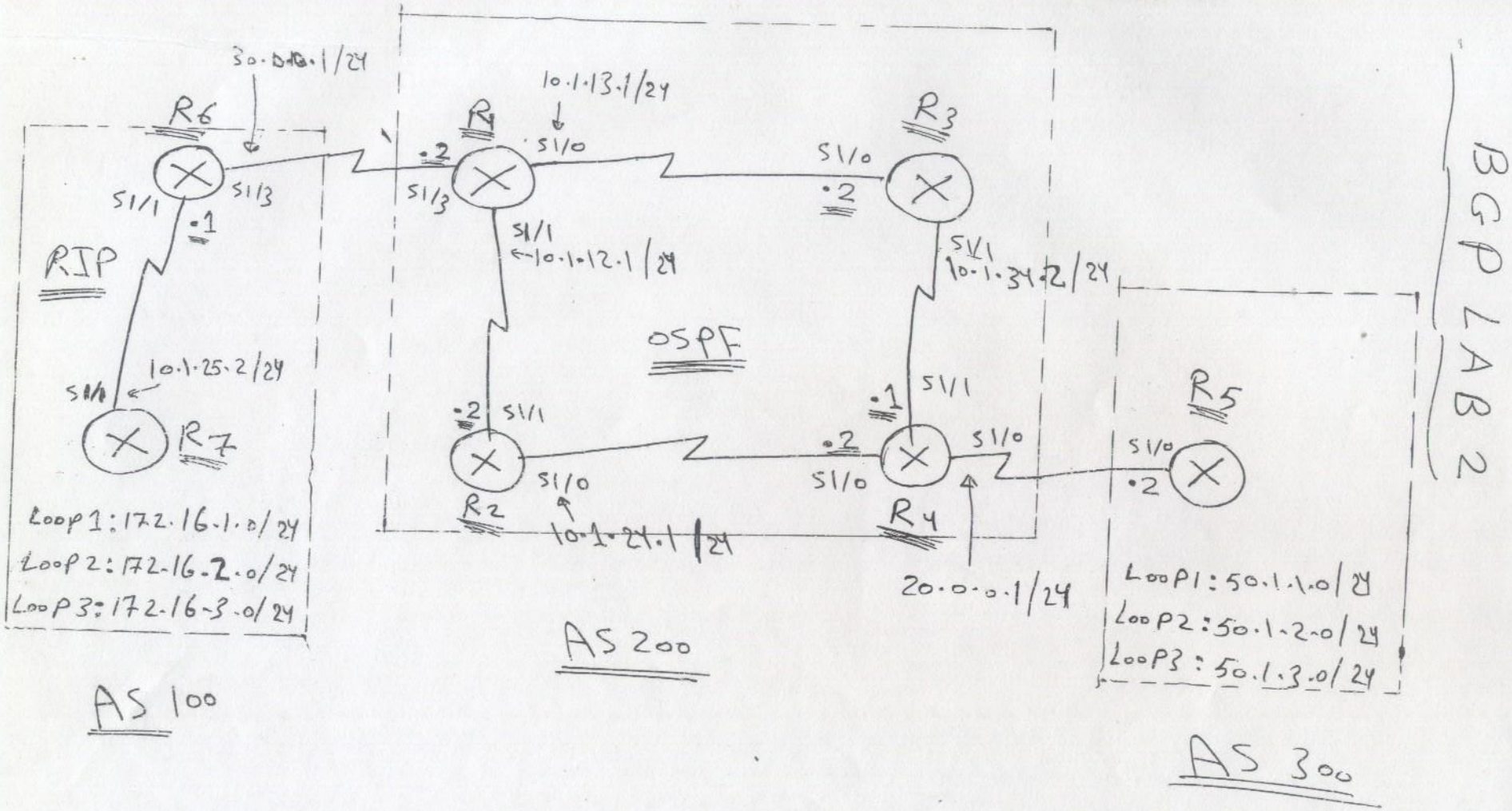
ISP 2 # ping 180.0.0.1

. . . .

ISP2 # Ping 180.0.0.1 source 200.0.0.1

!!!!!

لاحظ ان الشبكات ال public هيشوفوا بعض
أما لو عملت ping من شبكة private فان الشبكات ال public لن ترى



hint : For every router made Loopback 0 with IP of Router name

ex R2 (config) # int Loopback 0

if) # IP address 2.2.2.2 255.255.255.255

① configure the RIP domain and ospf domain

```
R7 (config) # router rip
    router) # version 2
    router ) # no auto summary
    router ) # network 10.0.0.0
    router) # network 172.16.0.0
```

```
R6 (config) # router rip
    router) # version 2
    router) # no auto-summary
    router ) # network 10.0.0.0
```

RIP

OSPF

```
R1 (config) # router ospf 1
    router) # network 10.1.13.1 0.0.0.0 area 0
    router) # network 10.1.12.1 0.0.0.0 area 0
            ) # network 1.1.1.1 0.0.0.0 area 0
```

```
R2 (config) # router ospf 1
    router) # network 10.1.12.2 0.0.0.0 area 0
    router ) # network 10.1.24.1 0.0.0.0 area 0
            ) # network 2.2.2.2 0.0.0.0 area 0
```

```
R3 (config) # router ospf 1
    router) # network 10.1.13.2 0.0.0.0 area 0
    router ) # network 10.1.34.2 0.0.0.0 area 0
            ) # network 3.3.3.3 0.0.0.0 area 0
```

```
R4(config)# router ospf 1
    router)# network 10.1.34.1 0.0.0.0 area 0
    router)# network 10.1.24.2 0.0.0.0 area 0
    router)# network 4.4.4.4 0.0.0.0 area 0
```

---

② Configure EBGP between R4 & R5 using Loopback interfaces

```
R4(config)# router bgp 200
    router)# neighbor 5.5.5.5 remote-as 300
    router)# neighbor 5.5.5.5 update-source Loopback 0
    router)# neighbor 5.5.5.5 ebgp-multihop 2
```

أى أنك لا تنفذ الأمر فقط حتى تصل لـ 5.5.5.5

```
    router)# exit
R4(config)# IP route 5.5.5.5 255.255.255.255 20.0.0.2
```

حتى تجعل R4 يستطيع الوصول (R5 5.5.5.5)

next hop IP

```
R4(config)# router bgp 200
    router)# network 10.1.34.0 mask 255.255.255.0
    )# network 10.1.24.0 mask 255.255.255.0
    )# network 10.1.13.0 mask 255.255.255.0
    )# network 10.1.12.0 mask 255.255.255.0
```

redistribute OSPF ⇐ علشان تعمل

هنا R4 يعتبر EBGP Router فلا بد أن يذيع عن الشبكات الـ public والتى توجد داخل الـ AS الذى يقع فيه

```
R5 (config) # router bgp 300
    router) # neighbor 4.4.4.4 remote-as 200
    router) # neighbor 4.4.4.4 update-source Loopback 0
    router) # neighbor 4.4.4.4 ebgp-multihop 2
    router) # network 50.1.1.0 mask 255.255.255.0
    router) # network 50.1.2.0 mask 255.255.255.0
    router) # network 50.1.3.0 mask 255.255.255.0
        # exit
(config) # IP route 4.4.4.4 255.255.255.255 20.0.0.1
```

---

③ Configure EBGP between R1 & R6 using Loopback interfaces

```
R1 (config) # router bgp 200
    -router) # neighbor 6.6.6.6 remot-as 100
    -router) # neighbor 6.6.6.6 update-source loopback 0
    -router) # neighbor 6.6.6.6 ebgp-multihop 2
    -router) # network 10.1.12.0 mask 255.255.255.0
    -router) # network 10.1.13.0 mask 255.255.255.0
    -router) # network 10.1.34.0 mask 255.255.255.0
    -router) # network 10.1.24.0 mask 255.255.255.0
    redistribute ospf 1 metric
R1 (config) # IP route 6.6.6.6 255.255.255.255 30.0.0.1
```

```
R6(config)# router bgp 100
    router)# neighbor 1.1.1.1 remote-as 200
    router)# neighbor 1.1.1.1 update-source Loopback0
    router)# neighbor 1.1.1.1 ebgp-multi-hop 2
    router)# network 10.1.25.0 mask 255.255.255.0
    router)# network 172.16.1.0 mask 255.255.255.0
    router)# network 172.16.2.0 mask 255.255.255.0
    router)# network 172.16.3.0 mask 255.255.255.0
    router)# exit
R6(config)# IP route 1.1.1.1 255.255.255.255 30.0.0.2
                                             ↑
                                             next hop IP
```

