UNICAST ROUTING PROTOCOLS (RIP, OSPF, BGP)

cost of passing N/W = metric
Metric depend upon type of protocol of each N/W.

RIP → each N/W is equal. Cost of passing a N/W is same

OSPF (Open Shortest Path First) → allows administrator to assign cost thro' a N/W based on type of service req'd.

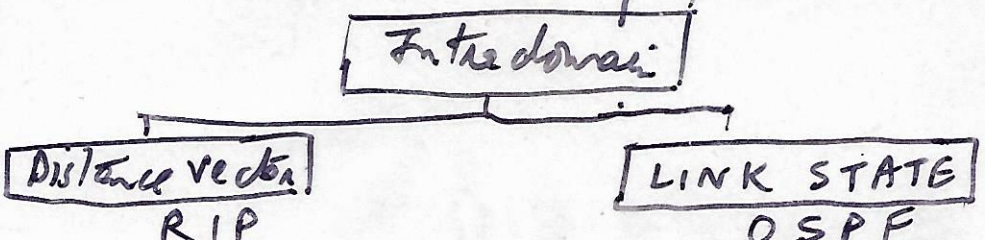
BGP (BORDER GATEWAY PROTOCOL) → defines metric as policy set by administrator.

- Routing Table → static or dynamic.

- Tables need to be updated as soon as there is change in internet like when router is down etc.
  - Routing protocols are for dynamic tables.
- Routing protocol is combination of rules & procedures that help routers inform each other of changes.
- Routing tables also have procedures for combining info recd from other routers.

Autonomous System group of N/Ws & routers under the authority of single administrator.

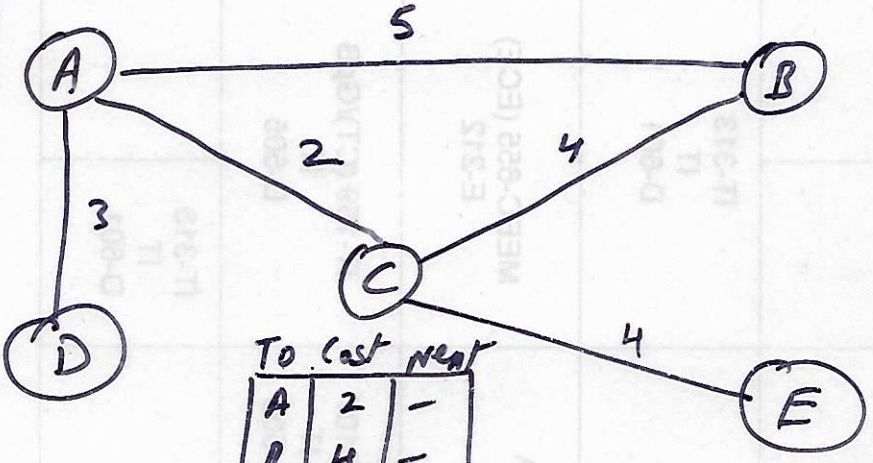
- Routing inside AS → Intradomain Routing.
- " between AS → Interdomain "
- Each AS may choose 1 or more protocols (intradomain) to handle routing.
- Only one interdomain routing protocol between AS.



DISTANCE VECTOR ROUTING least cost route between any 2 nodes is the route with minimum distance.

- Each node has a table of min distances to every node.

To	Cost	Next
A	0	–
B	5	–
C	2	–
D	3	–
E	6	C



To	Cost	Next
A	3	–
B	8	A
C	5	A
D	0	–
E	9	A

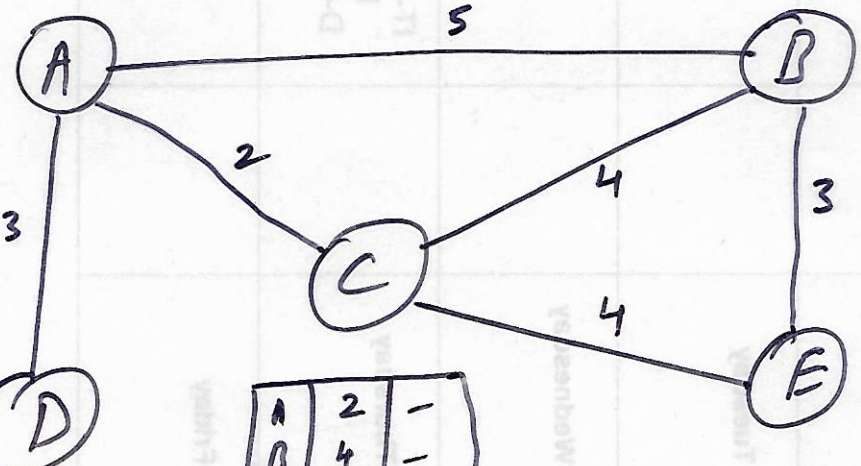
To	Cost	Next
A	2	–
B	4	–
C	0	–
D	5	A
E	4	–

STABLE TABLES

Initialization At the beginning, nodes don't know how to reach every node

- Every node knows only the distance b/w itself & its immediate neighbours, those directly connected to it.

A	0	–
B	5	–
C	2	–
D	3	–
E	∞	



A	3	–
B	∞	
C	∞	
D	0	–
E	∞	

A	2	–
B	4	–
C	0	–
D	∞	
E	4	–

A	∞	
B	3	
C	4	
D	∞	
E	0	

SHARING & UPDATING

When neighbour receives a table, 3rd column needs to be replaced with sender's name. So only 2 columns are shared.

