Part 3

Q1. Which is the main classification of customers in telecommunication market.

① Residential & business users.

Q2. Describe important services & features offered on operation of WAN for Packet data transport. which type of Packet switching technology is well suited for this requirement.

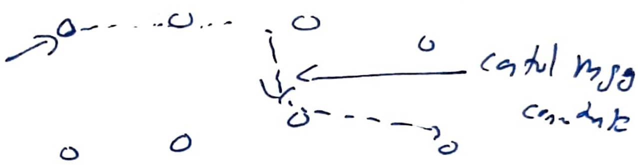
⇒ features are VPN's, traffic engineering & Resilience (Protection restoration).

which technology :- MPLS, segment routing. MPLS is well suited technology.

Q3. two main approaches setting up connection in connection oriented network.

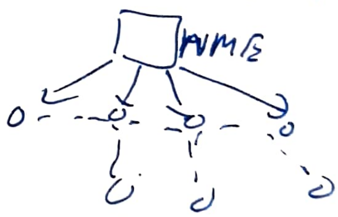
⇒ two use either control plane or management plane.

control plane. → our nodes will exchange control message with neighbour nodes. & then the connection is made, i.e. MPS connection table.



② using management plane.

The network management entity talk with all nodes to setup connection.



control plane was dynamic flow.
Short term

management plane was static long term connection ~~Permanent~~ Permanent.

Q4 Function of Label edge router :- ? LER :- ⇒ border node for a MPLS domain it forward Packets based from MPLS domain, inserting & removing the labels to Packets entering & going out from the domain.

+ ingress ~~LER~~ LER will analyze the Pkt, classify the Pkt, add the MPLS label & forward to Next LSR. + In MPLS Packets are forwarded using label.

* egress LER, remove the label & forward the Pkt on the IP destination.

2 routing table → ① ~~Standard~~ ~~IP table~~ IP routing table
② label lookup table. ∈ mpls labels

Q5 Describe two mechanisms that can be used by the coexistence of traffic forwarded at IP level & traffic forwarded at MPLS level ? (2)

⇒ 1 - a control label 0000 is assigned to regular IP Packets to indicate that they must be handled by IP forwarding.
If different than 0000 then it is MPLS label.
2. It is based on protocol field :- we use protocol field to differentiate btw. IP or MPLS Pkts. it is Possible to achieve Protocol multiplexing at layer 2

Q6 In MPLS network, which is the difference betn hop-by-hop LSPs & explicitly routed LSP?
⇒ If we choose same path as IP routing Path. Called Hop by Hop Path.
The MPLS Packet follow the Path chosen by the IP routing Protocol used in the network (OSPF, IS-IS etc)
in any case we create tunnel till destination.

2) Explicit LSP → The MPLS Pack follow a different Path with respect to the one selected by the IP routing Protocol used in the network.

Q7 Describe the concept and the usage of VRF (VPN Routing and Forwarding) routing tables in MPLS.
⇒ inside every Provider edge there is routing table (VRF table). (VPN routing & forwarding).
Routing table is separate for separate VLN.
FEC is implemented in VRF. corresponding tunnel to reach to destination.
we have do forwarding in 2 steps.
In MPLS we can use 2 labels.
So L_1 will be popped & send to VRF yellow.
& initial label is used only to know which is the correct VRF.
The IP can be same but label tells us that whether it is yellow or green one. Advantage :- Dont need to make tunnel once, not changed when customer is added.

MPLS forwarded packets & BGP distribute the routes.
here customer edge routers talks with Provider edge routers about the Paths.
Doing so PE give new instance of routes.
2 routing table - VRF VPN routing & forwarding ←
② global routing table ← inside operator network. ← operator keep this separate

Q8 Describe the MPLS "Link Protection" and "Path Protection" mechanism ~~Explain~~ the working Principle of the two approaches

=> The Link Protection mechanism Protects the traffic of all LSP that cross a Link in when there is failure. on a Link, the upstream node detects it & reroute all LSPs onto the backup tunnel LSP, which are setup previously. (N.B each link has backup tunnel.

○ Path Protection:- mechanism Protects a specific LSP from one edge to other i.e from ingress LER to egress LER if there is a failure on a link the failure information is sent backed to ingress node, that can then reroute the specific LSP on a backup LSP. The back up LSP is set only for the specific LSP that need to be protected.

More resources are needed in Path Link protection as all the Links are protected & less no of resources as the ~~Low cost of~~ csPath is protected.

Q9 :- Explain difference between routing function & forwarding function in IP networks.

=> Routing function:- The operations, Protocols & algorithms related to taking the decision of where to forward the Packets.

② Forwarding function:- The Process of sending a Packet usually the decision has already been taken

Routing function is responsible for determining the best Path for each Packet to follow through the network. This is done by many using routing function use algorithms such as OSPF BGP-RIP. & manage routing table

Forwarding function:- is responsible for physically forwarding the Packets along selected Path. Forwarding function uses the information in headers. Such as IP address to determine the next hop to send packet.

Q10. explain difference between RIB & FIB.

=> RIB is a database used by a routing protocols to store all the routing information, while FIB is a database used by forwarding devices to forward Packet to their destination based on the information in the RIB.

Q what are MPLS label Switching & label distribution Protocol.

LSP → A connection from source to destination you can through. Label switch router.

LDP → when we use control mpls to create the connection that Packet. is label distribution Protocol (control Packet).

Q12 Routing in IP & MPLS network.

→ In IP when router receive the PKT. / The router examine the destination IP address of the Packet & Looks up in the routing table to determine the next hop to reach destination.
The router forwards the Packet on the next hop based on routing info in routing table for. Specific has Low control.

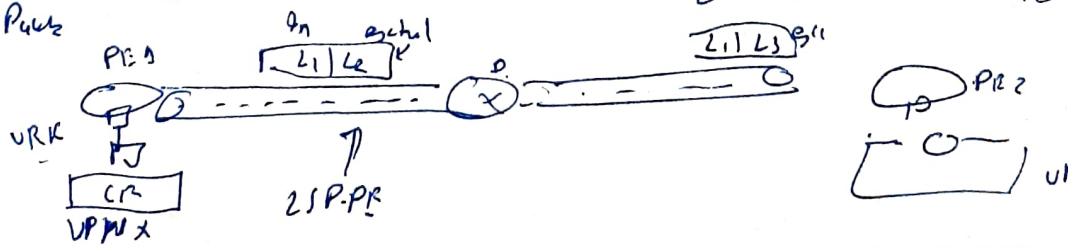
→ In MPLS the. Routing is done by Label Switch. Router. to deliver mpls Packet from. Source to destination.

→ In ingress node the label is inserted on the Packet. The Packet is forwarded to Next LSR based on the Label. The label are changed at each LSR label Switching.
at last the. LSR remove the. label & send the Packet to the destination.

PoPP

Q13 Consider an VPN offered by an Operator using the BGP/MPLS models. How many MPLS Labels are used to carry a Customer Packet with Private IP inside the Operator backbone? what is role of the external label & what is role of the internal label?