---

(4) you should made a default route on R7 to made R7 send all his traffic to R6 when he want to reach a network he did not know its way

```
R7(config)# IP route 0.0.0.0 0.0.0.0 10.1.25.1
```

⑤ configure IBGP between R_1 & R_2 & R_3 & R_4

R_1(config) # router bgp 200

R1 & R2

router) # neighbor 2.2.2.2 remote-as 200
router) # neighbor 2.2.2.2 update-source Loopback0
router) # neighbor 2.2.2.2 next-hop-self

R1 & R3

) # neighbor 3.3.3.3 remote-as 200
) # neighbor 3.3.3.3 update-source Loopback0
) # neighbor 3.3.3.3 next-hop-self

R1 & R4

) # neighbor 4.4.4.4 remote-as 200
) # neighbor 4.4.4.4 update-source Loopback0
) # neighbor 4.4.4.4 next-hop-self

وكرر نفس الخطوات على R4

R_3(config) # router bgp 200

R3 & R1

router) # neighbor 1.1.1.1 remote-as 200
router) # neighbor 1.1.1.1 update-source Loopback0

R3 & R2

router) # neighbor 2.2.2.2 remote-as 200
router) # neighbor 2.2.2.2 update-source Loopback0

R3 & R4

router) # neighbor 4.4.4.4 remote-as 200
router) # neighbor 4.4.4.4 update-source Loopback0

IBGP بدون R2 & R3 على (next hop self) تفعل مش محتاج انت

وكرر نفس الخطوات على R2

Trouble shooting

#sh IP route

#sh IP bgp

R7 # ping 50.1.1.1

!!!!

R6 # ping 50.1.1.1 source 10.1.25.1

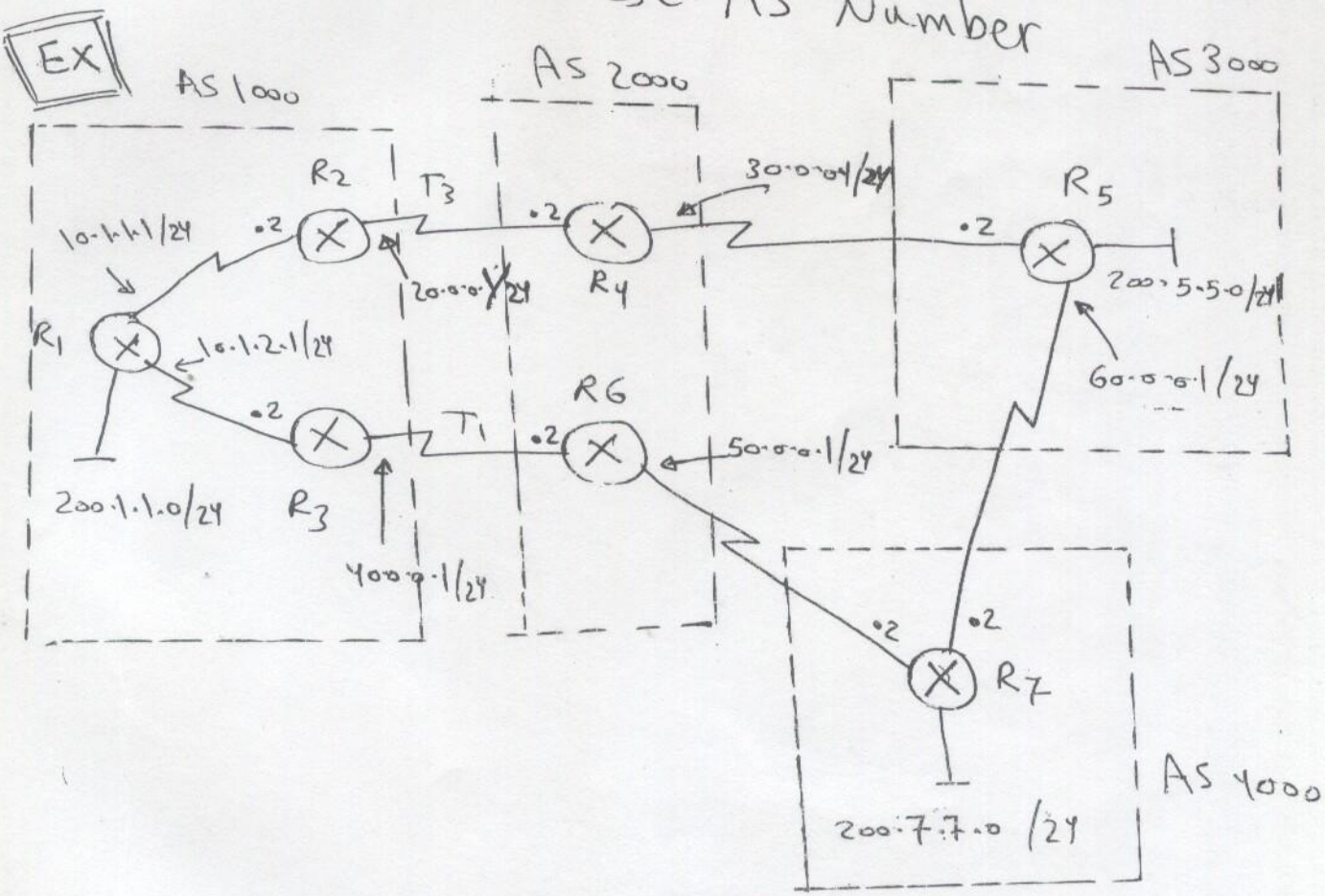
!!!!

tuning BGP attributes

- you can adjust BGP metric by playing in BGP attributes [As-Path, weight

[1] As path: by default BGP will choose The path with Lowest As Number

EX



→ Configure This Lab with bgp protocol

→ after configure bgp we will find that R_1 has 2 ways to reach N.W (200.7.7.0/24) and R_1 will choose the way [$R_3 \rightarrow R_6 \rightarrow R_7$] because this way has minimum AS. Number [AS 2000 & AS 4000]

→ if we want R_1 choose the way [$R_2 \rightarrow R_4 \rightarrow R_5 \rightarrow R_7$] [AS 2000 & AS 3000 & AS 4000] because this way has T3 link

```
R6 (config) #access-list 1 permit 200.7.7.0 0.0.0.255
(config) # route-map ZZ - permit 10
route-map) # match IP address 1
route-map) # set as-path prepend 2000 11 22 33 44
route-map) # route-map ZZ permit 20
route-map ) # router bgp 2000
router) # neighbor 40.0.0.1 route-map ZZ out
```

سوف يرسل هذه AS's

وفي هذه الحالة أنت أجبرت R_1 على أن يرى المسار العلوي

```
R1 # sh IP bgp
```

	next hop	metric	locprf	weight	path
*>i 200.7.7.0	10.1.1.2	0	100	0	2000 3000 4000

2 weight [cisco proprietary]

يستخدم بين EBGP Routers

→ default weight for any route = 0

→ higher weight is better

→ we want R_5 take the Lower path (T3) to reach N.W 200.1.1.0/24 using weight

```
R5 # sh IP bgp

                next-hop                weight    As-path
*> 200.1.1.0    30.0.0.1                0         2000-1000
*               60.0.0.2                → 0       4000-2000-1000
                                        default

R5(config) #router bgp 3000
  router) # neighbor 60.0.0.2 weight 500

R5# shIPbgp

                next-hop
*> 200.1.1.0    60.0.0.2                weight    As path
                                        500       4000-2000-1000
*               30.0.0.1                0         2000-1000
```

وهنا سوف يختار المسار صاحب الـ weight الأعلى

ولا تنسى * #clear IP bgp حتى يكوّن العلاقات من جديد

3 Local preference

يستخدم بين IBGP Routers

→ default value of Local pref = 100 & higher is better

- I need R_2 is The primary route & R_3 is a secondary route By playing in local preference