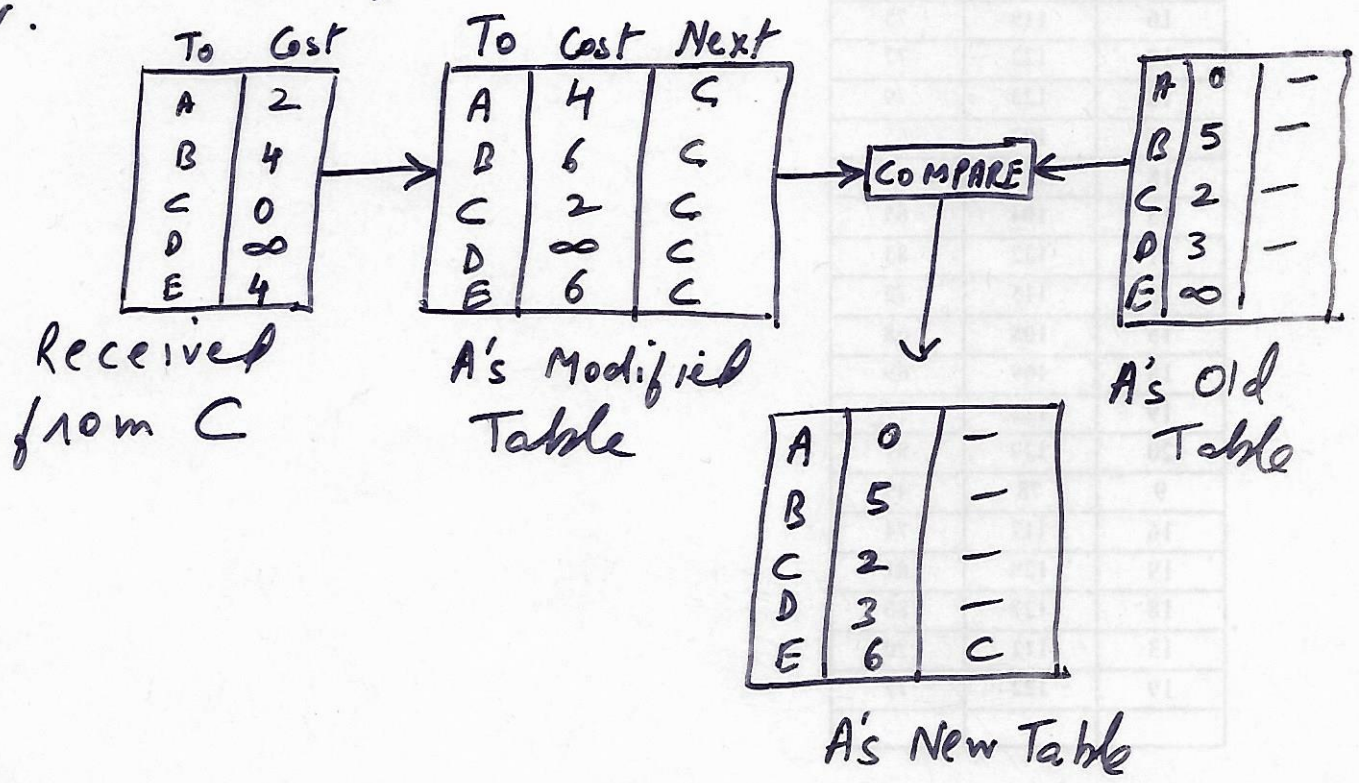
- Updating of receiver's table involves 3 steps

(a) Receiving node needs to add cost b/w itself & sending node to each value in 2nd column.

(b) Receiving node adds name of sending node to each row as 3rd column

(c) Receiving node compares each row of its old table with each row of its modified received table.

1. If next node entry is different, receiving node chooses node with smaller cost. If there is a tie, old one is kept.
2. If next node entry is same, receiving node chooses new row.



UPDATION OF Table A after receiving partial table from node C

SHARING is done

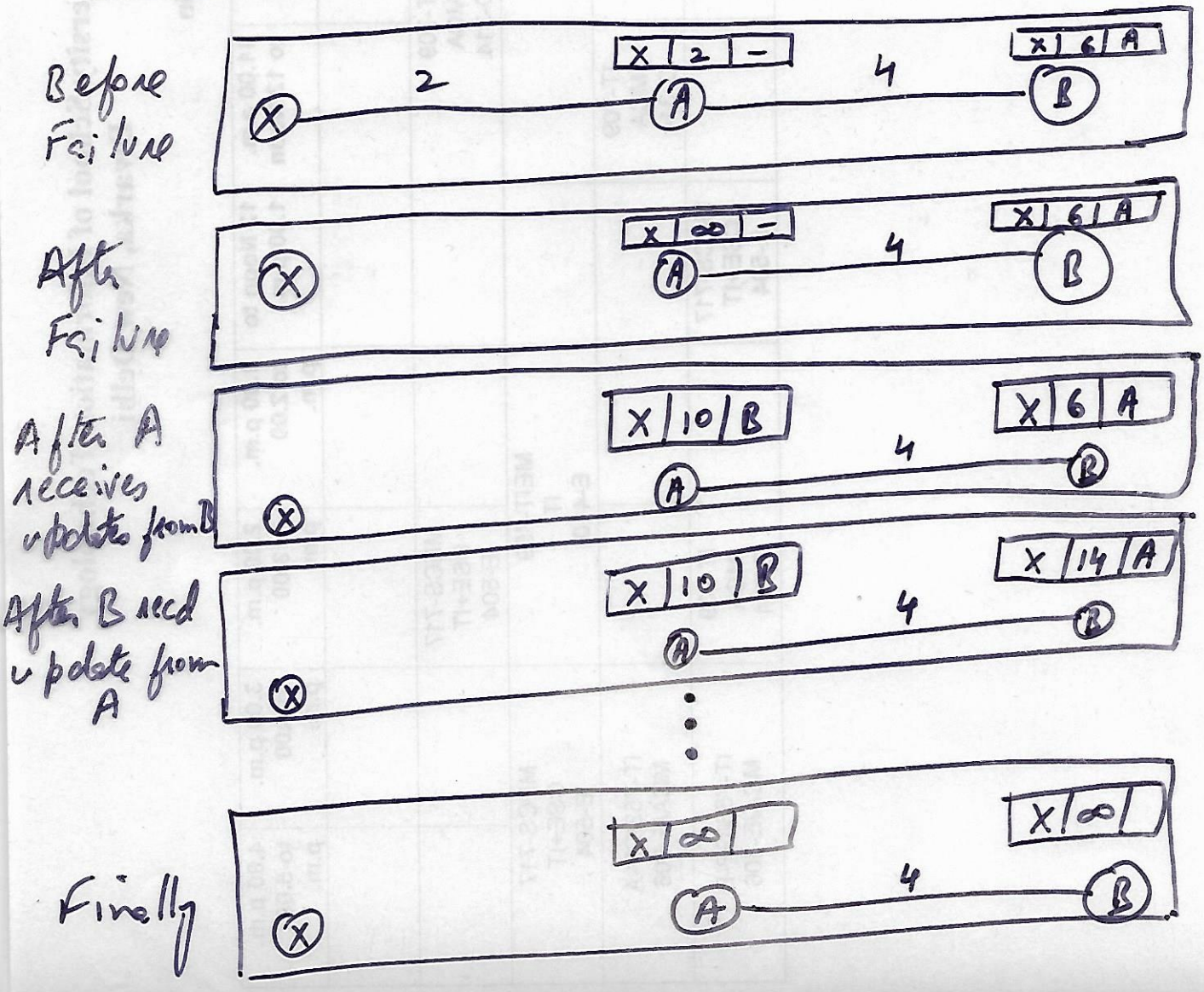
1. Periodic Update — normally every 30 sec, depends upon protocol using distance vector routing.

2. Triggered Update — Node sends its table when there is change in table.

(a) Node receives table from a neighbour

(b) Node detects some failure in neighbouring links, the dist changes to ∞.

Two Node Loop Instability



Suddenly link b/w A & X fails. A's table changes. If A sends its table to B immediately, then its OK. System becomes unstable if B sends its table before receiving A's table.

Result is that packets bounce b/w A & B

SOLUTIONS ARE:

(a) DEFINING INFINITY to smaller no, such as 100.