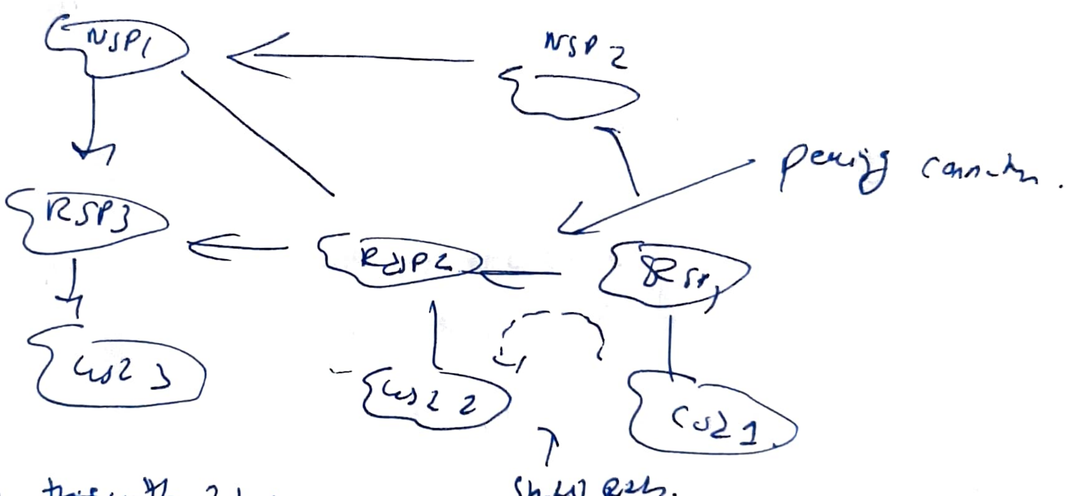
⇒ we use two labels in mpls.
1 is internal label & the external label.
1st label will be PoP & send to VRF by.
internal label is used to only to know which is correct VRF.
* External lable - identify the PE-PE LSP.
internal label :- used by destination PE to select the outgoing interface over which to send the Packet.



The outer label is used to route customer traffic from the ingress PE router to egress PE router. while inner label is used to deliver the customer traffic to correct destination within the customer site

Q14 Classify the OSPF routing protocol: Is it distance vector or link state IS-IS or EGP or IGP.
⇒ OSPF is IGP protocol in single AS system.
OSPF is an example of link state protocol.

Q15 Consider interdomain routing problem & discuss the following diagram which is the problem that regional ISP2 may face. What is related to traffic from cust 1 to cust 3? Which would be preferred policy for this type of traffic? How can ISP2 behave in order to implement this preferred policy.



For cust 1 to 3 transit with 3 hops is the shortest path.
Customer pay RS1 & RS1 pay to NSP1 to get traffic over Internet.
Regional ISP don't pay to each other to have good connectivity to customer of each other.
If cust 1 to cust 3 Regional ISP2 have transit but there is no advantage to RSP2. So it it do not want to work as transit.
So BGP also handle this complexity so no of hops will be taken into account by creating the commercial point of view.
So will have to use transit services provided by NSP1.

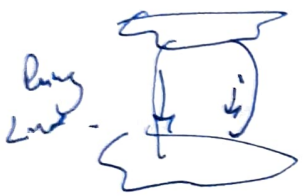
Q16 In BGP dosy how it is possible to influence the routing of Packets outgoing from an AS system ?
How this is Possible the routing of Packets that are incoming to an AS system 2 on which of the two type of traffic (outgoing, incoming) the administrator of AS System has a greater control ?

⑥

⇒ Inband routes → tells where to route the traffic. Here routes from other AS (How traffic goes out).

outband routes → tell how the traffic goes in.
we change the attributes how the traffic goes is controlled.
BGP gets inband routes & I change the Paths on some condition.

Parameters Like. Network next hop, → with AS Path length. Then we modify using Policy. Then we apply algorithm Like Bookeeping.



Backup Forces traffic through Ring Link when link is down.
So AS system has great control over the traffic that goes out by selecting the route or Policy.

* Inband traffic :- Going the traffic here from other AS system.

Like we can increase the hop to exit the AS Path. So the AS I will choose the shortest Path to send the traffic. but this always does work)
i.e we cannot control both way so we call as Asymmetric.
How control both ways then it is called Symmetric routing.

Q17 Describe the main category of classification of routing protocol as how IP network Consideration include Path is used & type of routing algorithm that is used.

⇒ When the routing Protocol are
Interior Gateway Protocol IGP
IGP Inside AS

Exterior Gateway Protocol EGP
Interior routing AS.
↓
BGP

Distance Vector Protocol
↓
RIP
distance vector

Link State Protocol
OSPF
IS2
Dijkstra.

Link state → node knows the state of links also the cost of link.
& all nodes needs to know the updated info.

distance vector:- full view is not known.
They use bellman Ford algorithm. we propagate info to other nodes.
So we get best path without knowing full topology.
has 3 info: cost of edge, other nodes info. (1) towards other node cost
(3) next hop towards the other node.
Routing table have the information of destination address.
& address of the best route. in the path towards destination.
also cost towards destination

OSPF link state: info is distributed using flooding. Router exchange msg with other routers.
"hello msg".

Eg. LR Link state protocol is having eg of OSPF it relies on Dijkstra algorithm.
each router knows the state of all network.
The routing changes are propagated quickly when they are notices using flooding mechanism.
Faster convergence with respect to distance vector. have detail view of topology have cost
Good for large size network. & is complex. Link state & network view update.

Distance vector → eg RIP → relies on Bellman ford algorithm. Routing information Protocol.
Each router informs only its neighbours about its routing table.
Routing changes are periodically distributed eg easy to use. They have small impact.
on link capacity.
used for small sized network & easy.
they have only distance & next hop to reach to destination in their routing table

BGP (Border Gateway Protocol)

BGP is based on TCP while OSPF is on layer 3 packets.

(EGP) with TCP we can establish BGP session with remote node with this.

in this session we can exchange info i.e. vector of AS paths.

4 types of BGP msg:
- open → establish a peering session.
- keepalive → handshake at regular intervals.
- notification :- shuts down a busy session.
- update :- announcing routes or withdrawing previously announced routes.

AS number is 32 bit.

Number of route = Prefix + attribute value.

In BGP the loops are avoided by AS Path attribute.

The routing Problem

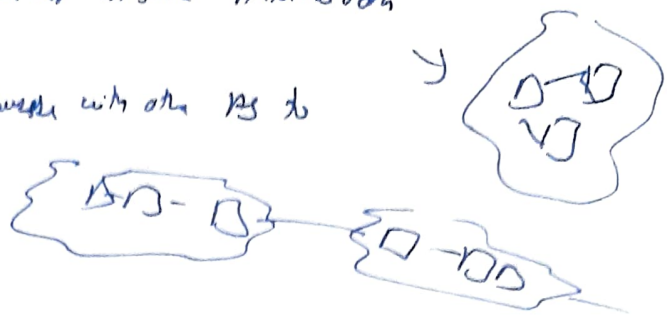
In Packet & ckt based n/w there is Problem. That router needs to decide what to send/pick to destination.

(1)

no of AS routers in.

intra-means choose the Path in same Autonomous System

inter domain means how you change with other AS to reach destination



In Layer 2 level the flooding is done so routing Protocol work here mostly done.

to Solve routing Problem: we use different routing algorithm.

Routing → the decision making how we choose decision which is next hop we receive the pkt

Forwarding:- → The Process of forwarding a packet. decision has already been taken.

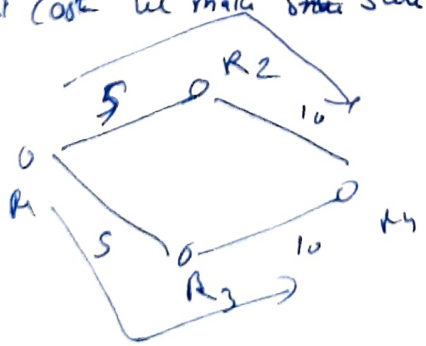
* with Spanning tree → we have Possibility of calculating all the Paths to the node.
  * BFS algorithm is working only with unit cost i.e 1.
* we have weighted graph.

Bellman Ford- Assume knows all topology & find shortest Path

dijkstra -> useless effort for same result. ← Best: Possible if we know the n/w & used in Routing. the which distribute all the information.

dijkstra → need that the node have all info about network. cost of nodes

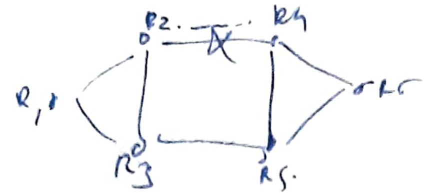
with minimal cost we make sure that there are no loops.