R_2(Config) # router bgp 1000

router) # bgp default localpreference 300

R_2 # clear ip bgp * ← نفرض الاتصال

R_1 # sh IP bgp

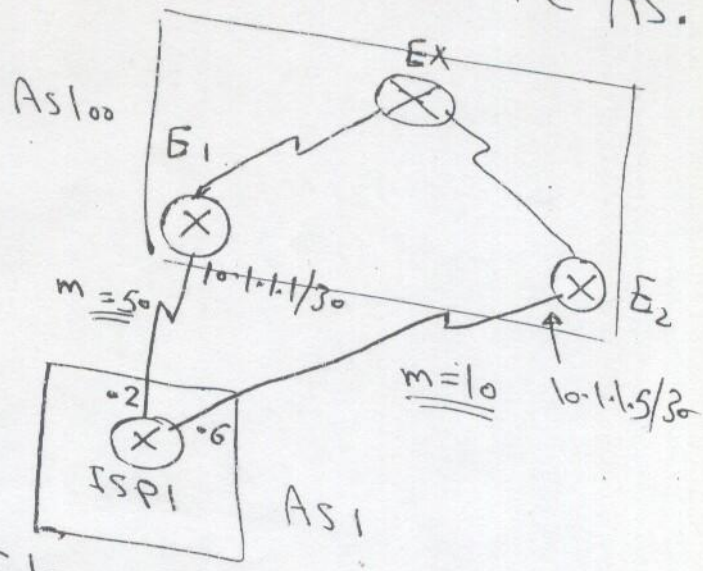
	nexthop	local pref	As-path
*> 200.7.7.0	10.1.1.2	300	2000-3000-4000
*	10.1.2.2	100	2000-4000

ملحوظة :- weight له الأفضلية على Local preference بالنسبة للروتر

4 metric

- default BGP metric = 0 & lower is better
- metric attribute is exchanged between AS's but metric attribute That comes into an AS does not leave The AS.
- The BGP metric attribute is a hint to external neighbors about The prefered path into an AS when There are multiple entry points into The AS.

ex: we want ISP1 take The path E2 with metric = 10 when he inter AS 100



E1(config) # router bgp 100
router) # neighbor 10.1.1.2 route-map aa out
E1(config) # route-map aa permit 10
route-map) # set metric 50

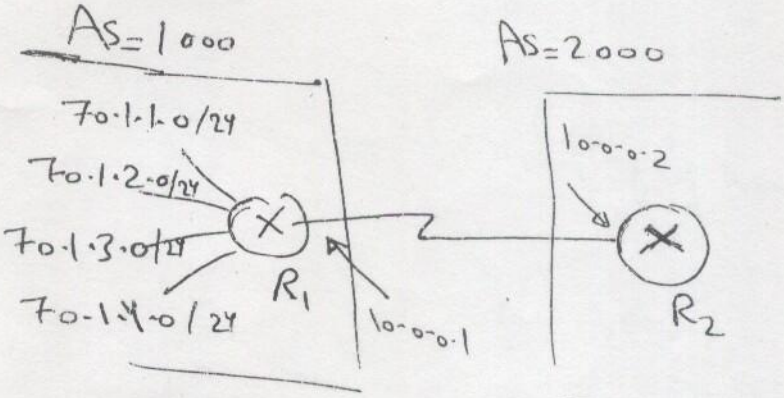
E2(config) # router bgp 100
router) # neighbor 10.1.1.6 route-map bb out
(config) # route-map bb permit 10
route-map) # set metric 10

important hint

internal BGP admin distance = 200
external BGP admin distance = 20

BGP summarization

إذا أردت أن تعمل summary
عليك أن تعلم عن الشبكات
والتي تقع داخل As ثم بعد
ذلك تقوم بعمل summary




```
R1(Config)# router bgp 1000
  router)# neighbor 10.0.0.2 remote-as 2000
  router)# network 70.1.1.0
  router)# network 70.1.2.0   mask 255.255.255.0
  router)# network 70.1.3.0   mask 255.255.255.0
  router)# network 70.1.4.0   mask 255.255.255.0
  router)# redistribute connected
```

ويمكنك بدلاً من أن تكتب الشبكات كل ↓
وسوف تكتب كل هذه الشبكات في R2
والآن سنقوم بعمل summary

70.1.1.0
70.1.2.0
70.1.3.0
70.1.4.0
الشبكات

```
R1(Config)# aggregate-address 70.1.0.0 255.255.0.0
```

summary-only

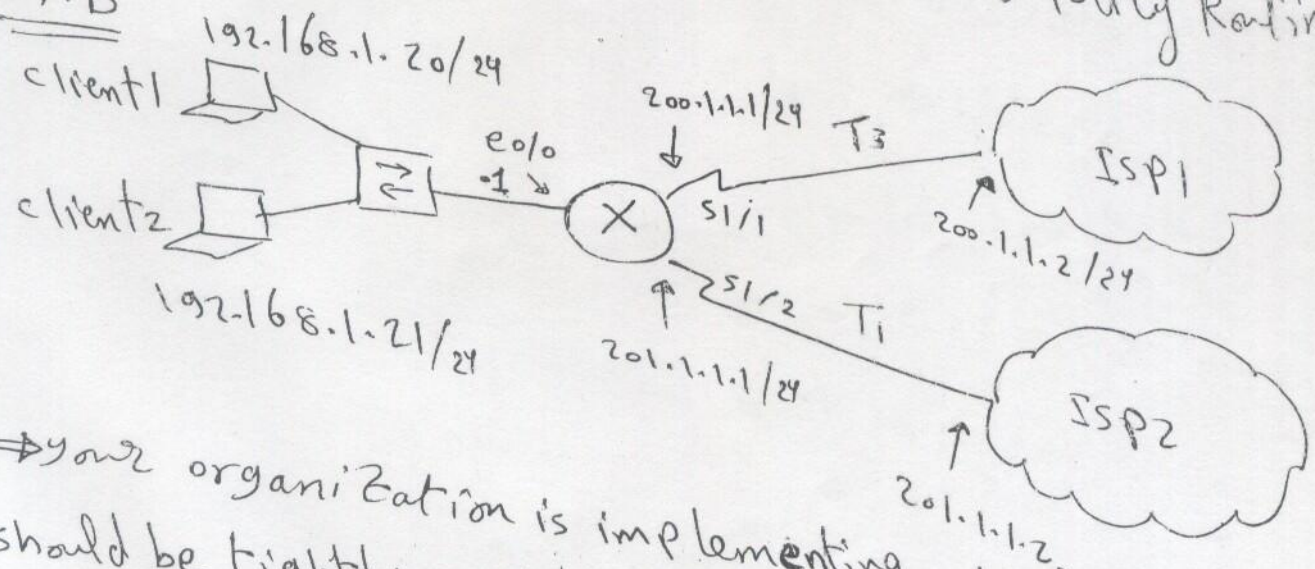
Path Control

what is policy Routing?

→ Policy Routing is The programming language of Routing table

→ we will take a LAB to understand policy Routing

LAB



⇒ your organization is implementing a dual ISP setup should be tightly controlled, They have requisted The Following Parameters

① client 1 surfs The internet all The day doing nothing Productive, all traffic from This client should Route out ISP 2, which is slower internet connection.

if ISP2 is down, client 1 should not be able to access The internet

② client2 handles sophisticated transactions
- Both telnet & https, traffic should Route towards ISP1, which is The more reliable connection.
- all other traffic from client2 should Route out ISP_2
- traffic from other clients [not shown in The diagram] should Route out ISP2

Policy Router (Config) # IP access-list extended client1
ext-nACL) # permit IP host 192.168.1.20 any
(config) # IP access-list extended client2
ext-nacL) # permit TCP host 192.168.1.21 any eq 23
ext-nacL) # permit tcp host 192.168.1.21 any eq 443
) # exit
(Config) # Route-map Policy permit 10
route-map) # match ip address client1
route-map) # set IP next-hop 201.1.1.2
map) # route-map Policy permit 20
map) # match IP address client2
map) # set IP next-hop 200.1.1.2
map) # Route map Policy permit 30
map) # set IP next-hop 201.1.1.2