Most implementations define dist b/w nodes = 1 & infinity = 16.

(b) SPLIT HORIZON Each node sends part of its table.

If B thinks route to reach X is via A, it doesn't send this info to A, because A already knows. B eliminates last line of its routing table before sending to A. In this case A keeps value of ∞ as dist to X.

when A sends table to B, B also corrects its routing table.

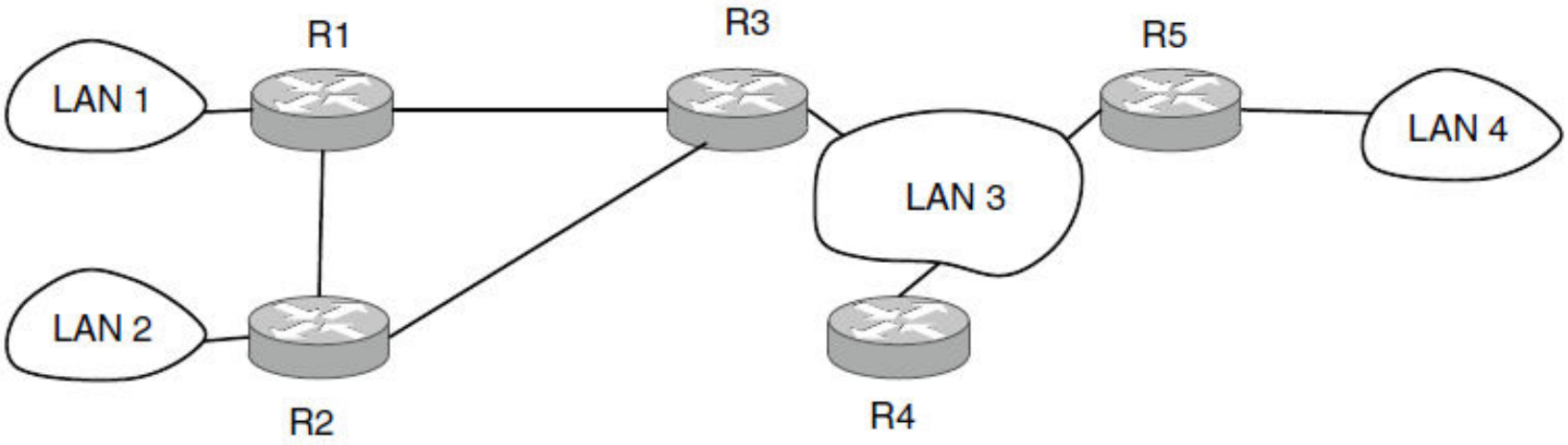
(c) SPLIT HORIZON & POISON REVERSE Split horizon has drawback.

Distance vector protocol uses a timer, and if no news about a route, then it is deleted. When node B doesn't advertise route to X, to A, node A can't guess that it is due to split horizon strategy. Split horizon strategy combined with poison strategy where node B can still advertise the value of X, but if source of info is A, it can replace dist with ∞ with warning

"Do not use this value, what I know about this route comes from you".

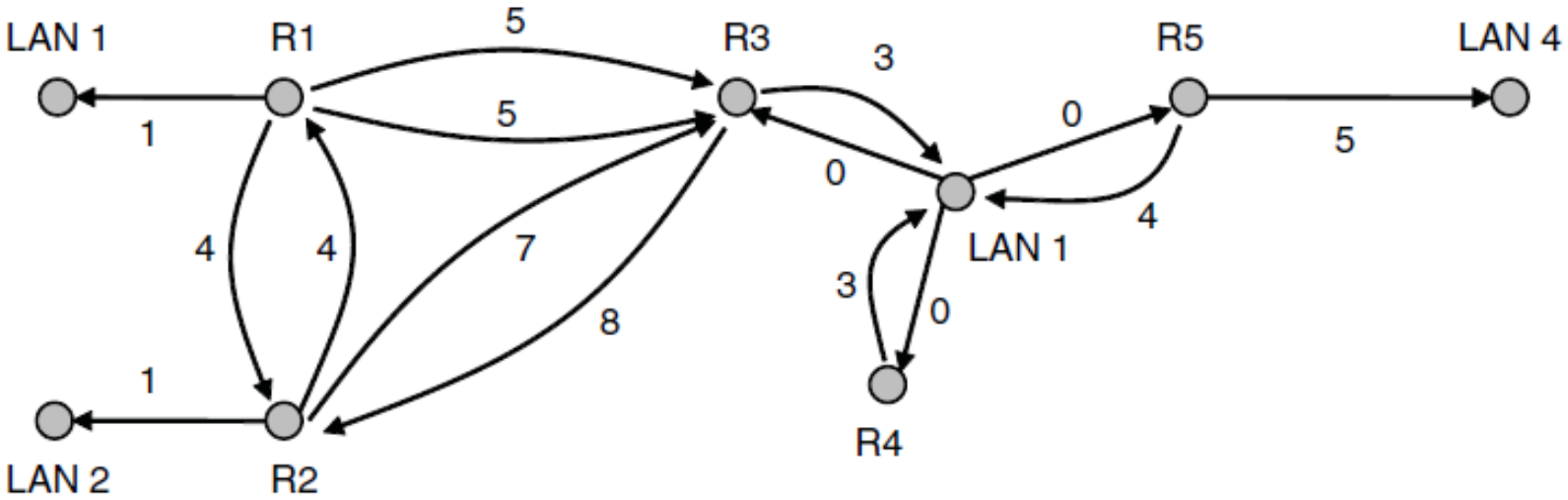
3 NODE INSTABILITY Stability can't be guaranteed.