Both Path are minimal cost Path
So which makes sure we will not have Loop

Real reason to have minimal cost in spanning tree is to avoid Loop

* All nodes share same vision of topology. no loops
* If nodes don't have same vision then we can have Loops



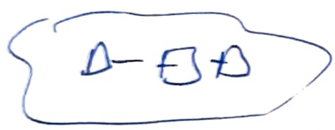
So if failure there is now vision to Router R2 & will forward to R4 with new R3 & R5. (2)
If R3 don't have info then it will forward to R2 so R2 & R3 will send to each other.
So we need that the information to be send to R3 also.

~~when there is~~
The goal of routing protocol is to be efficient to solve problem.

Routing protocol for IP products :- dynamically distribute the Routing information & so information is updated when there is change.

where two types of problem in routing. i.e how we find path in one domain AS or how to find the path in different domain AS.

Intra AS
interior gateway protocol



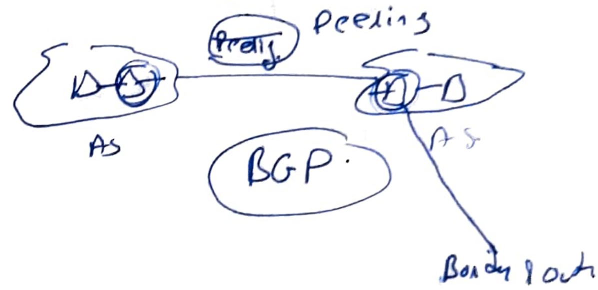
~~RIP~~
distance vector protocol

RIP

Link state protocol
OSPF
IS IS

Every domain will have its own protocol for routing inside its own n/w.
where freedom to choose the solution which best for the domain.

inter AS
exterior gateway protocol



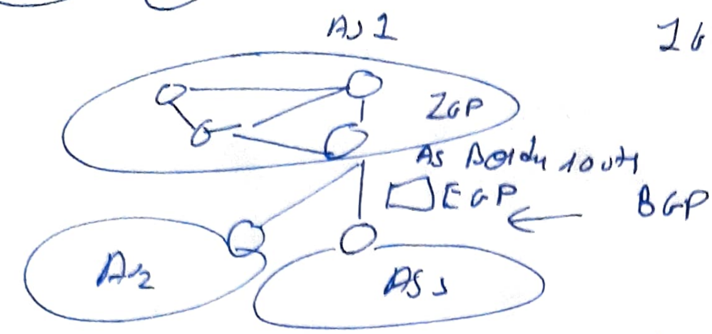
if link working or node

Link state :- nodes know the state of links also the cost of link.
& all nodes needs to know the updated info.

Distance vector protocol :- Full vision is not known.
They use bellman ford algorithm there is a solution in which we propagate some info to other node.
So we get best path without knowing full topology

IGP EGP

IGP between A single AS system.



Border gateway protocol for border routers.

IGP have 2 protocol.

RIP	OSPF
① distance vector	Link state
② Bellman Ford	Dijkstra.
③ give info to its neighbours. about routing table.	③ each router knows the state of all n/w.
④ Small size n/w like IOT Small system	④ OSPF might used for hierarchical system.
⑤ The convergence is slow	⑤ Faster convergence ← Dijkstra

OSPF is same as link state

Routing information Protocol. ← every nodes exchange info with neighbour node.

two nodes are neighbours when they are connected to same n/w or Layer 2.

Each node knows 3 info.

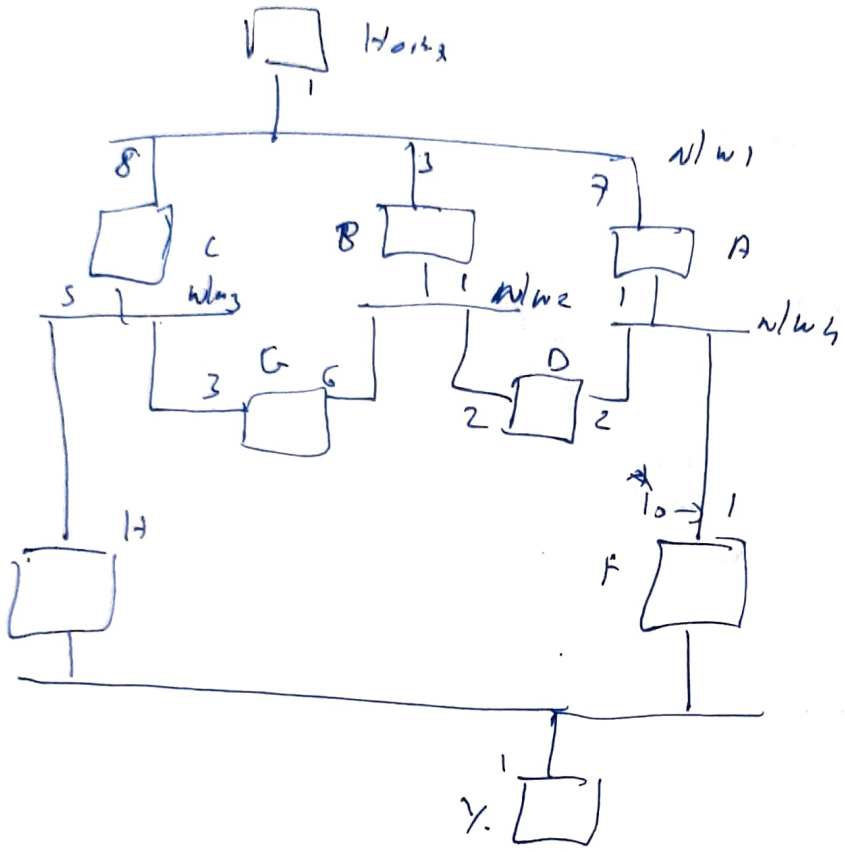
cost of the edges outgoing from node. | Minimal cost towards the other nodes | next hop towards the other n/w.

Router has limited view of what happens to the. Prefix.

Rer

Routing table. :- contain Row for each destination n/w.
Row contain identification of the destination n/w.
& the address of the first router in the Path towards destination i.e (next hop)
also cost of the Path towards the destination.

RIP Cont



Dist X to B = 1
Dist B to X = 5

Nodes will get the updated info ✗ & then they will find the new Path to get to destination

---

OSPF Link state Pkt : info is distributed using flooding mechanism.

Router share exchange info with other routers with "hello" msg

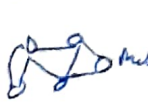
Packet that carries the Link State are called as Link state Packet. (LSP)

LSP are distributed to all other routers. will hello msg are exchanged to Point to Point only with neighbours.

Link state Packet is sent when new hello msg is received from new node or link is ~~lost~~ lost then or after 2 minutes the Link state Pkt is flooded.

LSP is flooded on all interface only the one which they send except the one.

* As we know flooding in mesh is Problem.



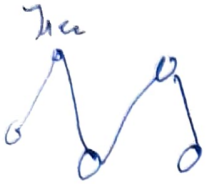
Routers will receive LSP then flood but if it receive the copy it will discard the LSP copy. only

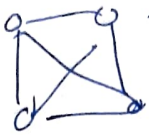
Flooding mechanism (1/2)

when routers receive the LSP. then info is added to routing tables (DB).
also the new flooding is done to update the link information.

Flooding mechanism (2/2)

Properties of flooding -
all possible paths from origin to destination is efficient.
it is very reliable.
atleast one copy of the LSP will follow the shortest Path.

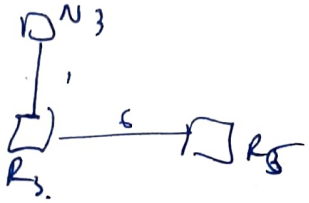




Paths have many msg of flooding.

OSPF : network topology (2/2).

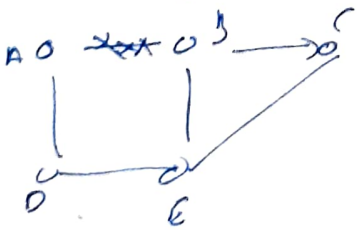
Spanning tree & Routing table



Building routing tables (1/2)

* Routers get in contact with neighbour routers using hello msg. This msg are not flooded
* only LSP msg are Propagated to flood
* Solver send LSP msg and get all vision of network topology.
* and in Steady Steady state all nodes have the full vision of the whole network.
and on topology database the routers build the routing table.