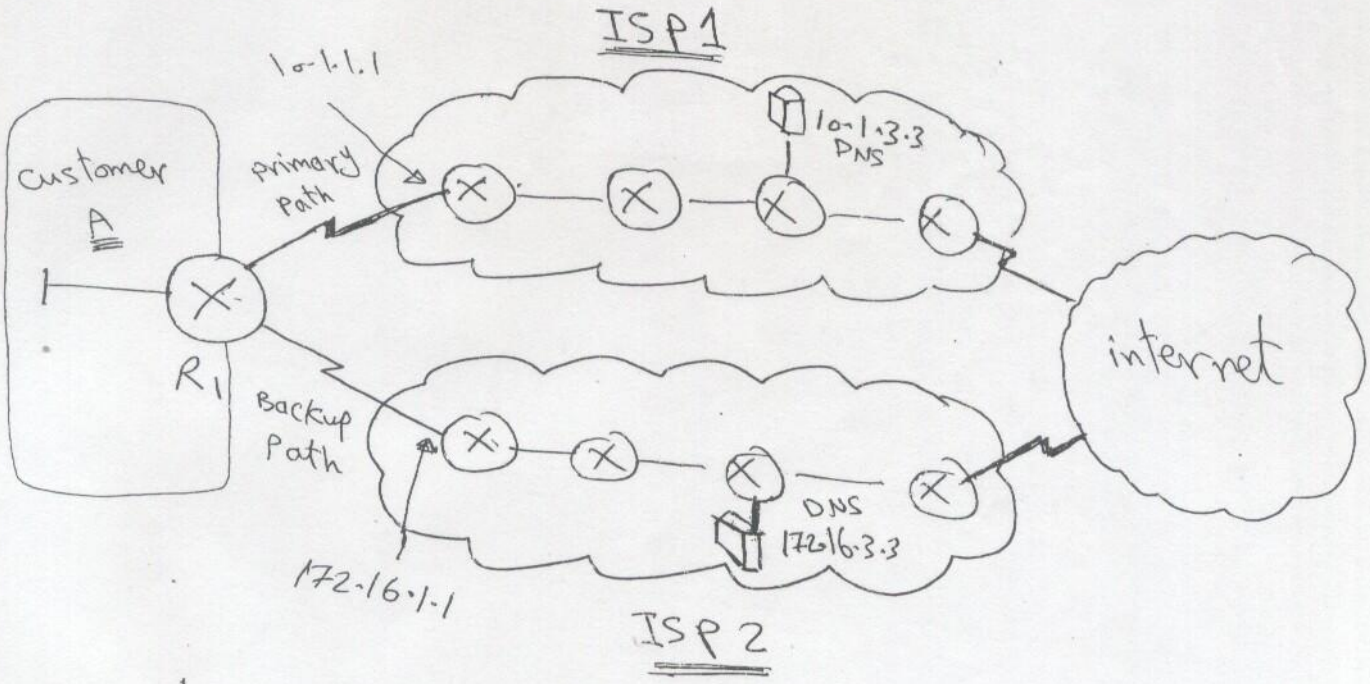
والآن سوف نضع الـ Route-map التي تسمى policy

على الفتحة e0/0

```
(config)# int e0/0
-if)# IP policy route-map policy
```

IP SLA

→ The Following example will help us to understand The meaning of IP SLA



- Customer A is multihoming to two ISPs using R1 which is configured with two default Floating static Routes

- The static route to R_2 (ISP-1) has been given an adminstrative distance of 2 making it preferred and there for the primary default route.
- The static route to R_3 (ISP-2) has been given an adminstrative distance of 3 making it the backup default route.
- what would happen if a link within ISP 1 provider infrastructure were to fail?

→ The link from R_1 to R_2 would still remain up and the R_1 would continue to use that link because the default static route would still be valid

- The solution to this issue is the Cisco IOS IP SLA feature.

→ configuring IP SLA to continuously check the reachability of a specific destination {such as the ISP's DNS server, edge router & any other specific destination} and conditionally announce the default route only if the connectivity is verified.

R1 (Config) # IP sla monitor 11 ← Probe No.

sla-monitor) # type echo protocol IPicmpecho 10.1.3.3

DNS of ISP1

monitor) # time out 1000

عندما أرسل ping سوف
يرد عليها في وقت لا يزيد عن 1 sec

monitor) # frequency 3 → سوف أرسل ping كل ٣ ثواني

monitor) # exit

رقم الـ probe

(Config) # IP sla monitor schedule 11 start-time now life forever

R1 (Config) # track 1 rtr 11 reachability

رقم الـ track

هو IPsla

track) # exit

admin distance

R1 (Config) # IP route 0.0.0.0 0.0.0.0 10.1.1.1 2 track1

R1 (Config) # IP route 0.0.0.0 0.0.0.0 172.16.1.1 3

admin distance

IPV6

* There is an IP address shortage!
- USA is still
- Asia & Africa received single class C for entire country
* Current IP address poorly allocated
- agencies needing class C asked for Class B
- estimates on IPV4 exhaustion largely depated [2009 - 2041]

سنة 2041 سيتم إستهلاك IPV4

* new network devices on the rise
* NAT [our current solution] is now seen as
- a hindrance to innovation عائقاً أمام الإبداع
* addressing size moved from 32 bits (IPV4) to 128 bits (IPV6) which provides 2^{128} IP's
* to make addresses more managable, devided into 8 groups of 4 hexa characters each

ex

2001:0000:0000:3F24:0000:0000:0000:0058

① Drop leading zeros

2001:0:0:3F24:0:0:0:58

② eleminate groups of consecutive zeros

2001::3F24:0:0:0:58

or

2001:0:0:3F24::58

hint

Loop back in IPV6 is ::1

hint: IPV6 header is smaller Than IPV4 header

والسبب ان الـ BW الذى يشغله IPV6

أقل من BW الذى يشغله IPV4

Types of communications

- unicast : one to one
- multicast : one to many
- any cast : one to closest

مدواحد إلى الأقرب

مثلاً لو إنت داخل على www.yahoo.com فيقوم بإرسالك لأقرب سرفر لبلدك
ولنكن مثلاً في ألمانيا

Types of addresses

① link local scope address

- assigned automatically as an IPV4 host comes online
- similar to the 169.254.x.x address of IPV4
- always begin with "FE 80" [First 10 bits : 1111 1110 10]
  Followed by 54 bits of zero's
- Last 64 bits is the 48-bits mac address with "FFFE" sequeezed (توضع) in the middle.

FE80

mac = 0019.D122.DCF3

1111 1110 1000 0000 0000 0000 0000 ...	

0019.D1(FF.FE)22.DCF3

② unique/site local scope address

→ private address use for organizations

③ global address

- have their high level 3bits set to 001 (2000::/3)

N bits	(64-N) bit	64 bits
global Routing prefix 001...	subnet ID	interface ID

- global Routing prefix is 48 bit or less
- subnet ID is comprised of whatever bits are left over after global Routing prefix
- The primary addresses expected to comprise the IPV6 internet are from the 2001::/16

(config) # int f0/0

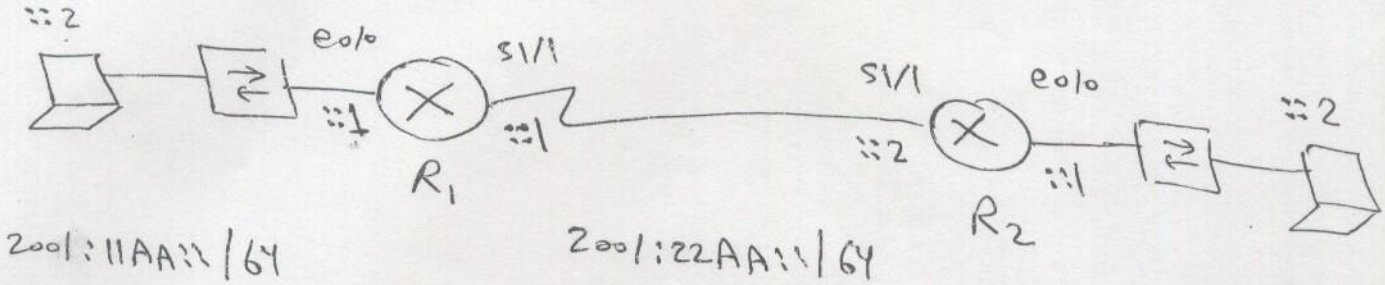
if) # IPV6 address 2001:1234:ABCD:5678::/64 eui-64

وهناك أن الروتر سوف يكمل الجزء الباقي من الـ IPV6 بطريقة أوتوماتيكية بدلاً أن تكتبه أنت

extended unique identifier

sh IPV6 int f0/0

IPV6 LAB




```
R1(Config)# int e0/0
    if)#IP V6 address 2001::11AA::1/64
  if )#int S1/1
  if )#IPV6 address 2001:22AA::1/64
```

```
R2(Config)# int e0/0
    if)#IP V6 address 2001:33AA::1/64
    if)# int S1/1
    if)# IPV6 address 2001:22AA::2/64
```

