8c). Data = Roll Number = 419 in binary.

419's binary equivalent is 110100011
876543210

Divisor = 1011

I) Data in polynomial.

Dataword should be right shifted by 3 times because the divisor is of 4 bits or 3+1 bits.

Therefore final data word,

1 1 0 1 0 0 0 1 1 0 0 0
11 10 9 8 7 6 5 4 3 2 1 0
x^3 x^2 x 1

$x^{11} + x^{10} + x^8 + x^4 + x^3$ in polynomial.

Codeword is 1011
3 2 1 0

$x^3 + x + 1$

codeword = $\underbrace{D.2^r}_{\text{right shifts by r bits}}$ XOR $\underbrace{C_r}_{\text{appends r bits}}$

↓ right shifts by r bits

↓ appends r bits

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II) Source side

$$x^3+x+1 \,)\, \cancel{x^{11}}+x^{10}+\cancel{x^8}+x^4+x^3 \,(\, x^8+x^7+x^6+x^5+x+x^2$$

$$x^{11}+x^9+x^8$$

$$\cancel{x^{10}}+x^9+x^4+x^3$$

$$\cancel{x^{10}}+x^8+x^7$$

$$\cancel{x^9}+x^8+x^4+x^3+\cancel{x^7}$$

$$\cancel{x^9}+\cancel{x^7}+x^6$$

$$\cancel{x^8}+x^4+x^3+x^6$$

$$\cancel{x^8}+\cancel{x^6}+x^5$$

$$\cancel{x^4}+x^3+x^5$$

$$\cancel{x^4}+x^2+x$$

$$\cancel{x^5}+\cancel{x^3}+\cancel{x^2}+x$$

$$\cancel{x^5}+\cancel{x^3}+\cancel{x^2}$$

$$x$$

Redundant bits = is made of 3 bits as generator is of 4 bits. So redudant bits is 010. or x.

Codeword = $x^{11}+x^{10}+x^8+x^4+x^3+x$.

3) If error occurs in x^2 i.e is my case 0 should be flipped to 1. as 010 was redudant bits x^2 is 0 turning it to 1 will change the codeword as

Codeword - $x^{11}+x^{10}+x^8+x^4+x^3+\underline{x^2}+x$

↳ made 1

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$$
\begin{array}{r|l}
 & x^8 + x^7 + x^6 + x^5 + x^2 + x \\
\hline
x^3 + x + 1 & \cancel{x^{11}} + x^{10} + \cancel{x^8} + x^4 + x^3 + x^2 + x \\
 & \cancel{x^{11}} + x^9 + \cancel{x^8} \\
\hline
 & \cancel{x^{10}} + x^9 + x^4 + x^3 + x^2 + x \\
 & \cancel{x^{10}} + x^8 + x^7 \\
\hline
 & \cancel{x^9} + x^8 + \cancel{x^7} + x^4 + x^3 + x^2 + x \\
 & \cancel{x^9} + \cancel{x^7} + x^6 \\
\hline
 & \cancel{x^8} + \cancel{x^6} + x^4 + x^3 + x^2 + x \\
 & \cancel{x^8} + \cancel{x^6} + x^5 \\
\hline
 & \cancel{x^5} + x^4 + \cancel{x^3} + \cancel{x^2} + x \\
 & \cancel{x^5} + \cancel{x^3} + \cancel{x^2} \\
\hline
 & \cancel{x^4} + x \\
 & x^4 + x^2 + \cancel{x} \\
\hline
 & x^2 \\
\hline
\end{array}
$$

Source adds remainder of codeword by generator to codeword if no error occurred then codeword should be completely divisible at ~~sender~~ reciever side But it is not the case as x^2 was flipped. Hence remainder is non zero and destination identifies the error has occured.

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1a) $N=3$ nodes are active.