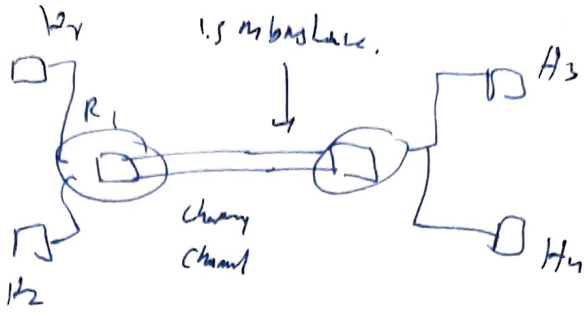
OSPF Example (3/3)



If A-B link is failed the all the LSP msg are flooded & all nodes know the A-B is failed
& create the LSP of msg.
both we need quick destination so we need to pay the Price of this msg offline. & new routing tables are made.

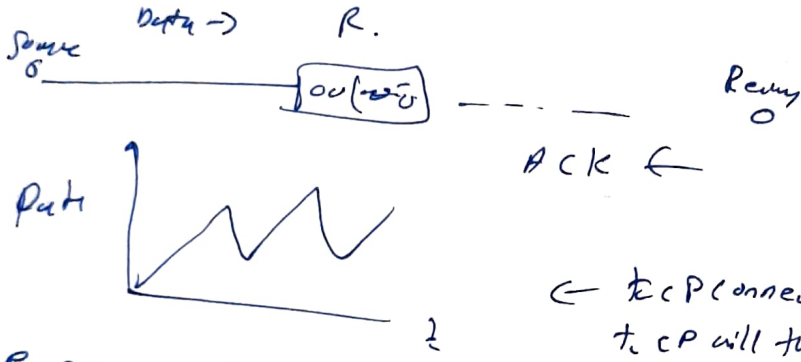
Now EGP Now the policy is done in whole world. i.e BGP.
work.

Goto QoS in IP network.



Best effort model.

Qos is like the operator says that you can send up to 2mbps with no problem
TCP protocol adapt the sending rate to the available rate.
(capacity)
If you have low capacity default is slow and take lot of download time.
* If not enough capacity then the packet may be lost or delayed.



TCP source understand the congestion & understand that the packet is lost
when new source will come in then same capacity then they will adapt.

← in this way ← So tcp is very good model / All station can increase & reduce the capacity to get the best.

The application with priority will take the whole capacity that is why we need policy.
To measure how much resource our application needs & to be sure the capacity is using by them is. okay or not or they are using more capacity.

(R3) * we can also split like in client n/w. we can make a fixed the flow capacity like. tcp 1mbps. & . os to other
this is not good because it is fixed so some time its waste capacity.

(Pg) A new flow can enter n/w, style call admission.

Usual

QoS for n/w which.

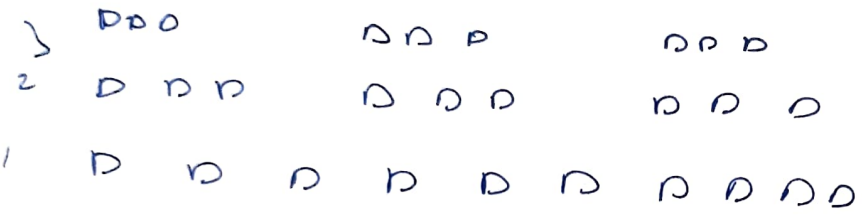
Packet classifying | is shaping. scheduling Policing | Leaky bucket algorithm. | call admissions

Scheduling: How can Router decide which packet to tx

↑ FIFO / Priority queue.
↑ Round robin / WFQ
↑ weighted fair queuing

* Buffer size

Small buffer low delay.
Large buffer ⇒ increase delay.



different bucket sizes with same no of packets.

Flows that can regulate are good for n/w like 2
but the bursty with Lot inputs with low time both outgoing will not be capable of seeing it like no 3 & you will drop the pkt
So like small buffer will drop the pkt
but large buffer will have delay.
So we need to solve this.
which can be done with token bucket algorithm.

* when flow sent some pkts & find the bucket empty that is bursted pkts so this is out of profile.
so we can take different action if it is out of profile.

* Assume the token bucket parameters to police the flow.

R ⇒ = average transmit rate.

$R_{min} = R$

How the dimension of the bucket size B. Assume you have burst to at rate R_b.
then $R_c = (R_b - R)$ at which Bucket is emptying

$$T_c = \frac{B}{R_c} = \frac{B}{(R_{b}^{\text{Rate at bursty}} - R_{R}^{\text{rate of token bucket}})}$$

All AS are connected with BGP Protocol.

~~Gathchar2~~ Gain n/w

Routers interact in same. & this network needs to ~~interact~~ interact with other.

Exchange with IXP internet exchange point or Peering point

Many operator have their n/w and they need to exchange the pkts to other like WP & Google they it needs to go to Google or WP so this N/w need to give pkts to exchange point.

In single domain IS-IS routing protocol is set up for routing in IAS.

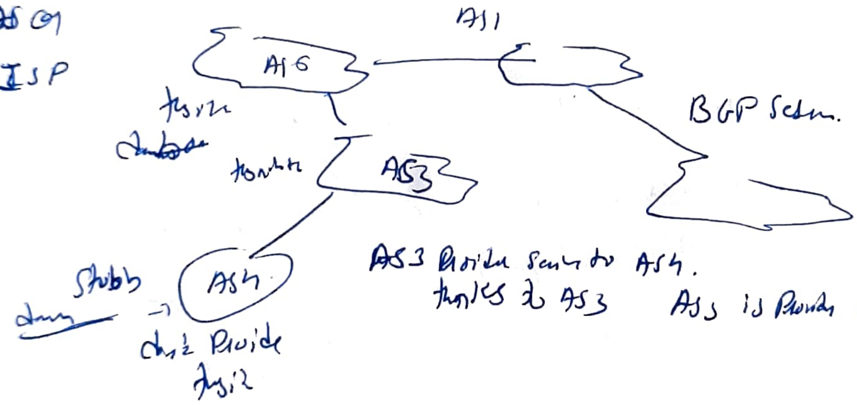
* How multiple domains like Gain are interconnected.

-d.vorus.ro.nz.   17 routers to ~~reach~~ reach destination.

Trace route tool.

~~Intra~~ inter domain (EGP) BGP

Tier 1 AS or
Tier 1 ISP



AS3 Provide service to AS4.
thanks to AS3   AS3 is Provider and AS4 is customer.

Link state - node has view of all links in n/w
Vector :: nodes have little information.

intra domain - use link state.

	Link state.	Vector.	
IGP	OSPF, IS-IS	RIP, IGRP	← intra domain.
EGP		BGP	← inter domain

in BGP we advertise the vector of path or path to be used to the destination.

if I need to reach 135.207.0.0/16 then this is the sequence of AS path you need to follow

Stubb is not transit n/w it is the final part of system

BGP with tolls

Path vector

N/w 1 -> AS Path..
N/w 2 -> AS Path
N/w 3 -> AS Path.

this tells Path of AS n/w and tell how to reach.

exchange of info with AS system is complex & single AS in independent System.

BGP is based on TCP. while OSPF is just on layer 3 PKts.

with TCP we can establish ~~BGP session~~ BGP session with remote node with this session we can exchange the info i.e vector of AS Path.

* 4 types of BGP msgs

① Open -> establish a peering session.
② Keep alive -> that share at regular intervals
③ notification -> shuts down a peering session.
④ update: Announce new routes or withdraw previously Announced routes with drawn.

Announcements of (attribute) => Prefix + attribute values.

AS number = 32 bit.. Some more AS system

before 2007 it was 16 bit = 65536 only.