IPV6 Routing

① static Route

R1 (config) # IPV6 unicast Routing ← يجعل الروتر يقوم بعمل Routing خاص بـ IPV6 Table

R1(config) # IPV6 Route 2001:33AA::/64 2001:22AA::2

next hop IP

R1 # sh IP V6 Route

```
S 2001:33AA::/64 [1/0] via 2001:22aa::2
```

R2 (config) # IPV6 unicast Routing

R2(config) # IPV6 Route 2001:11AA::/64 2001:22AA::1

next hop IP

R2 # sh IP route

```
S 2001:11AA::/64 [1/0] via 2001:22AA::1
```

R2(config) # IPV6 Route ::/0 2001:22AA::1 يعمل default Route

R2 # sh IP Route

```
S ::/0 [1/0]
```

② IPV6 RIP-[NG] next generation

R1(Config) # IPV6 unicast-Routing

R1(Config) # int e0/0

if) # IPV6 rip aa enable

if) # int s1/1

if) # IPV6 RIP aa enable

R2 (Config) # IPV6 unicast-Routing

config) # int e0/0

if) # IPV6 RIP aa enable

if) # int s1/1

if) # IPV6 RIP aa enable

Troubleshooting

sh IPV6 Route

debug IPV6 RIP

sh IP Protocols

③ EIGRP for IPV6

R1 (Config) # IPV6 unicast Routing

(Config) # int e0/0

if) # IPV6 eigrp 1

if) # int s1/1

if) # IPV6 eigrp 1

if) # exit

(Config) # IPV6 router eigrp 1

rtr) # no shut down

) # router-id 1.1.1.1

R2 (Config) # IPV6 unicast Routing

) # int e0/0

if) # IPV6 eigrp 1

if) # int s1/1

if) # IPV6 eigrp 1

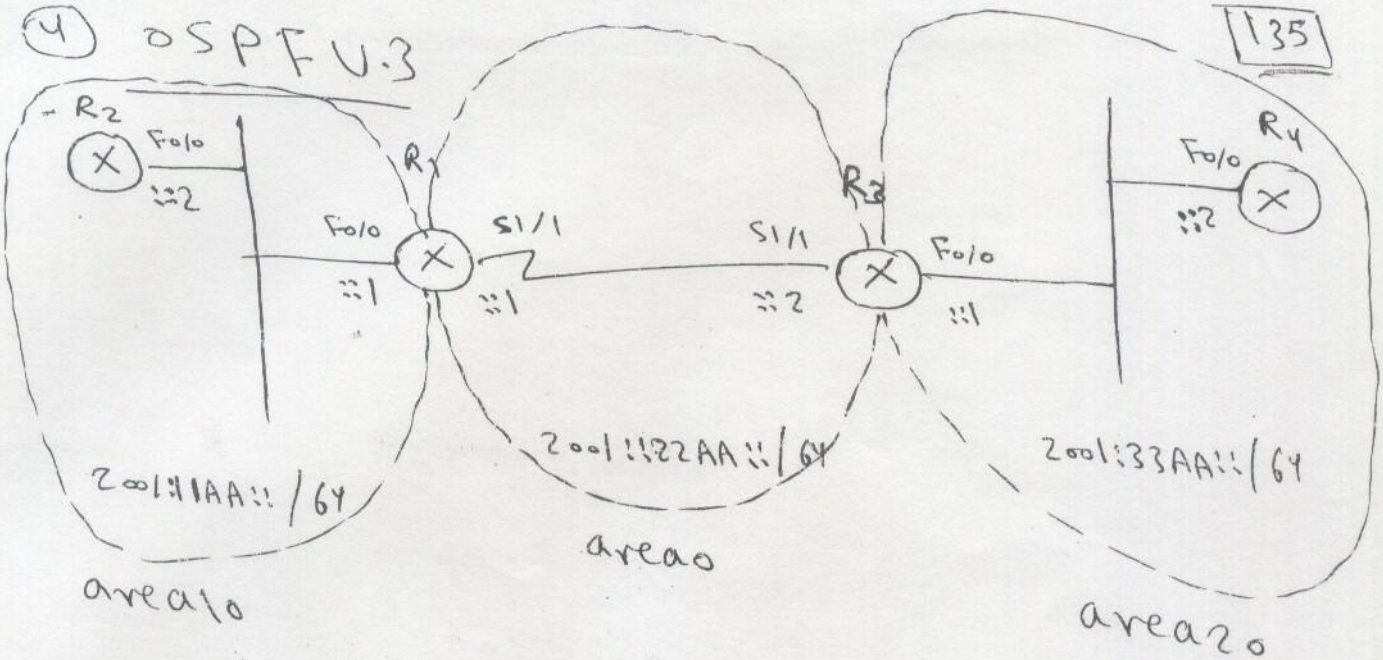
if) # exit

(Config) # IPV6 router eigrp 1

rtr) # no shut down

rtr) # router-id 2.2.2.2

4) OSPFV.3




```
R1 (Config) # IPV6 unicast-Routing
  (Config) # int Fo/0
      if) # IPV6 OSPF1 area 0
        int S1/1
      if) # IPV6 OSPF1 area 0
      if) # exit
  (Config) # IPV6 router OSPF1
    rtr) # router-id 1.1.1.1
```

← IPV4 يطلق Router-id
لأنه updates ترسل منه
إلى الروتر المجاورة

```
R2 (Config) # IPV6 unicast-Routing
  (Config) # int Fo/0
      if) # IPV6 OSPF1 area 0
      if) # exit
  (Config) # IPV6 router OSPF1
    rtr) # router-id 2.2.2.2
```

```
R3(config)# IPV6 unicast-Routing
R3(config)# int s1/1
    if)# IPV6 ospf1 area 0
    if)# int Fo/0
    if)# IPV6 ospf1 area 20
    if)# exit
  (config)# IPV6 router ospf1
    rtr)# router-id 3.3.3.3
```

```
R4(config)# IPV6 unicast-Routing
  (config)# int Fo/0
    if)# IPV6 ospf1 area 20
    if)# exit
  (config)# IPV6 router ospf1
    rtr)# router-id 4.4.4.4
```

Troubleshooting

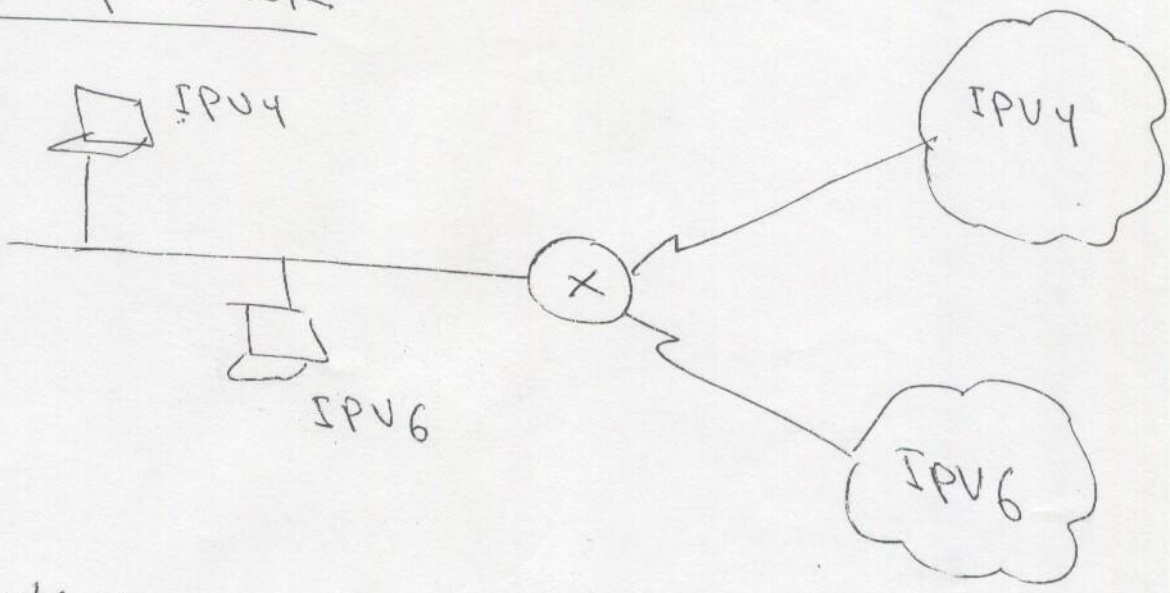
```
# sh IP route
# sh IP ospf interface
# sh IP protocols
```