OSPF—An Interior Gateway Routing Protocol



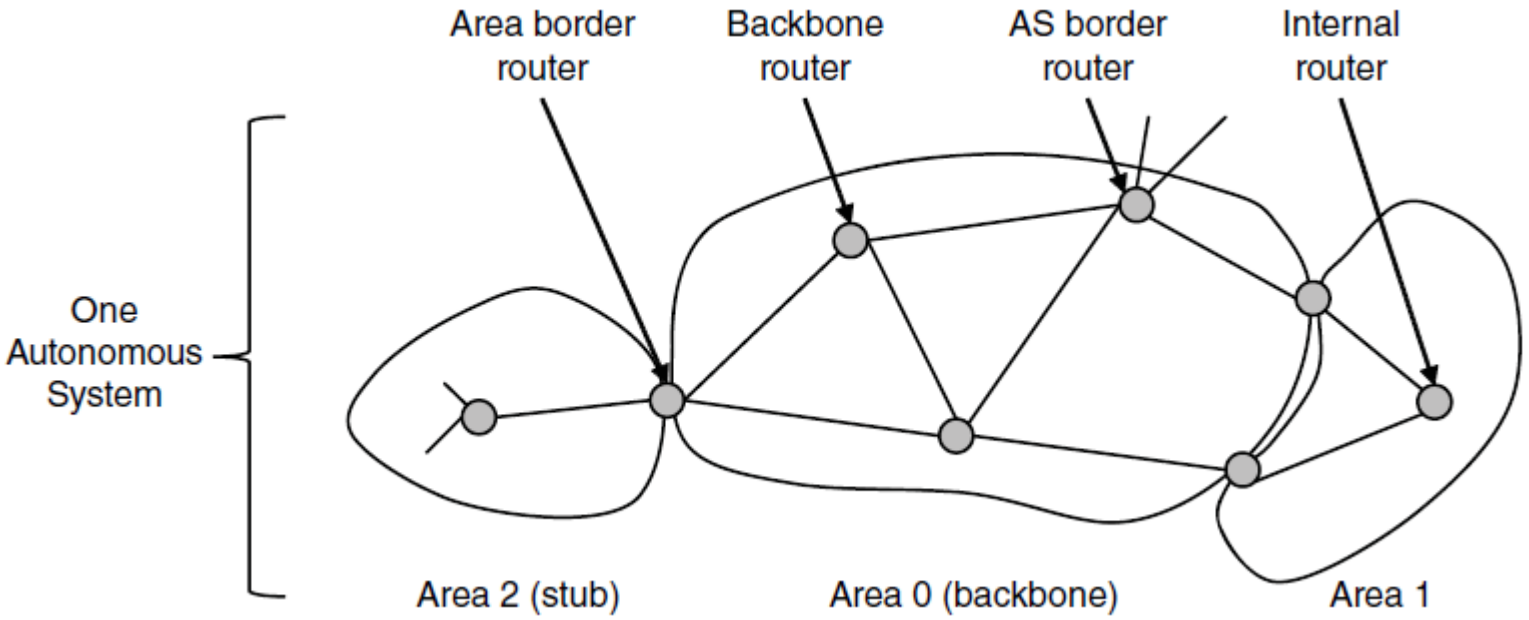
An autonomous system

OSPF—An Interior Gateway Routing Protocol



A graph representation of the previous slide.

OSPF—An Interior Gateway Routing Protocol



The relation between ASes, backbones, and areas in OSPF.

OSPF—An Interior Gateway Routing Protocol

Message type	Description
Hello	Used to discover who the neighbors are
Link state update	Provides the sender's costs to its neighbors
Link state ack	Acknowledges link state update
Database description	Announces which updates the sender has
Link state request	Requests information from the partner

The five types of OSPF messages

LINK STATE ROUTING

Each node in domain has entire topology of domain – list of nodes & links, how they are connected including type, cost (metric), and condition of links (up/down) — node can use Dijkstra's Algo to build a routing table.

Link state Routing is based on assumption that global knowledge about the topology is not clear, but each node has partial knowledge.

whole topology can be compiled from partial knowledge of each node.

Building Routing Tables involves 4 steps.

1. Creation of state of links by each node, called Link state packet or LSP.
2. Dissemination of LSPs to every other route, called flooding, in efficient & reliable way.
3. Formation of shortest path tree for each node
4. Calculation of routing table based on shortest path tree.

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Creation of LSP

LSP are generated on 2 occasion

1. Change in topology of domain
2. On a periodic basis. (usually 60 min or 2 hrs based on implementation)

Flooding of LSP

After a node has got LSP, it should be shared with all nodes, not only to its neighbours. Process is called flooding.

1. Creating node sends copy of LSP out of each interface
2. Receiving node compares it with copy it has. If newly arrived LSP is older than one it has (found by seq no) it discards the LSP.
   If it is newer, then
   a. Discards old LSP, keeps new
   b. sends copy of it to everyone, except from where it came from.

Formation of Shortest Path Tree : Dijkstra Algo.

Topology is not sufficient to find shortest path to every other node, ∴ shortest path tree is needed.

Tree is a graph of nodes & links, one node is called the ~~root~~ root.

OSPF (Open Shortest Path First) protocol based on link state routing. Domain = autonomous system (AS)

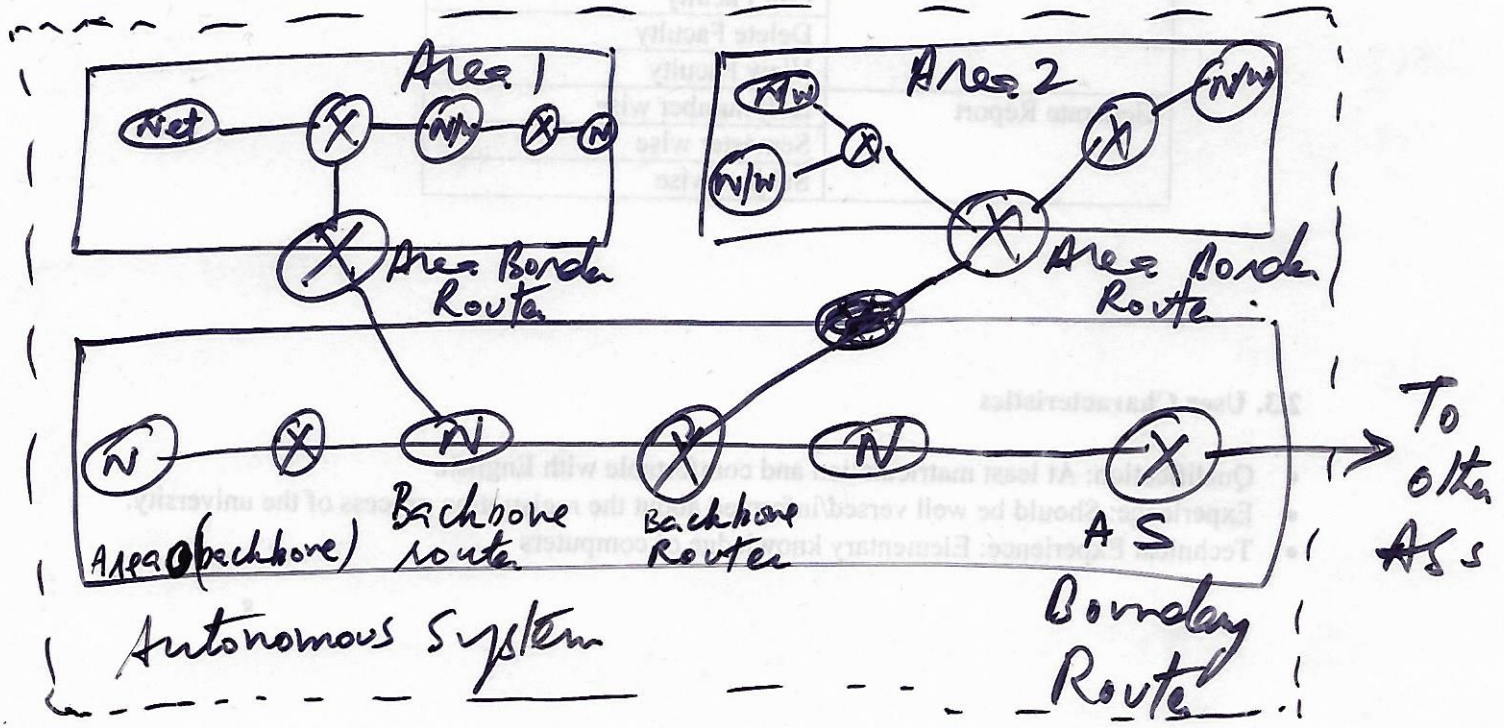
In OSPF AS is divided into AREAS (collection of nws). Routers inside area flood area with routing info.