* We can talk about

default ~~free~~. zone -> ~~it is so.~~ If ACK don't belong to the specified 10 N/w then PKt send to default route.

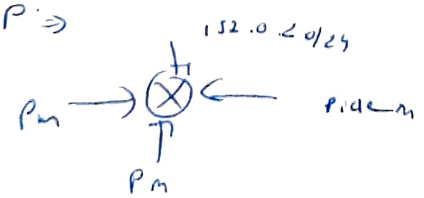
So How many different Prefix we have in default..

In small n/w we have default reachable route

In the case of internet we have default free zone

dual stack: some are using IPv6 and IPv4. Some of the service using this two technology:

* In BGP =>



node

If multiple routes to the same Prefix a BGP System must pick at most one best route. based on Policy

* could could reject all.

Once decision taken it also forward to other.. nodes neighbour.

AS Path is most important, most important goal of routing protocol; which is problem in routing.
-> it is Loops

i, if routing is not working then Pack with loop.

The reason to choose shortest distance is to avoid Loop.

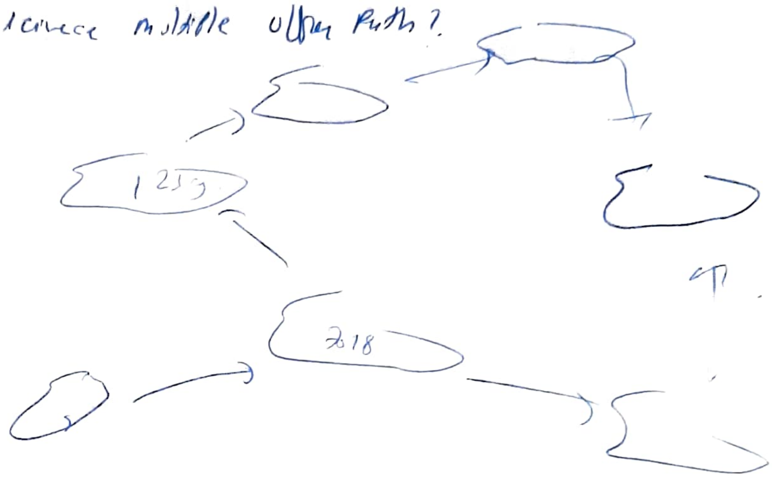
in BGP How to Avoid Loop → using AS Path attribute.

* If AS system dem the PKT to reach destination that includes its own AS number this is clearly a loop. not a good idea.

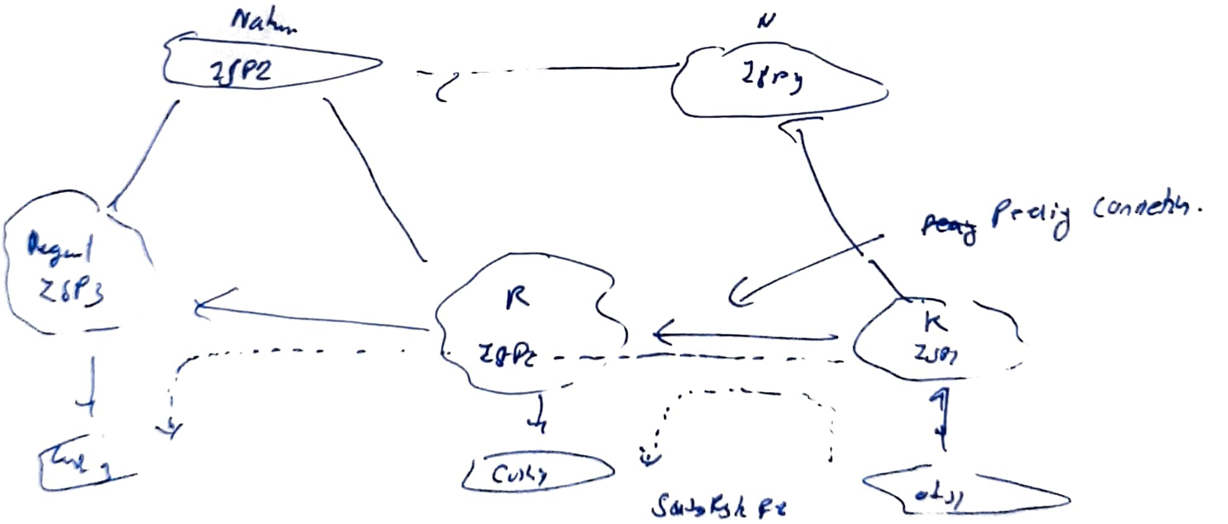
Any other choice is good. if I receive the Path which don't have my no so it's not Loop.

with this trick we avoid Loop. is AS Path so this info is updated continuously.

* How we select Path when I receive multiple other Path?



why not to minimize AS hops..?



Satisfy it
Cust 1 → R1 → R2 → Cust 2

Then cust 1 to 3
3 hops this is short and best one.

Cust Pay RS1 & RS1 Pay to NSP1 to go further over internet.

Regional ISP do not Pay to each other. to have good connection to cust any of each other.

if cust 1 to cust 3; Regional ISP2 being transit but no advantage to RSP2
So if it don't want to work as transit.

So BGP also handle this complexity so no. of hops will be taken into account by watching the commercial Point of view

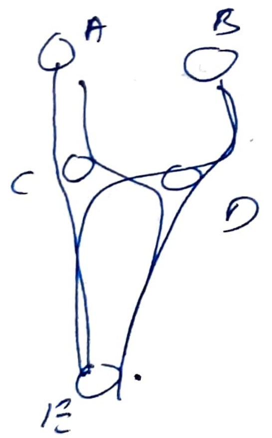
* Peering Peering relationship — with Peering we have shortest path otherwise we need to go higher hierarchy..

* Peering ways

* if we don't want the transit the BGP will have to reconfigure.

* BGP route Processing → additional to the ASPath we have some attribute to take decision
we receive the info from the neighbour → then we apply the rule
then we get the best routing table.
we filter the routes at the end that like which are exported & which routes are not exported on the. table that thing that whether we want to act transit or not and etc.

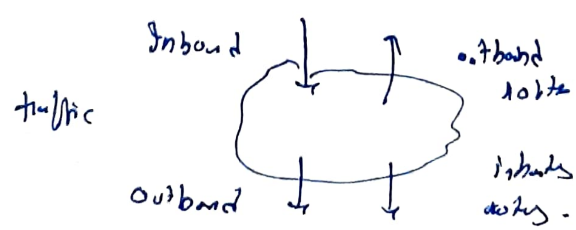
* Shortest doesn't always mean shortest!
when we run BGP on internet. So the routing is not symmetry.



AS Path are independent in one & other direction.
& routing completely Assymetry.
→ only info is destination at n/w. so because of independent. the routing is independent..

* Policy to control the traffic → tweak
change attribute to. forwarding traffic usage.

* operator like to change the attribute. like less expensive or/ highly link.
Sutomour traffic flow.



The Inbound traffic i.e. the inside of the lots of info that AS sends to Another AS.

The AS will make an announcement that I can reach to the AS. based on the announcement the AS will send traffic

Inbound routes → tells where to route the traffic. Receive routes from other AS (How traffic goes out).

Outbound routes → tell how the traffic goes in.

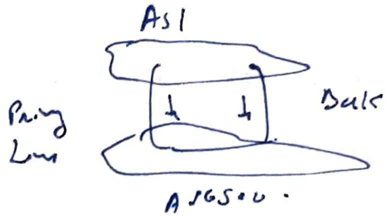
12

we change the attributes how the traffic is controlled.

BGP gets Inbound routes & change the Parameters as some condition.

Parameters like. N/w next hop - weight → AS Path length. then we modify using Policy & then we apply Algorithm like. Best path.

*



Set the Parameter with set of values.

forces the traffic to use Primary Link, unless Link is down.

So AS System has control over the traffic that goes out by setting the rule or Policy.

* influence how the traffic receive from other AS System

Inbound traffic.

we try to change the behavior of other system like AS1 but AS1 has upper.