$P = 0.43$. $Np = 3$

(i) Slotted Aloha (only one station per slot)

$$\text{Efficiency} = p(1-p)^{(N-1)} * Np$$

$$= 0.43(1-0.43)^{(3-1)} * 3$$

$$= 0.43\,(1-0.43)^{2} * 3$$

$$= 0.43\,(0.57)^2 * 3$$

$$= 0.43 * 0.3249 * 3$$

$$= 0.1397 \text{ or } 13.97\% * 3 = 41.97\%.$$

[illegible]

(ii) Aloha for data transmission.

$$\text{efficiency} = p(1-p)^{2(N-1)} * Np = 0.43(1-0.43)^{2(3-1)} * 3$$

$$= 0.43\,(0.57)^{2*2} * 3 = 0.43(0.57)^4 * 3$$

$$= 0.04539 * 3$$

or $4.53\% * 3$ efficient

$$= 13.59 \text{ or } \approx 13.6\%$$

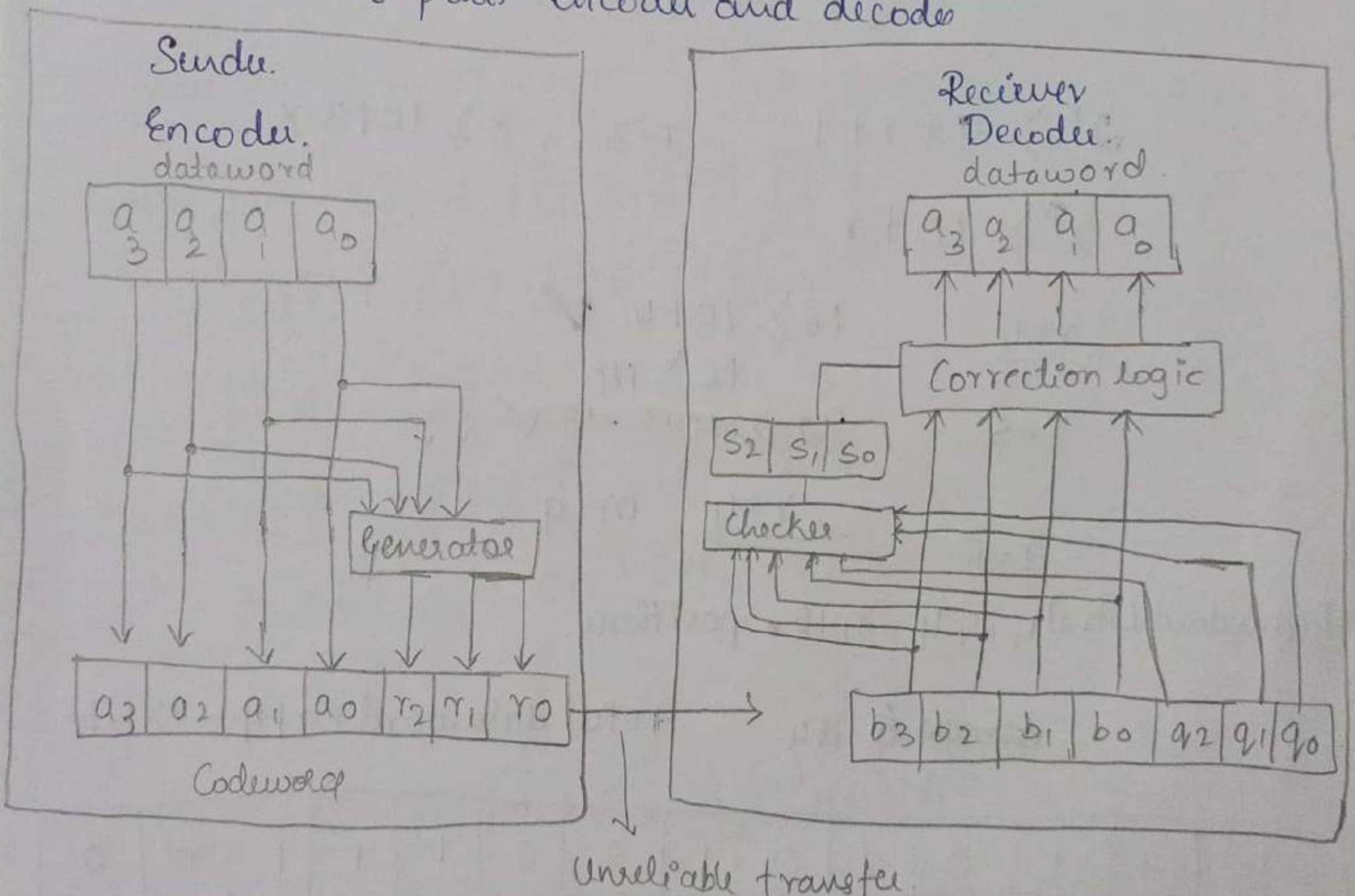
[illegible]