At Border of area we have Area Border Routers, which summarize info about the area & send it to other areas.

Special Area = Backbone, all areas inside AS must be connected to Backbone (Area 0)

Routers inside Backbone are called Backbone Routers. Backbone router can also be AREA BORDER ROUTER.

Each area has identification.

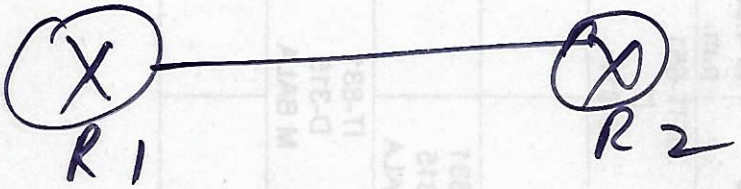


Metric in OSPF is type of service (min delay, max thru put)

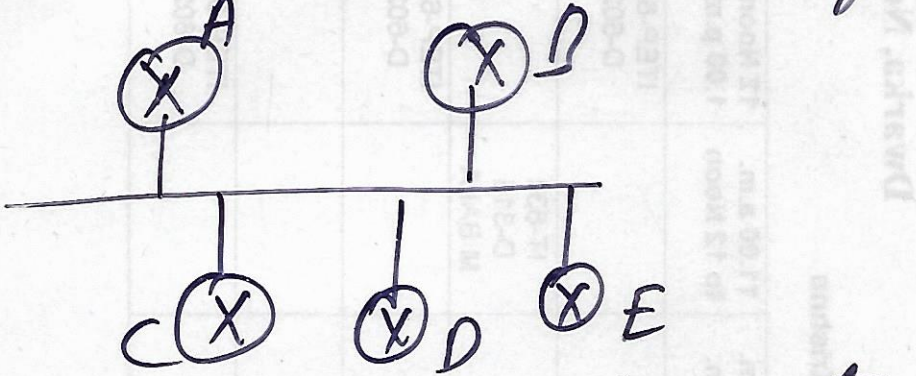
- A router can have multiple routing tables each based on different type of service.

TYPES OF LINKS

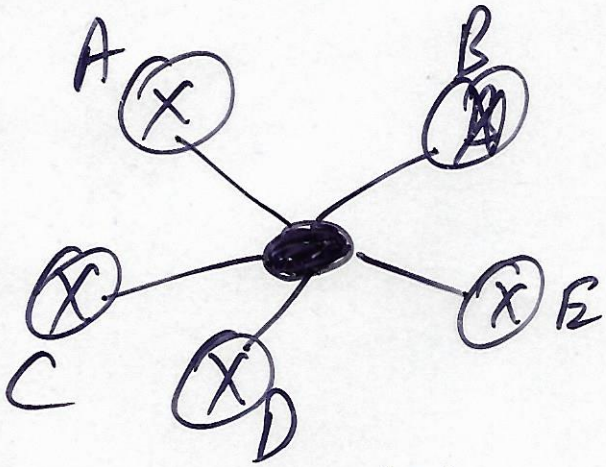
(a) Point to Point connects 2 routers directly.



(b) Transit Link is a N/w with several routers attached to it. Data can enter any router & leave any router. Each router has many neighbours.



Actual Connection



Representation

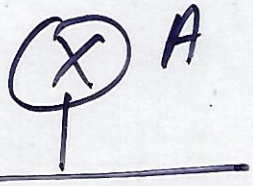
N/w itself is represented by node to show connection of each router with others. One of routers takes the role of designated router. N/w is not a router.

Each router has only one neighbour, the designated router (N/W).

No metric from designated router to any other node. ∴ designated router represents N/W.

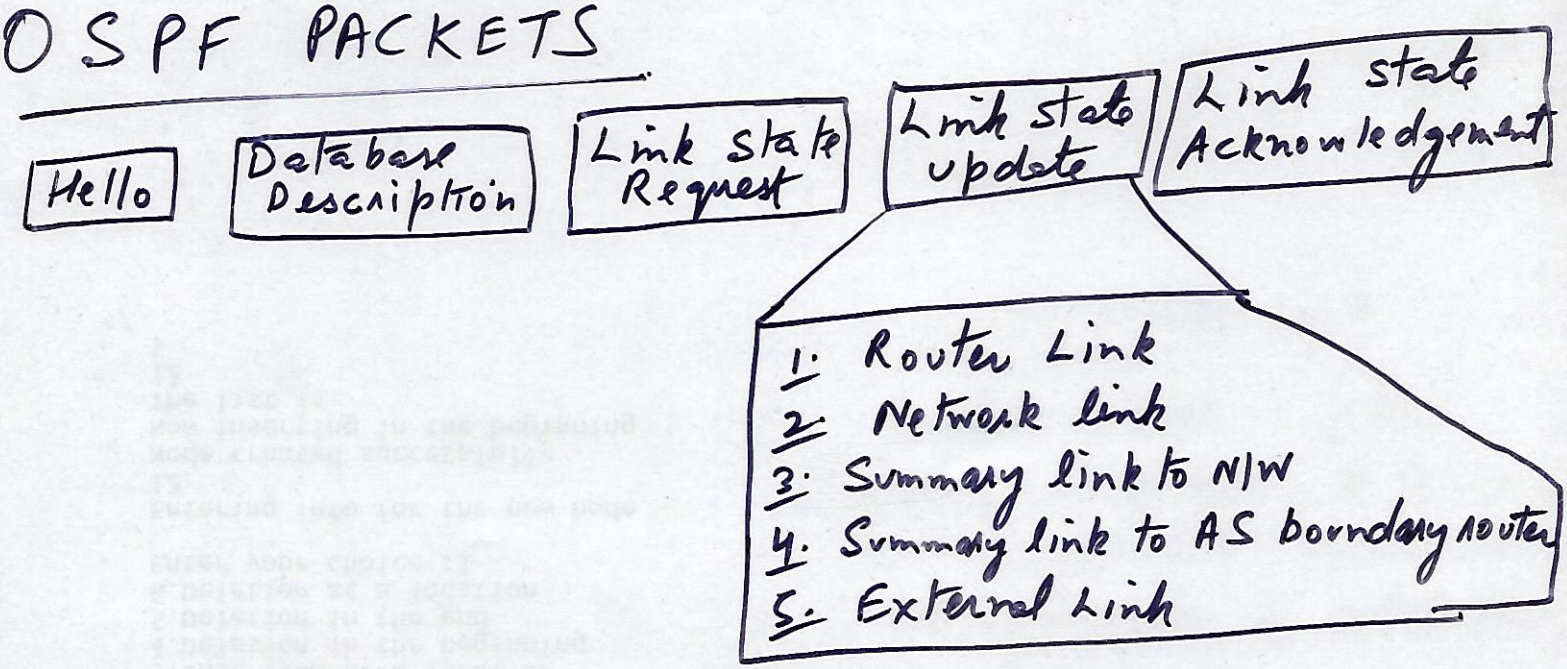
STUB LINK connected to only 1 router.