Like we can just include the hop. to extend the AS Path so the. AS1 will chose the Shortest Primary Path to send the traffic. but this always do not work. (Path Prepending.

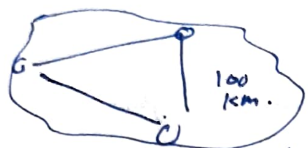
i.e we cannot control the both ways so we called as Asymmetric If we can control both ways then it is Symmetric control.

So at last every AS will put with his own rules and Policy.

* How Wide Area Network works to transport IP Pkt.

* Services for them
  VPN, Traffic engg, Resilience (Problem should be solve asap) Restoration.
* Which technology
  -> Connection Oriented vs connectionless.
  -> MPLS, Segment Routing (SR v6)

WAN

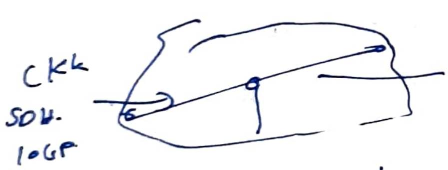


How the nodes are connected.
1st n/w was for telecom. Phones. That carry analog signal.
They try make digital n/w to carry data.. So using PCM. to convert voice
In bits of 64Kb. called digital transport n/w.

Next transport techno is SDH or Sonet it offered channel with high capacity.
we can transport using this channel with 600mbps.

* Intermediate techno to transport IP over SDH network called ATM.
  IP over ATM

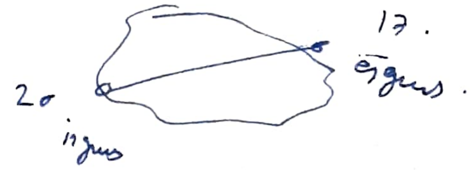
* Framing Protocol called PPP using this we can put IP Pack.



Protocol.
PPP allows IP Packets to carry on layer 2.
SDH is physical channel of given capacity.
with this we can carry IP over our transport n/w.

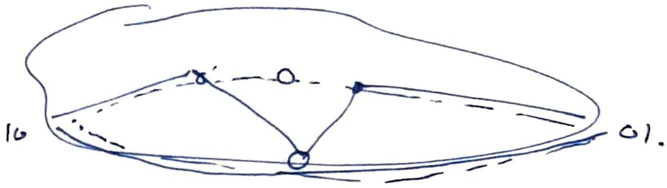
* we can send PKts in connection oriented or connectionless way.. to get to destination.
* in connectionless -> only info used to send PKt is final destination. & 2 Packet same dest address can follow different Path.. Operator do not have control ; due to decision is taken by individual routers
  but in VCircuit n/w -> they will follow same Path.
  virtual

* The operator have the control over -> here it have label. called connection oriented.
  So before sending PKt we need to prepare the. Path. & Any node will have a table called connection table: which checks where to forward. on which label to forward.
  and labels are changed from node to node & operator will have full control.
  when the PKt goes inside operator will have to prepare the n/w.



Connection oriented the connection is called as tunnel.

we just consider MPLS.



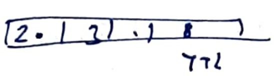
* is connectionless → the routing tables just look for the destination address & forwards.
unlike Path aggregation. in connection less n/w. they all follow same Path.

Note Not Possible to separate flow.

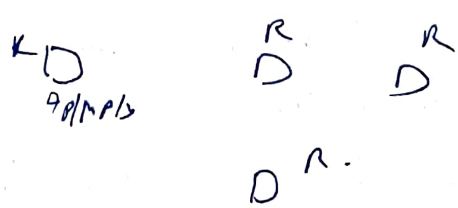
* in Connection oriented we can have Path differentiation.
+ we will Put MPLS Packets inside PPP frame. so MPLS will carry over IP Packet.
+ with only IP I cannot do differentiation So with MPLS you have Path differentiation & have full control.

* PPP is frame format. we know SDH just Provide CKT of 10GB or 5Gb.
we put Pkts on the CKT The goal of PPP is to separate 1 Pkt from another PKT. i.e Perform layer 2 framing functionality.
and PPP has Payload. inside PPP. structure. the Protocol field tells us that PPP carry IP or MPLS Pkt.
So we can use same PPP to carry IP or MPLS or MPLS can have IP inside it.

* how MPLS is formed - MPLS header have 4 bytes i.e 32 bits 20bits for label.



label is used to choose for next hop in Connection oriented
after then we have regular IP PKT.
So we carry IP in MPLS just adding. 4 bytes. Header.



* So on IP router can be replaced with IP/MPLS router. just by changing the software card.
So this can receive IP & also MPLS PKTs

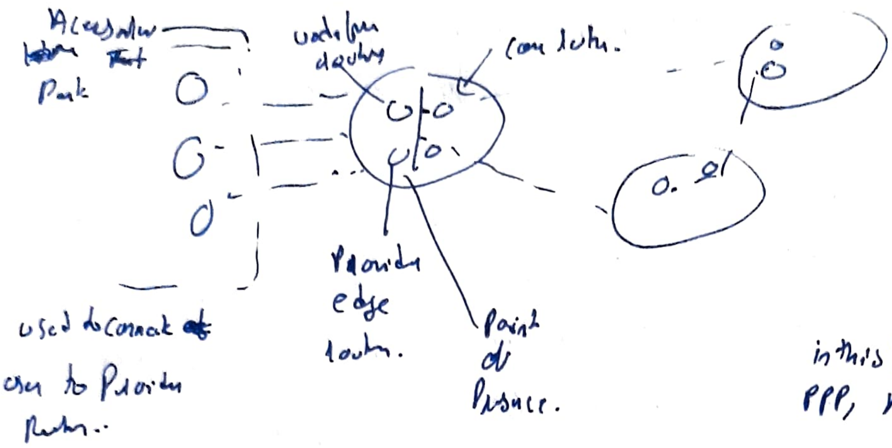
So we can have same network with IP router. we can process both type of PKT. So any exhibition do IP network to have connection oriented facility .

* The market of telecom.:

* Residential user & business user

Provide voice & data service.

Connect PoPs.



in the network of PoPs is backbone of our internet infrastructure

in this backbone we have SDH PPP, MPLS or IP.

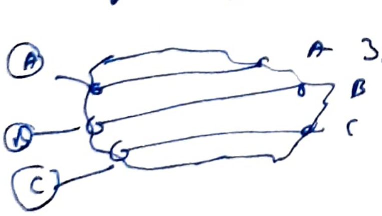
* Offer services to customer.
 -> offer: good quality of services - QoS.
 -> Service level agreement, - SLAs

+ also VPN
+ Traffic engineering.
+ Protection - restoration mechanism restore ASAP.

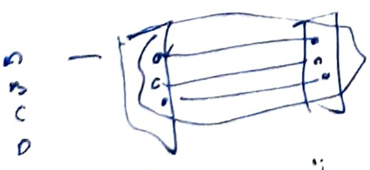
* So if company want to create the N/W to connect the sites

* ① A company can ask the operator to have the Physical. circuit.. ie layer 1.

② The operator offer layer 3 services. offer IP / MPLS connection services most effective & used solution. efficient way to share resources



A 3 SDH ckt.
B dedicated ckt when capacity is wasted
C



Layer 3 Service. shared resources:

many company can use it

So more efficient way to use the services.

Operator can resource the services. to provide the services to others.

Guarantee service

Multiple level of services → Best effort service ← no guarantee but will provide the services

like capacity will be variable.
& time to send large file will be variable

* In connection oriented we need to create a connection to transfer with MPLS. So it is like if a packet is coming from 1 need to send to S. So this need to be setup. In connectionless the routing tables are there & routing tables are updated. In connection oriented we need to create the tables to configure the flow which is coming.

* So how we create connection. In network we have user, control, management plane.

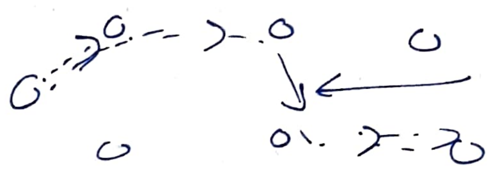
In control - we populate routing table.

management - we configure router.