لو شيء زي ospfv2 مفيش أي إختلاف سوف في

طريقة عمل الـ configuration

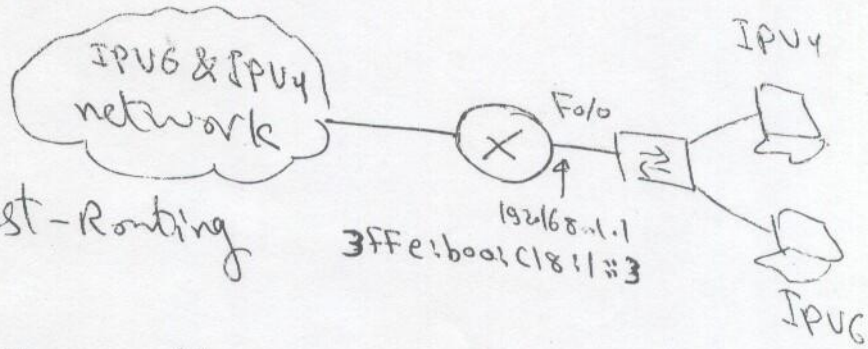
Imigration to IPV6

1 Dual stack



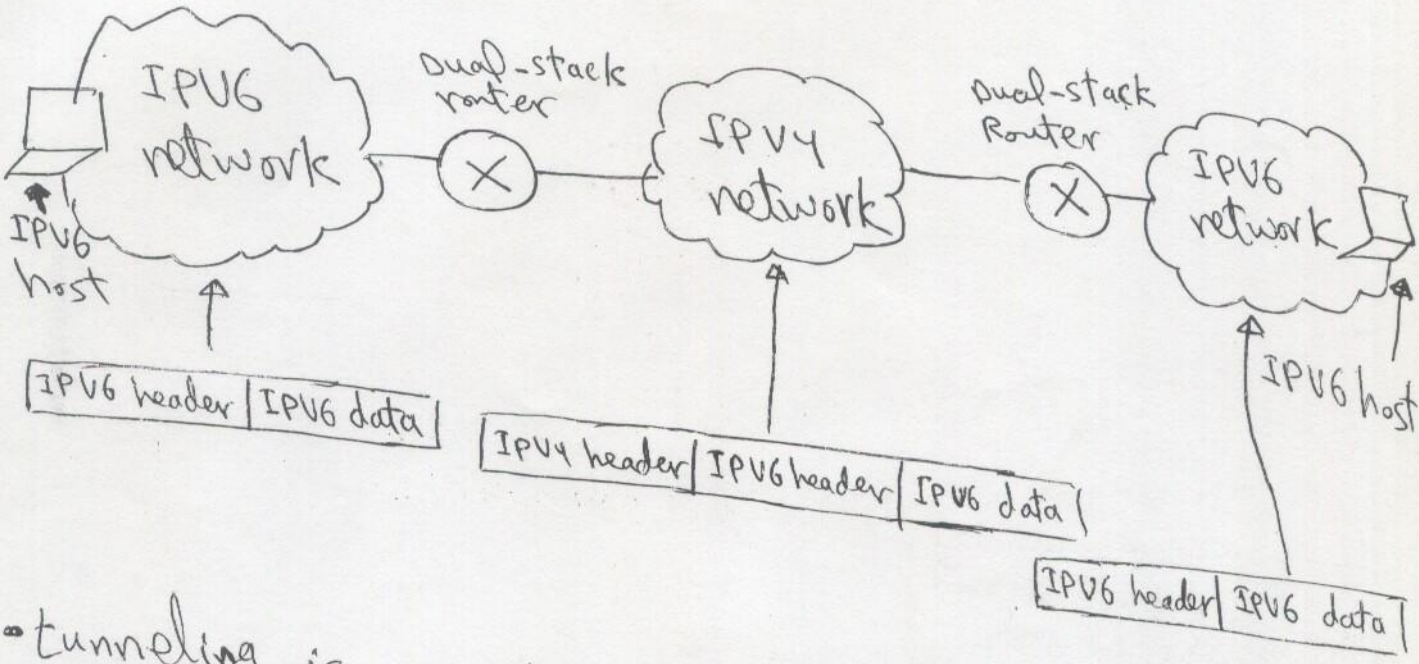
- Dual stack is an integration method where a node has implementation and connectivity to both an IP V4 & IPV6 network.
- if both IPV4 & IPV6 are configured on an interface, This interface is dual-stacked

ex



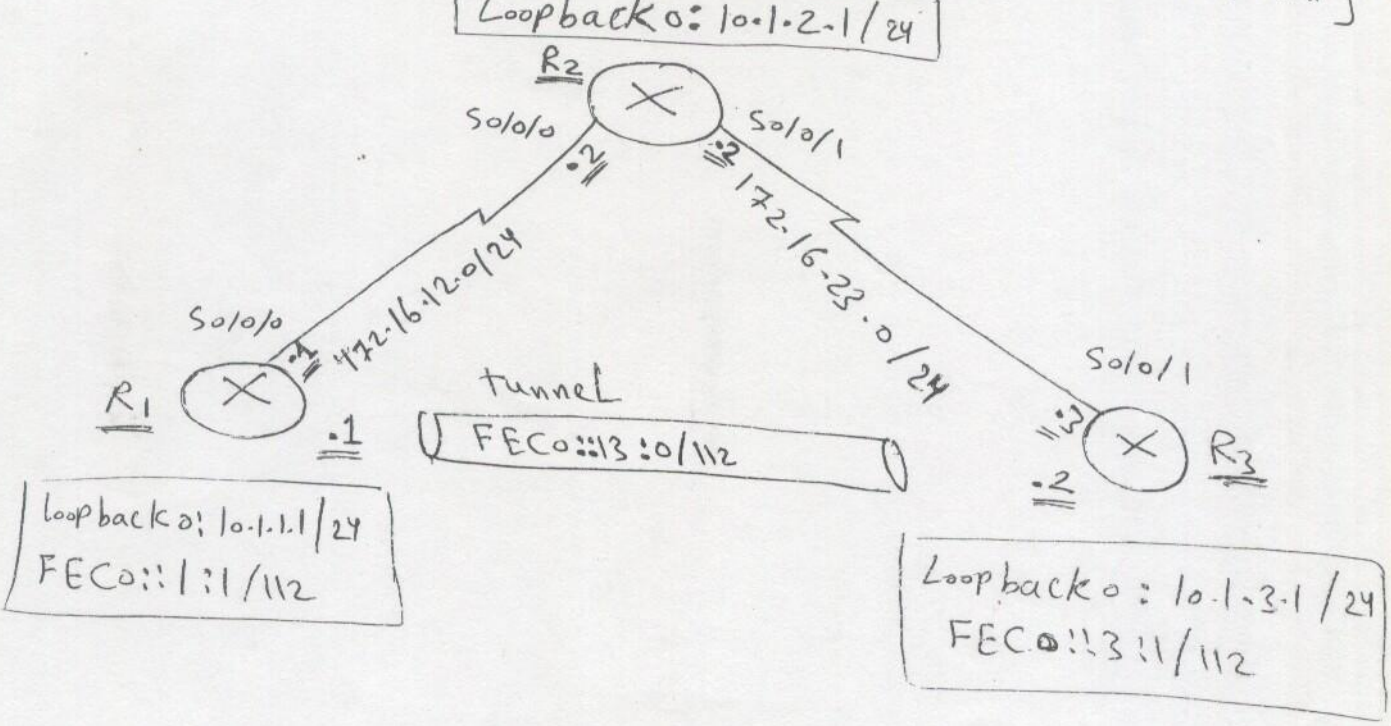
(config) # IPV6 unicast-Routing
(config) # int Fo/o
if) # IP address 192.168.1.1 255.255.255.0
if) # IPV6 address 3ffe:b00:c18:1::3 /64

2 tunneling



- tunneling is an integration method where an IPV6 packet is encapsulated within another protocol such as IPV4

LAB 11 manual IPV6 tunnels [Point to Point]



R1 (Config) # int loopback 0
if) # IP address 10.1.1.1 255.255.255.0
if) # IPV6 address FEC0::1:1/112 ← dual stack
if) # int S0/0/0
if) # IP address 172.16.12.1 255.255.255.0

R2 (Config) # int loopback 0
if) # IP address 10.1.2.1 255.255.255.0
if) # int S0/0/0
if) # IP address 172.16.12.2 255.255.255.0
if) # int S0/0/1
if) # IP address 172.16.23.2 255.255.255.0