Packets enter & leave thro' same router.



VIRTUAL LINK Link b/w 2 routers is broken, the administrator may create a virtual link b/w them via a longer path that probably goes thro several routers.

OSPF PACKETS



All OSPF packets have common header

PATH VECTOR ROUTING (PVR)

Distance vector routing encounters instability if there are more than few hops. Link state routing need huge amt of resources to calculate routing tables. It also creates heavy traffic ∵ of flooding.

There is need for 3rd protocol called ~~BGP (Border Gateway Protocol)~~ path vector routing.

In PVR we assume one node in each AS acts on behalf of entire AS. Let us call it <u>speaker node</u>.

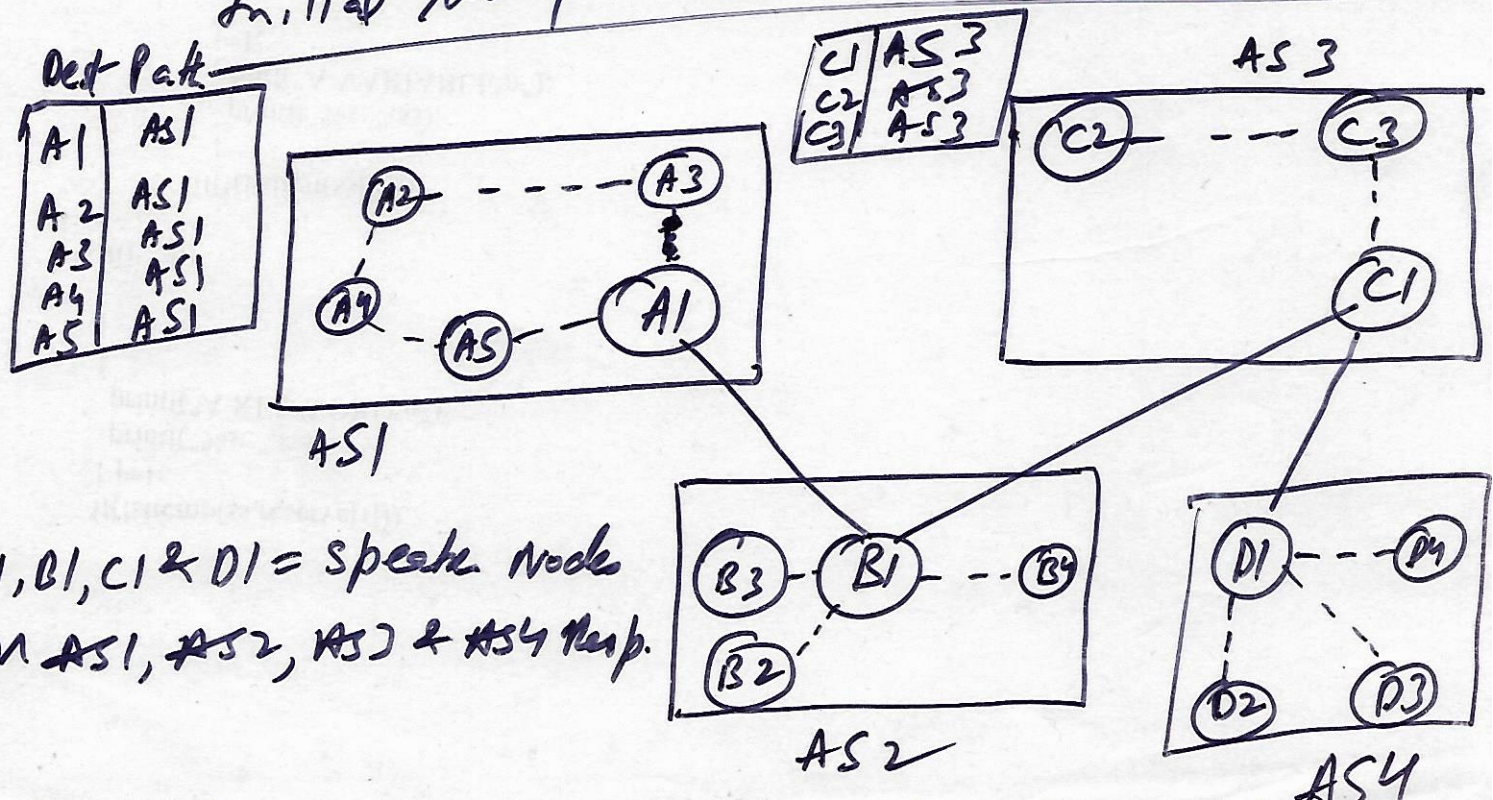
Speaker node in AS creates routing table & advertises it to speaker nodes in neighbouring ASs.

Only speaker nodes can talk to each other.

Speaker node advertises path, not metric of nodes, in AS or other AS.

<u>INITIALIZATION</u> At the beginning, each speaker node knows only reachability of nodes inside AS.

Initial routing Tables in path vector routing



A1, B1, C1 & D1 = speaker nodes for ~~AS1~~, ~~AS2~~, AS3 & ~~AS4~~ resp.

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SHARING & UPDATING speaker node in an AS shares its table with immediate neighbours.

POLICY ROUTING

~~LOOP PREVENTION~~ when router receives message, it can check the path. If one of AS listed in the path is against its policy, it can ignore that path & that destination. It doesn't update its routing table & doesn't send message to its neighbours.

~~POLICY ROUTING~~ LOOP PREVENTION when router receives a message, it checks whether its AS is in path or not to the dest. If it is, looping is involved & message ignored.