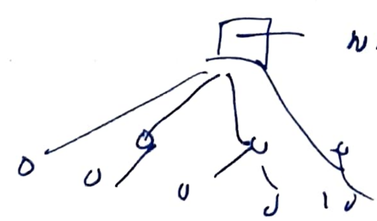
data → forwarding plane.

* In connection oriented we can create connection with control & management plane.

Either using control plane - So our router will exchange control msg with neighbour routers & then the connection is made. ie MPLS connection tables.



& using management plane:- This network management entity talk with all routers to setup conn.



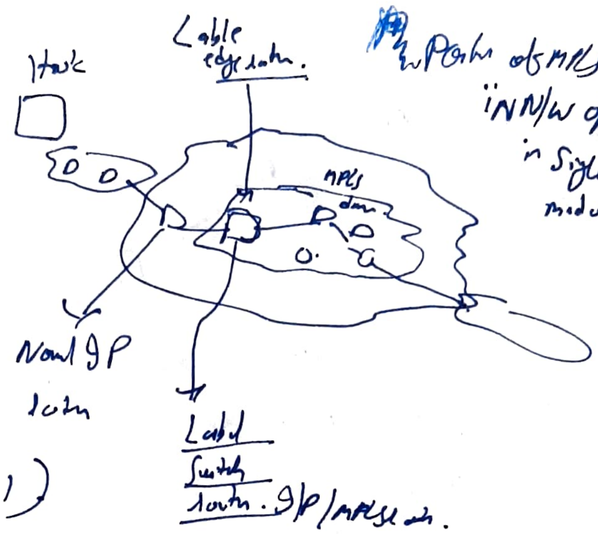
Control plane was dynamic. Short term permanent.

management plane was static long term. connection permanent.

SDN software defined networking
with SDN we can have different distinct control & management.
SDN is combination of control & management.

* MPLS architecture :- uses label instead of IP address on IP/MPLS routers.
MPLS network node will have control + forwarding component (label)
* This control + forwarding combination have both is included in IP/MPLS routers.
* Control plane will take care of creation & maintenance of labels.
* Forwarding → will check the label & forward the packet.

* different nodes in MPLS router

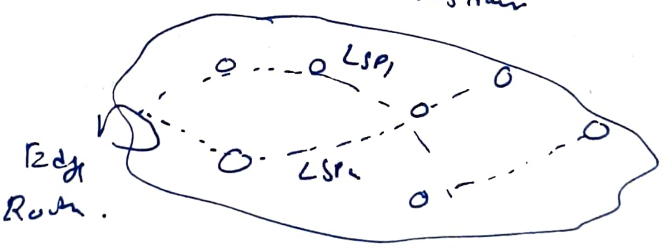


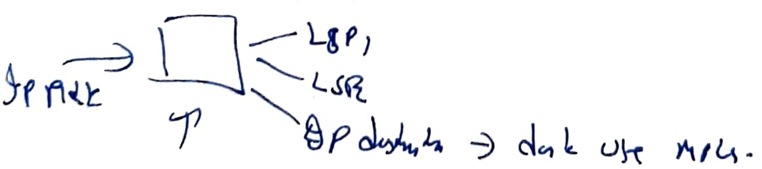
* Label Switch Path → A connection from source to destination you create with edges.
Label Switch router.

* Label distribution Protocol :- when we use control msg to create connection that protocol is Label distribution Protocol. (control Protocol)

* Forwarding equivalence class :- FEC :-

IP packets wants to classify whether they have to forward through LSP1 or LSP2 or just IP as router can also work only IP or MPLS.





classification in LER.
I.e. classification is based on FEC forwarding equivalence class.

* Sources destination is
FEC
10.6.0.0/24 goes to → LSP1.
This class of packet is given to LSP1.

① Ingress Procedure → The ingress LSR of MPLS domain analyze the IP header of the packet. classify the PKT add the MPLS label & forward to next hop LSR.

② In MPLS domain the PKT is forwarded using Labels

③ the exit LSR removes the Label & send the PKT on the IP table.

* Label switch router has 2 Routing table. ① traditional routing table.

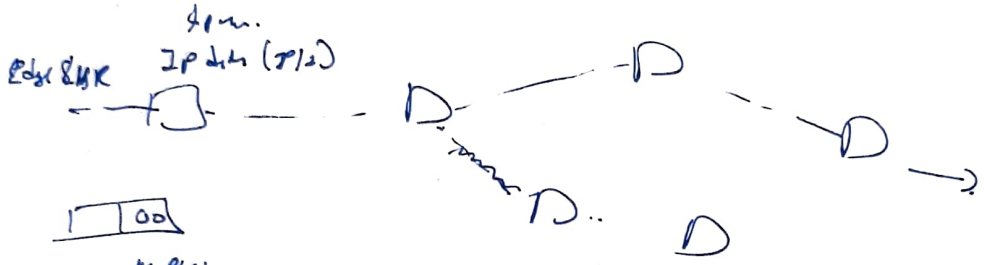
② Label look-up table ← deals with MPLS label.

Imp point

if MPLS label is all 0000 then it is IP type PKTs

if it is other than 0000 then it is an MPLS label.

another is we use Pseudo wired → that in header this is IP or MPLS PKT.



MPLS label. Any hop will come as an IP packet.

instead if used MPLS label

Then we will do

12. with label switch path. in ingress we have FEC classification so it will push the label. ie.

Ip FEC	out
160.8.1.1/16	Push 12

at last node.

then entry	IN	out
	67	POP. ← This is to terminate the LSP

remove the label

* with this MPLS we can build services & optimize the network utilization by choosing a shortest Path.

change of VPN using MPLS is simplified also we can use MPLS to improve the resilience. we can reduce the time to recover.

How the LSP Path is chosen? - Hop by Hop LSPs.

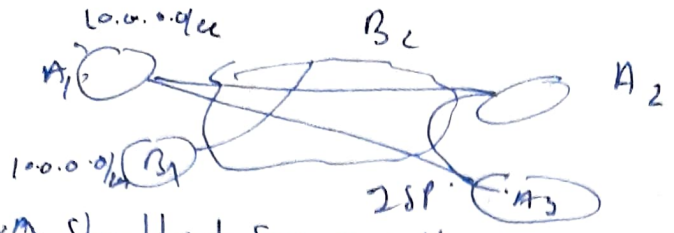
if we choose same Path as IP route Path. called Hop by Hop Path.

* in any case we create a tunnel till destination. already tunnel is important if it is similar to IP routing then also we need to modify.

* if we choose different Path. we called as explicit route LSP. it follows existing Path. in both cases we have tunnel.

VPNs with MPLS

Company decide want to mix the traffic with another one for speed. the VPN from ISP/Service Provider (2)



This A1,A2,A3 should not see any info from company B.

A1 & A3 want to connect with some network shared n/w.

We can have same IP address & we can separate this to two diff. n/w we need to be secure. & needs to separate the IP address & MPLS is S-forwarding as they give an MPLS label.

* Some will create tunnel & we will add the label to PKT.

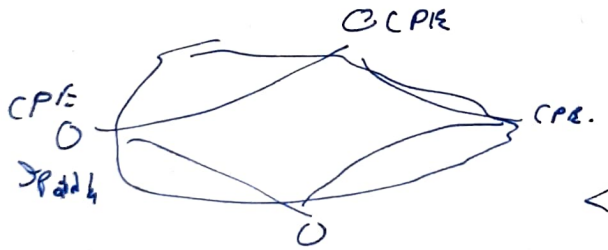
* How to build VPN now :-

Operator has own n/w and operator give access lines to some circuits from them.

if I buy a circuit of 2mb fixed.. So problem will be waste of capacity if I don't use the capacity. buying the 1gm 1 is not efficient.

* So solution is layer 3 VPNs eg MPLS.

CPE based VPN



tunnel is between every couple of CPEs.