1c) i) Explain Hamming code.

* Hamming code was designed by mathematician R.W. Hamming
* It follows that for data of m bits the no. of redudunt bits is 'r'. And this r should satisfy

$$2^r \geq m+r+1.$$

* It has two parts encoder and decoder



$$r_0 = a_2 + a_1 + a_0 \text{ modulo } 2$$
$$r_1 = a_3 + a_2 + a_1 \text{ modulo } 2$$
$$r_2 = a_1 + a_0 + a_3 \text{ modulo } 2.$$

Using modulo 2 redudant bits are generated and embeded with dataword using generator to form codeword

At recive side

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$S_0 = b_2 + b_1 + b_0 + q_0$ modulo 2

$S_1 = b_3 + b_2 + b_1 + q_1$ modulo 2

$S_2 = b_1 + b_0 + b_3 + q_2$ modulo 2

S_0, S_1, S_2 bits indicate the error location.

ii) Roll No = 419 = 1 01 00011
8 7 6 5 4 3 2 1 0

$2^r \geq 9 + r + 1$ $\quad r = 3$, $8 \geq 10 + 3$ ✗

$2^r \geq 10 + r$

$r = 4$ $\quad 16 \geq 10 + 4$ ✓

$16 \geq 14$.

$\underline{\underline{r = 4}}$ $\quad m = 9$

Redundant bits at 1, 2, 4, 8, positions.

total dataword = 9+4 = 13 bits.

1	1	0	1	0	1	0	0	1	1	1	0	0
13	12	11	10	9	8	7	6	5	4	3	2	1

Even parity

$R1 = [illegible]\ 3 \oplus 5 \oplus 7 \oplus 9 \oplus 11 = 1 \oplus 1 \oplus 0 \oplus 0 \oplus 0 = 0$

$R2 = 3 \oplus 6 \oplus 7 \oplus 10 \oplus 11 = 1 \oplus 0 \oplus 0 \oplus 1 \oplus 0 = 0$

$R4 = 5 + 6 \oplus 7 = 1 \oplus 0 \oplus 0 = 1$

$R8 = 9 \oplus 10 \oplus 11 \oplus 12 \oplus 13 = 0 \oplus 1 \oplus 0 \oplus 1 \oplus 1 = 1$

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Hamming code = 11 0 1 01 0011100

iii) 2nd bit from binary is at third position.
i.e 1 should be flipped to 0
So new hamming code incorporating error is

$$\begin{array}{ccccccccccccc} 13 & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & \underline{\underline{0}} & 0 & 0 \end{array}$$

↳ error.