R3(Config)# int Loopback 0
if)# IP address 10.1.3.1 255.255.255.0
if)# IPV6 address FEC0::3:1/112
if)# int S0/0/1
if)# IP address 172.16.23.3 255.255.255.0

Dual stack

→ Configure EIGRP 1 for IPV4 networks

R1 (Config)# router eigrp 1
router)# no auto-summary
router)# network 10.0.0.0
router)# network 172.16.0.0

R2(Config)# router eigrp 1
router)# no autosummary
router)# network 10.0.0.0
router)# network 172.16.0.0

R3(Config)# router eigrp 1
router)# no auto-summary
router)# network 10.0.0.0
router)# network 172.16.0.0

→ a tunnel is a logical interface that acts as a logical connection between two end points

→ An IPV6 manual tunnel is a type of tunnel that has hard-coded source and destination addresses with an IPV6 address on the tunnel itself

R1 (Config)# int tunnel 0
-if)# tunnel mode IPV6IP
if)# tunnel source s0/0/0
if)# tunnel destination 172.16.23.3
if)# IPV6 address FEC0::13:1/112

R3 (Config)# int tunnel 0
if)# tunnel mode IPV6 IP
if)# tunnel source s0/0/1
if)# tunnel destination 172.16.12.1
if)# IPV6 address FEC0::13:3/112

R1 # Ping FEC0::13:3
!!!!

→ configure ospf v3 on those routers to run over the tunnel and advertise the loopback interfaces into ospf v3

→ ospf v3 will be used to route IPV6 network

→ EIGRP is used for IPV4 networks

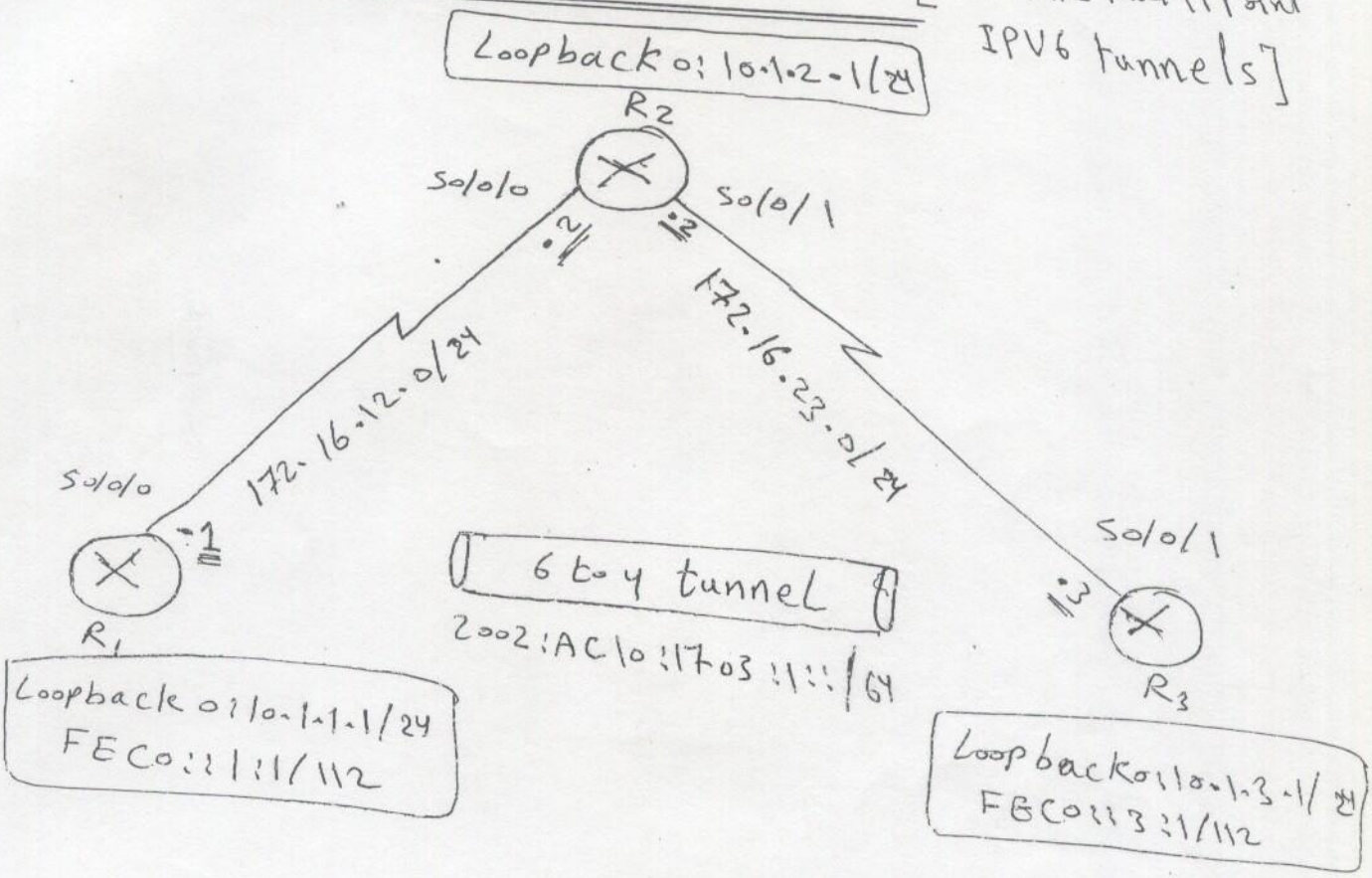
R1(Config) # IPV6 unicast-Routing
(Config) # int loopback 0
(Config-if) # IPV6 ospf 1 area 0
(Config) # int tunnel 0
(Config-if) # IPV6 ospf 1 area 0

R3 (Config) # IPV6 unicast-Routing
(Config) # int loopback 0
(Config-if) # IPV6 ospf 1 area 0
(Config) # int tunnel 0
(Config-if) # IPV6 ospf 1 area 0

R1 # ping FEC0::3::1
!!!!

R1 # sh IPV6 ospf neighbor

LAB 2 configure 6 to 4 tunnels [Dynamic multipoint IPV6 tunnels]



① Configure EIGRP for IPV4

② create 6 to 4 tunnel

③ Configure static IPV6 routes

→ an automatic 6 to 4 tunnel allows isolated IPV6 domains to be connected over an IPV4 network to remote IPV6 networks.

→ The Key difference between automatic 6 to 4 tunnels and manually configured tunnels is That The tunnel is not point-to-point ; it is point-to-multipoint

① Put IPV4 & IPV6 like LAB 1

② Configure EIGRP1 For IPV4 networks

R1 (Config) # router eigrp 1
router) # no auto-summary
router)# network 10.0.0.0
router) # network 172.16.0.0

R2 (Config) # router eigrp 1
router) # no auto-summary
router)# network 10.0.0.0
router)# network 172.16.0.0

R3 (Config) # router eigrp 1
router) # no auto-summary
router) # network 10.0.0.0
router) # network 172.16.0.0

→ A 6to4 tunnel uses special IPV6 addresses in The 2002::/16 address space

→ The first 16 bits are The hexa decimal number 2002, and The next 32 bits are The original source IPV4 address in hexa decimal Form

→ A6to4 tunnel does not require a destination address because it is not a Point-to-Point link.