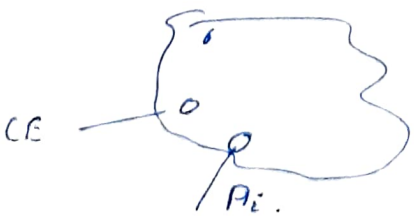
Note

In this we can not use IP tunnels. I Per traffic. instead of MPLS tunnel.

<= this is not provided by network operator. disadvantage So all tunnel need to be done by customer side not by operator.

UNPV types → - tunnel VPN
- CPE based VPN
- MPLS based VPN

* VPN : BGP / MPLS model.

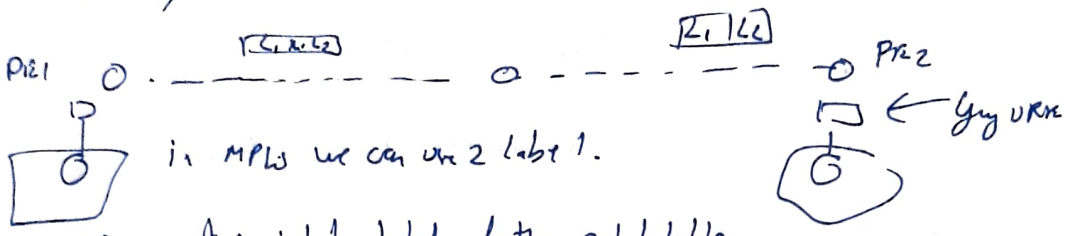


VPN : BGP MPLS mode.

inside eg Provider edge there is routing table (VRF Table).
(VPN routing & forwarding)

Routing table is separate for Yam, Yellow Like one for each VPN, this Routing. each
table will tell that address is reachable to the site.

* Fec is inserted in VRF configuring tunnel that used to reach destination.
* Special packets to signify configuration of the tunnel
→ tunneling in 2 steps. , with this we can resolve the Path.



in MPLS we can use 2 label 1.

VPN. Sg2 inner label & the global table.

Sg1 will be POP & send to VRF Yam.

inner label 1 is used only to know which is the couple VRF.

the Sg can be same but label tells us that whether it is for Yam or Yam one.
advantage is we only need to make tunnel once. not changed when new customer is added.

* MPLS is used to send the PKT & BGP distribute routes

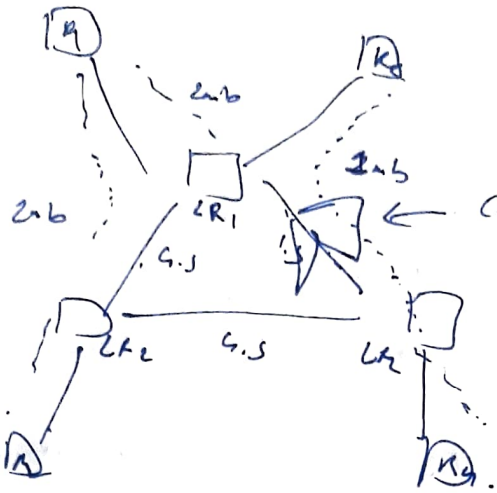
here the customer edge router talk with. Provider edge router about the Path.
Peering so PE Yam router needs to Yam the information.

two kind of Routing table :- VRF (VPN Routing Forwarding) ← VPN customers.
② global routing table. ← inside the operator networks.
Operator keep this two separate.

BGP MPLS : working mechanism is like we have tunnel in inside a tunnel so we can have.
different fabric.

* Traffic engineering

Suppose they follow shortest Path.
eg OSPF.

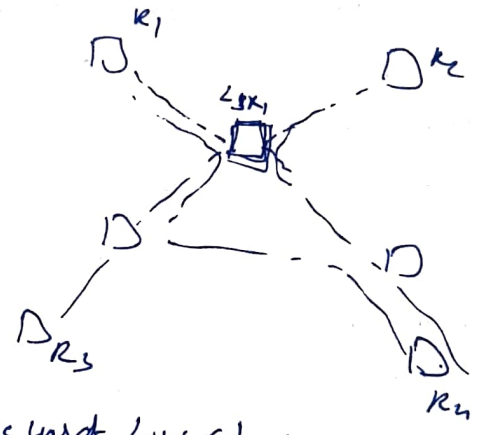


← congestion. all links 1mb & BS is gen..

we can change routing. like R_1. $R_1 R_3 - R_2 R_4 - R_4$ by changing the cost of Path 1.
we put the traffic on another Link.

② Equal path multipath cost. :- we can apply route to split traffic.

* we can't have the solution with OSPF because for OSPF we can use R_4 as destination address.
because we only route the destination.
but with MPLS we create the tunnel.
R_1 to R_4 - R_1 R_3 & R_2 R_4.
so we put the traffic for R_3 - R_4.
we directed the the Path where the Link has of low capacity.



* changing the route of Specific Congestion. to solve congestion which we cannot do with simple OSPF routing is called traffic engineering.

* we can create the Link with high capacity is called core housing.

* Traffic engineering is not needed more because. OSPF Load-balancing is enough. if I want to increase the utilization of my N/w then I do traffic engineering if buying the capacity is easy then. do Load balancing. or no need to do traffic engineering.

* How traffic engineering worked? If I want to do explicitly routed LSP. there are 3 different approaches :- ① static config of new connection by using SDN or. Mgmt create the Path.
② use dynamic approach that is RSVP label edge router send. signaling msg to other routers to make Path. decision in case 2. the Path decision is taken by central entity.
③ In this case everything is done automatically by routers.

3rd approach is note work now because now routers should take autonomous decisions.

* Protection mechanism :- we need to solve the problem as ASAP. i.e < 50ms.

* Like MPLS will Perform a Link backup. before only. ← backup solution.
  in OSPF after the failure new backup is found.
  Link & Path are Perform pre planned solution we create a protection tunnel & we allocate some resources.

* with MPLS we can achieve same. Performance with circuit switching also i.e < 50ms. no interruption in real time.

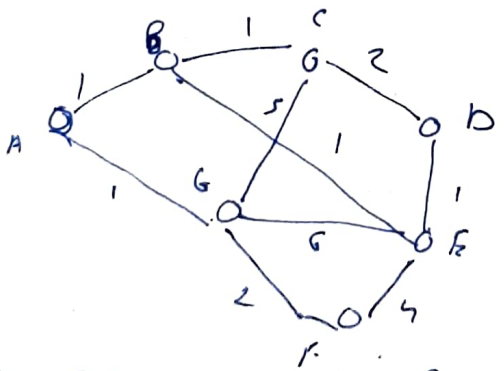
with MPLS we have two protection Link & Path Protection the idea is to solve the problem in advance i.e what to do when there is failure.
Examples we can Push two labels i.e tunnel inside tunnel.

* normal condition we use L & then we have Protection tunnel i.e Protect the Link. i.e we need Protection.
  then all links same Packet in the normal Link will be carried on the Protection tunnel.

* Penultimate hop PHP is making it is easy for Protection. i.e it removes the external label & proceeds with internal label
  The amount of resources given in Path Protection is high.

* Path Protection. → we create another LSP. → backup LSP. (label switch Path).
  more reliable after link Protection is given as single individual Links are protected.
  Low amount of resources are needed to reserve.

*. dijkstra Algorithm



T(G,A)

Step	T	L(A)	Path	L(B)	Path	L(E)	Path	L(D)	Path	L(e)	Path	L(F)	(Path)
0	G	1		∞		5		∞		6		2.	
1	G,A	1		G-A	2		5		∞		6		2
2	G,AB	1		G-A	2	GAB	3		∞		3		2
3	GABF	1		G-A	2	GAB						2	GF.
4	GABE	1		G-A	2	GAB	3		4 GABED		3 GABE	2	GF.
5	GABED	1		G-A	2	GAB	3		4 GABED		3 GABE	2	GF.
6	GABEDC	1		G-A	2	GAB	3	GABC	4 GABED		3. GABE	2	GF.