Identification of error. (Even parity)

$R1 = 1 \oplus 3 \oplus 5 \oplus 7 \oplus 9 \oplus 11$

$= 0 \oplus 0 \oplus 1 \oplus 0 \oplus 0 \oplus 0$

$= 1$

$R2 = 2 \oplus 3 \oplus 6 \oplus 7 \oplus 10 \oplus 11$

$= 0 \oplus 0 \oplus 0 \oplus 0 \oplus 1 \oplus 0$

$= 1$

$R4 = 4 \oplus 5 \oplus 6 \oplus 7 = 1 \oplus 1 \oplus 0 \oplus 0 = 0$

$R8 = 9 \oplus 10 \oplus 11 \oplus 12 \oplus 13 \oplus 8 =$

$1 \oplus 0 \oplus 1 \oplus 0 \oplus 1 \oplus 1$

$= 0$

R8 R4 R2 R1

$\underline{\underline{0 \quad 0 \quad 1 \quad 1}} = 3$ - i.e 2nd bit position.

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8b) ARP -or- Address Resolution Protocol.

→ It is a plug and play device protocol.

→ It is used to obtain MAC address from IP address.

→ It has two types of messages:

i) Query message: When some host wants to know the MAC of another it uses a query message puts destination IP and tells its adapter it needs MAC of this IP. Then adapter adds broadcast MAC FF-FF-FF-FF address and forwards this broadcast packet to all nodes. The one with matching IP replies back with it's MAC

ii) Response message: This is unicast message. As the destination knows the sender's MAC. He will reply only to sender his MAC address.

→ It is helpful for MAC addressing. and to achieve forwarding with switches in LAN's such as our University.

→ why? for obtaining MAC address of nodes that can in turn achieve forwarding without much of layer 3 overhead.

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3a)

Data center accomodates the resources of organizations like servers, switches, routers etc all of these are connected via network. Different types of cables are also used. Eg: Optic fibres.

There are different elements of data center that follows hierarchial topology:

i) Switches : Mainly used for LAN's. They can be mangeable which helps the administrator to configure or program them - or - not manageable or normal switches.

Mangeable switches allows port configuration and are more costlier than normal ones. It operates at L2. It is also called as bridge.

But this might to inefficient usage when users in a LAN are less so we go for virtual LAN's to make it efficient and logically isolate port groups to give a separate isolation feel as a physical LAN independent of their positions.

Physically differed but logically on same LAN. It also increases a layer of security.

VLAN Trunking → Scalable approach to interconnecting VLAN switches.

VLAN tags → It is added in header that carries the identity of the VLAN to which frame belongs

2) Firewalls: Used for security purpose. The protect internet traffic and not end systems. For end systems we use Anti-Virus.

Firewalls

↙ ↘

Software Hardware

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→ Software firewalls are programmed to detect suspicious activities.

→ Hardware firewalls : looks like switches and come with dedicated preinstalled software. Costs around 21-50 lacs.

Eg: Cisco checkpoint firewall
Sofos xg450

(3) Routers: L3 device helps to handles packets moving out in WAN.

(4) Gateway: L4 device with knowledge of transport layer protocols. Helps to translate between heterogenous protocols.

(5) Access-points

(i) Entry-level: The come with 2/4/6 antennas
More the antenna more the speed, price and users support.

(ii) High-end access points : More costly than entry levels
All antennas are internal.

Eg: - Aruba, Cisco

To control access point we need access-point controller unit

3A'S - Authentication, Authorization and Accounting
Radius Server.

→ L3 switch is more useful as it can switch as well as route

→ Core-switch - DHCP is configured

→ DHCP server for dynamic IP allocation so a separate server. Port 67 is used.

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(8) Local DNS

→ It reduces latency

→ Eg: Windows and Linux Update Servers.

→ Lower Bandwidth consumption

(9) NMS- Network Management Systems.

→ To detect loops

→ Which link is down

→ SNMP (protocol) (Simple network management protocol) is used and packets are sent to check health status.

→ firewall monitoring

→ Get to know which users have browsed what, when, how long

→ All users currently logged in and history

This is applicable for university data centers. But in case MNC's they have set of data centers. Highly maintained. Usually shown with that colorful optic fibre's in google.

MNC's are more secured for their data they use own security rules.