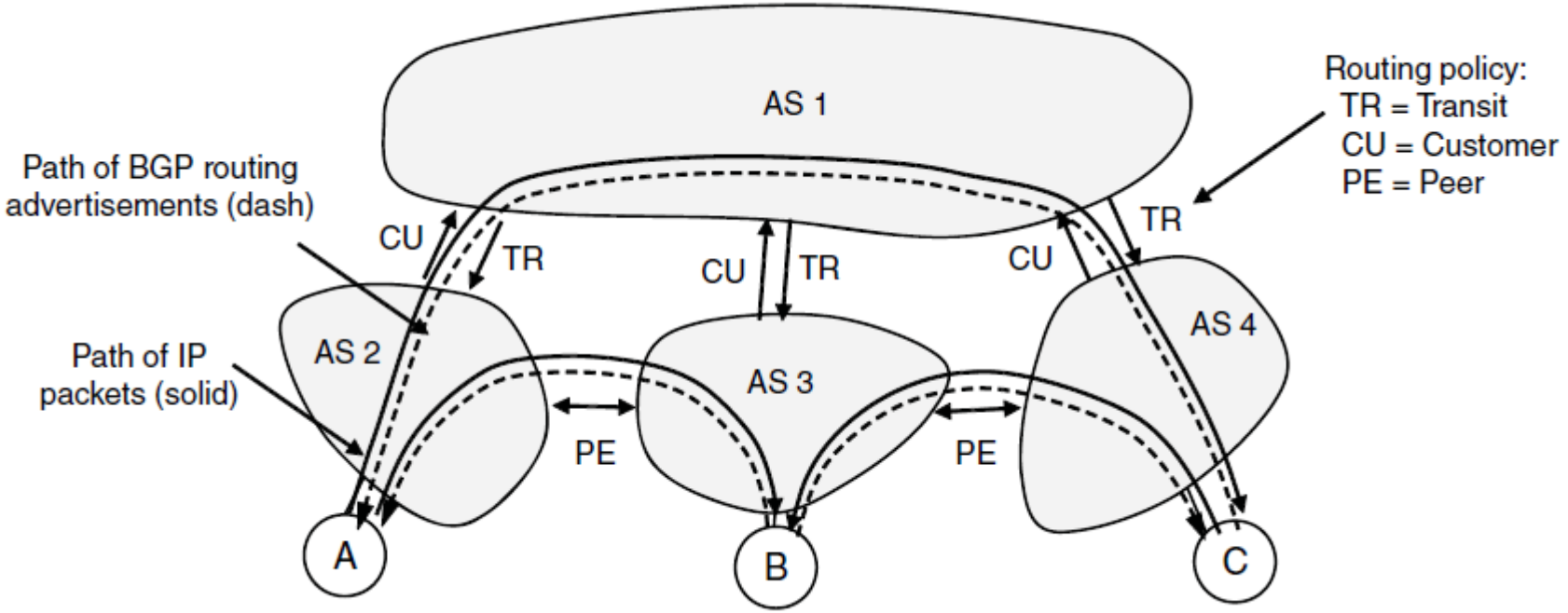
OPTIMUM PATH path that fit the organization. We can't choose a path with lower no of ASs (assuming more that 1 path exists to a dest) as other factors like safety, reliability & security are also to be considered.

BGP—The Exterior Gateway Routing Protocol

Examples of routing constraints:

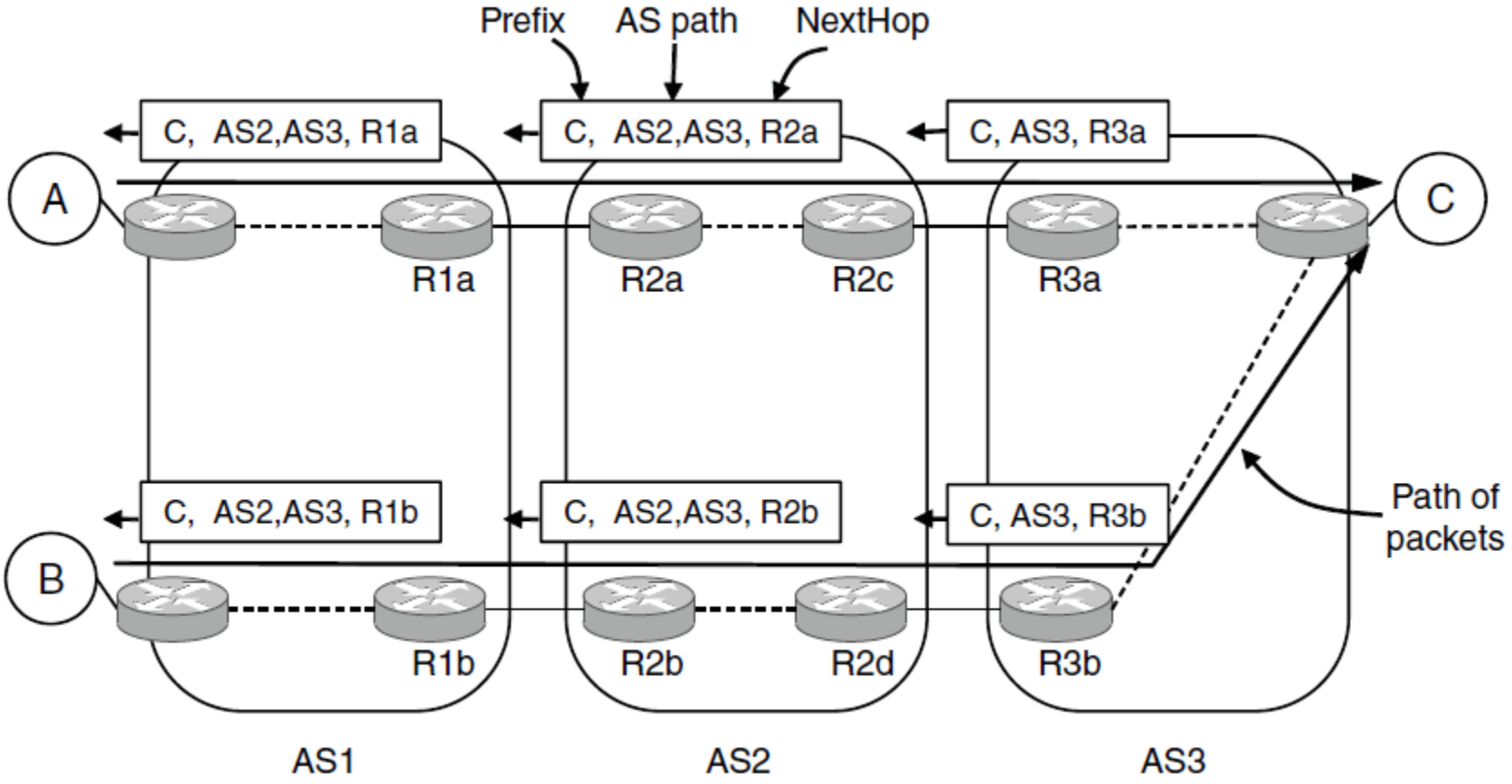
1. No commercial traffic for educat. network
2. Never put Iraq on route starting at Pentagon
3. Choose cheaper network
4. Choose better performing network
5. Don’t go from Apple to Google to Apple

BGP—The Exterior Gateway Routing Protocol



Routing policies between four Autonomous Systems

BGP—The Exterior Gateway Routing Protocol



Propagation of BGP route advertisements

BGP

ASs can be divided into 3 categories

(a) Stub AS: Only 1 connection to other AS. Hosts in AS can receive data from hosts in other ASs. Data traffic can't pass thro' stub AS.