* set The tunnel mode with The Following Command

R1(Config) #int tunnel 0

if) #tunnel mode IPV6IP 6to4

* set The IPV6 address

R1(-if) # IP V6 address 2002:AC10:0C01::1/64

hint

2002:AC10:0C01:1::1/64

172.16.12.1 → AC 10 0C 01

subnet ID

host address

* set The source interfale For The tunnel with The Command

R1

(config-if) # tunnel source S0/0/0

وكرر نفس الأوامر على R3 كالصفحة التالية

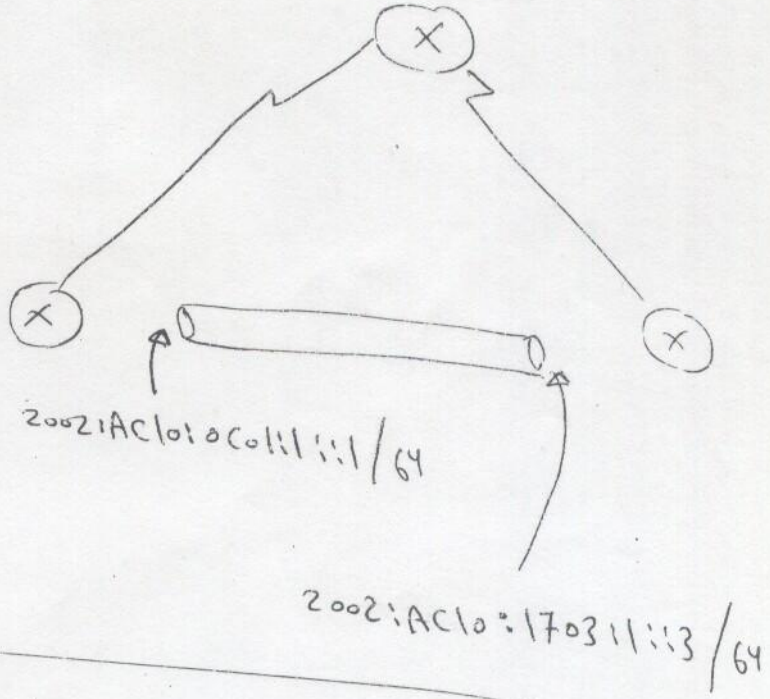
R3(config)# int tunnel 0

if)# tunnel mode IPV6ip 6to4

if)# IPV6 address 2002:AC10:1703:1::3/64

if)# tunnel source S0/0/1

→ Put static Route
For establish
The tunnel



R1(Config)# IPV6 unicast-Routing
R1 (Config)# IPV6 route 2002::/16 tunnel 0

R3 (Config)# IPV6 unicast-Routing
R3 (Config)# IPV6 route 2002::/16 tunnel 0

R_1 # Ping 2002:AC10:1703:1::3

!!!!!

R_3 # Ping 2002:AC10:C01:1::1

!!!!!

→ Put astatic Route on R_1 telling it how to get to R_3's loopback address

→ also put astatic Route on R_3 telling it how to get to R_1's loopback address

hint: The next hop for Both routers is The IPV6 address of The other end of The tunnel.

R_1(Config) #IPV6 Route FEC0::3:0/112 2002:AC10:1703:1::3

R_3(Config) #IPV6 Route FEC0::1:0/112 2002:AC10:C01:1::1

R_1 # Ping FEC0::3:1

!!!!!

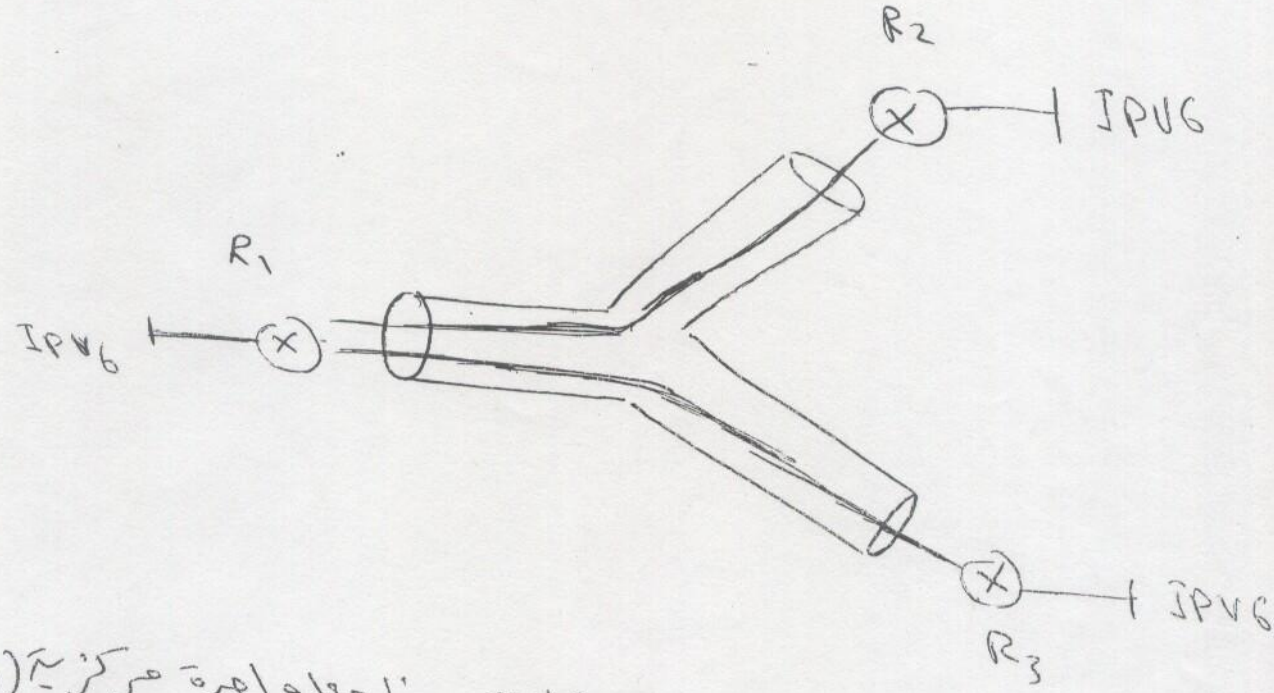
R_3 # Ping FEC0::1:1

!!!!

Trouble shooting

#sh IPV6 Route

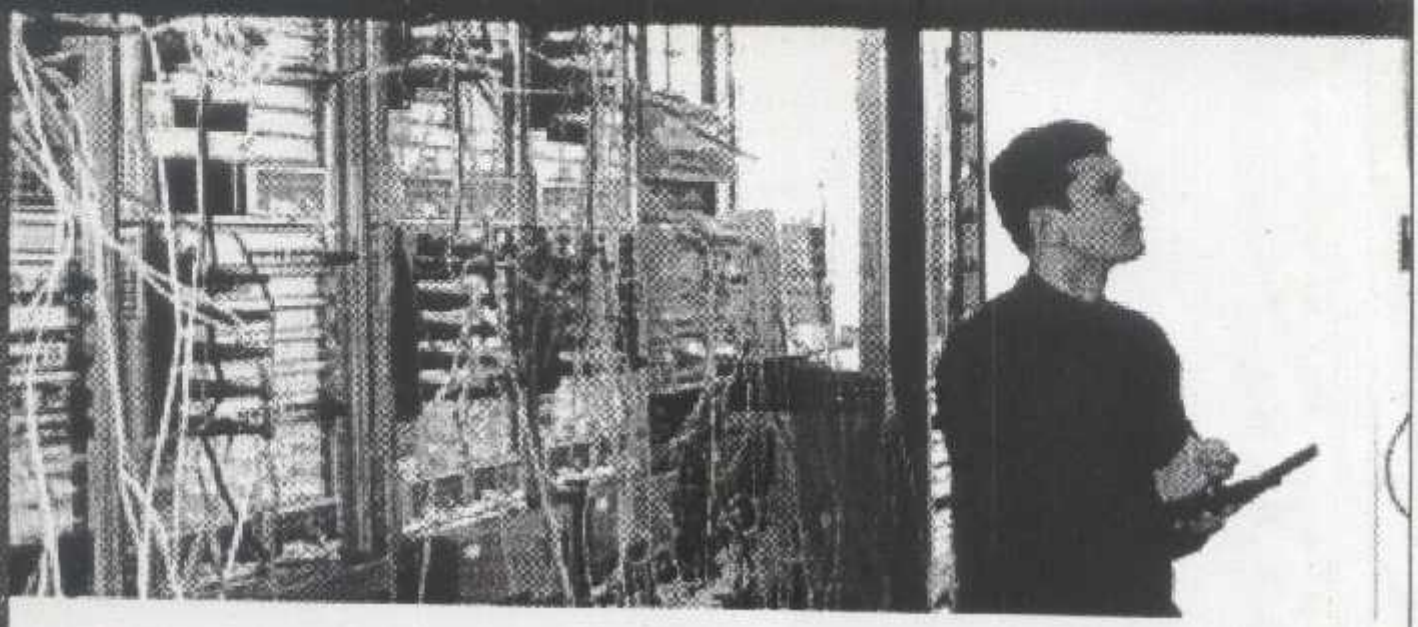
hint



إذا كان هناك أكثر من شبكتين IPV6 فإجعل واحدة مركزية (R_1)

و الجميع مربوط عليها (point-to-multi point)

وسوف يكون R_1 هو حلقة الوصل بين R_2 & R_3



CCNP ROUTE

Prepared by
ENG: Ahmed Abdallah