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3b)

Multi-protocol label Switching (MPLS)

-> Combines both the benefits of circuit and packet switching

-> Switches based on labels.

-> Each interface and dest have unique labels assigned

-> Multi protocol as it takes best of two circuit and packet switching and is independent of lower layer protocols.

-> It works at border. i.e between L3 and L2.

-> Label switching => Based on packet i/p label are assigned and they are replaced by output labels just like in virtual circuits.

-> It acts as router and switch. So also called as label switched router.

-> Achieves extremely fast forwarding.

-> It takes IP packet from layer 3 then add label and transmits to layer 2

-> If router was used it would do longest prefix match for dest i/p then decide on which of its interface it needs to forward which is time-consuming.

-> In virtual circuits VCI or virtual circuit identifiers are used instead of labels

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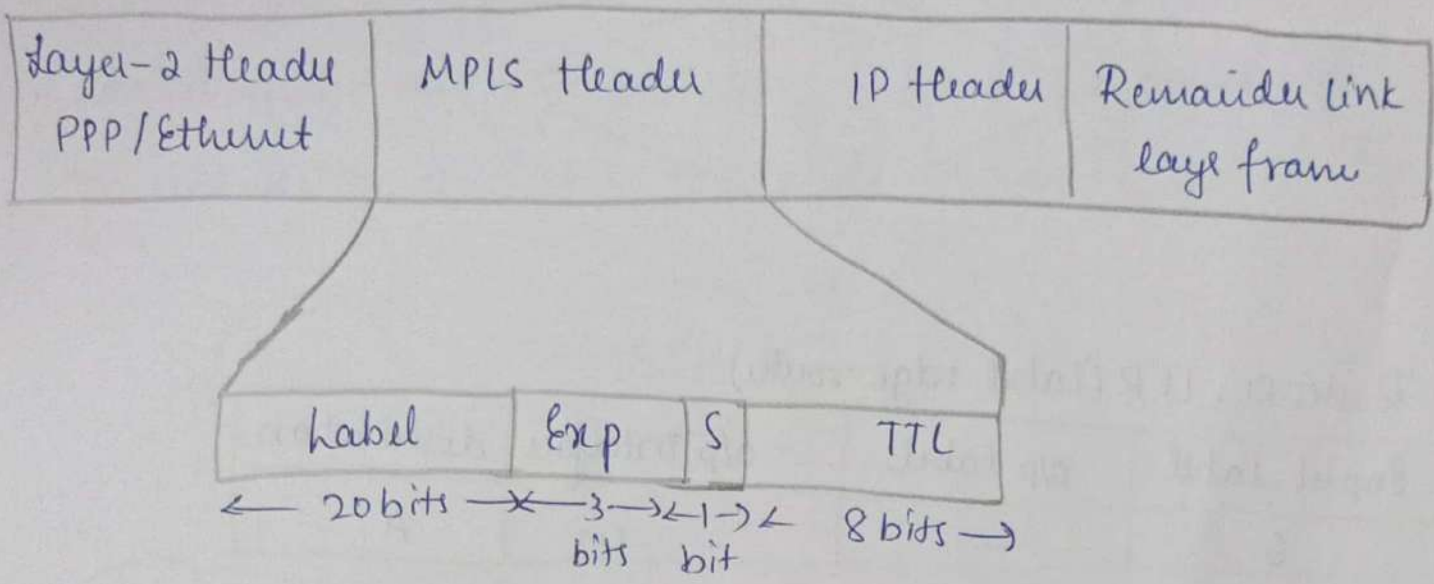


MPLS header is situated between layer 2 and layer 3 header. As it acts at border.