(b) Multihomed AS: more than 1 connection to other ASs. It can receive data from more than 1 AS & send to more than 1 AS. Doesn't allow data from one AS to other AS to pass thro' it.

(C) Transit AS is multihomed AS that also allow transit traffic. Example of Transit AS are National & International ISPs.

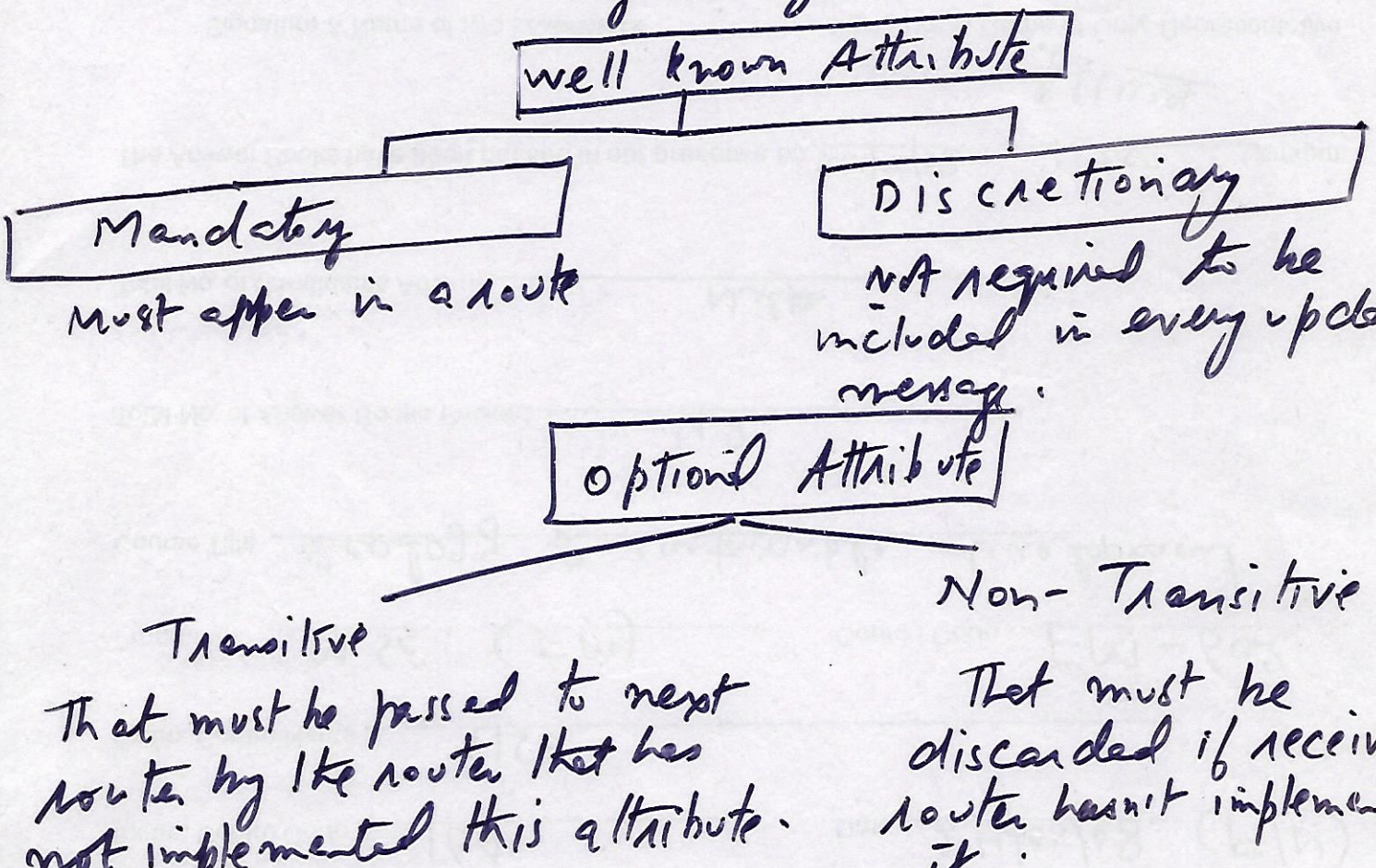
BGP uses a prefix to define dest address i.e uses CIDR. The address & no of bits (prefix length) are used in update messages.

PATH ATTRIBUTES Path presented as a list of ASs is in fact a list of attributes. Each attribute gives some info about path.

2 Types of Attributes

(a) well known attribute is that every BGP must recognize

(b) Optional Attribute that needs not be recognized by every router.



BGP Session Session is a connection b/w 2 BGP routers for exchanging info and are called semi-permanent connections as they last a long time until something unusual happens.

EXTERNAL & INTERNAL BGP

2 Types of sessions called external BGP & internal BGP.

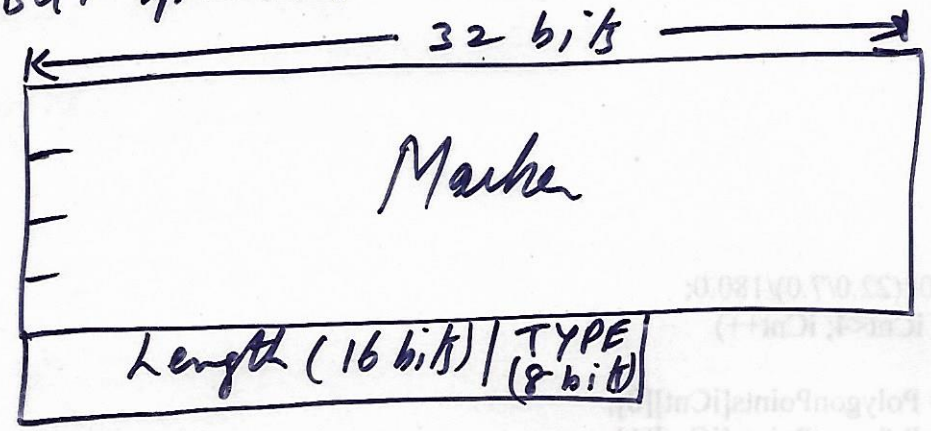
E-BGP ⟶ Exchange info b/w 2 speaker nodes of 2 ASs
I-BGP ⟶ " " " " routers inside an AS.

TYPES OF PACKETS

(a) Open (b) Update (c) Keepalive (d) Notification

PACKET FORMAT

All BGP packets share same common header.



BGP COMMON HEADER

Marker 16 byte marker field reserved for authentication

Length 2 " field defines total length of message including header

Type 1 byte field defines type of packet. Value 1–4.

ENCAPSULATION

BGP messages are encapsulated in TCP segments using well known port 179. So no need for error & flow control.