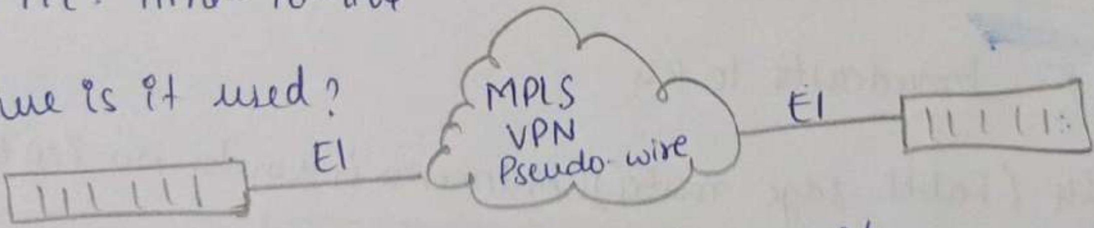
(i) Labels: It acts as virtual circuit identifier as in case of virtual circuit switching.

(ii) Exp: 3 bits for experimental use.

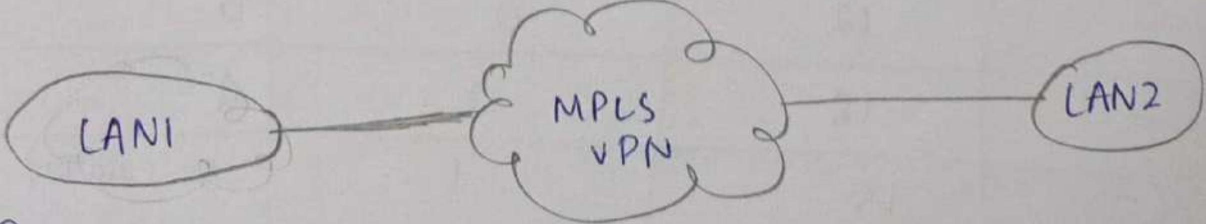
(iii) S: 1 bits indicating end of series of "stacked" MPLS header.

(iv) TTL: Time-to-live.

Where is it used?



(i) when point-to-point connections exits.



(ii) In Private LAN switches.

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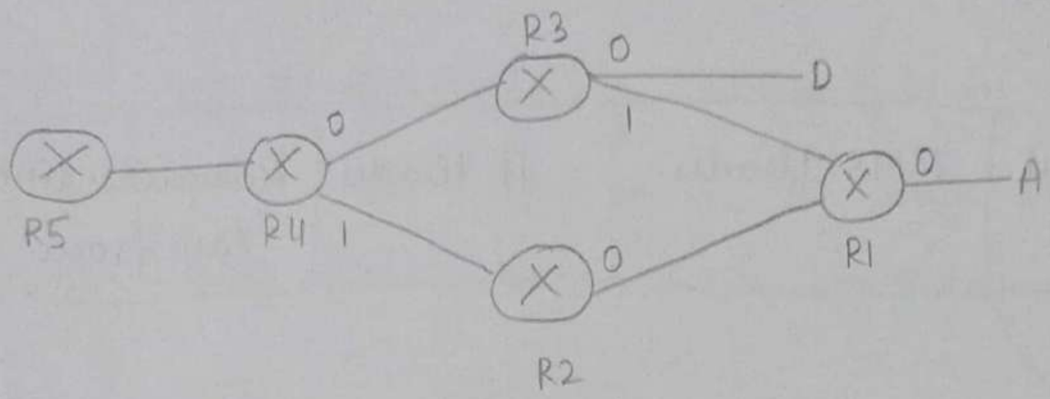

Router R1 : LER (Label edge router)

Input Label	o/p label	o/p interface	destination
6	–	0	A

This table is broadcasted to R3 and R2.

Router R3 (LSP - label switch router)

i/p label	o/p label	o/p interface	destination
12	–	0	D
18	6	1	A

Router R2 (LSR)

i/p label	o/p label	o/p interface	destination
15	6	0	A

R2 and R3 broadcasts to R4

Router R4 (Label edge router)(As income is router no i/p label)

i/p label	o/p label	o/p interface	destination
–	12	0	D
–	18	0	A
–	15	1	A (via R2)

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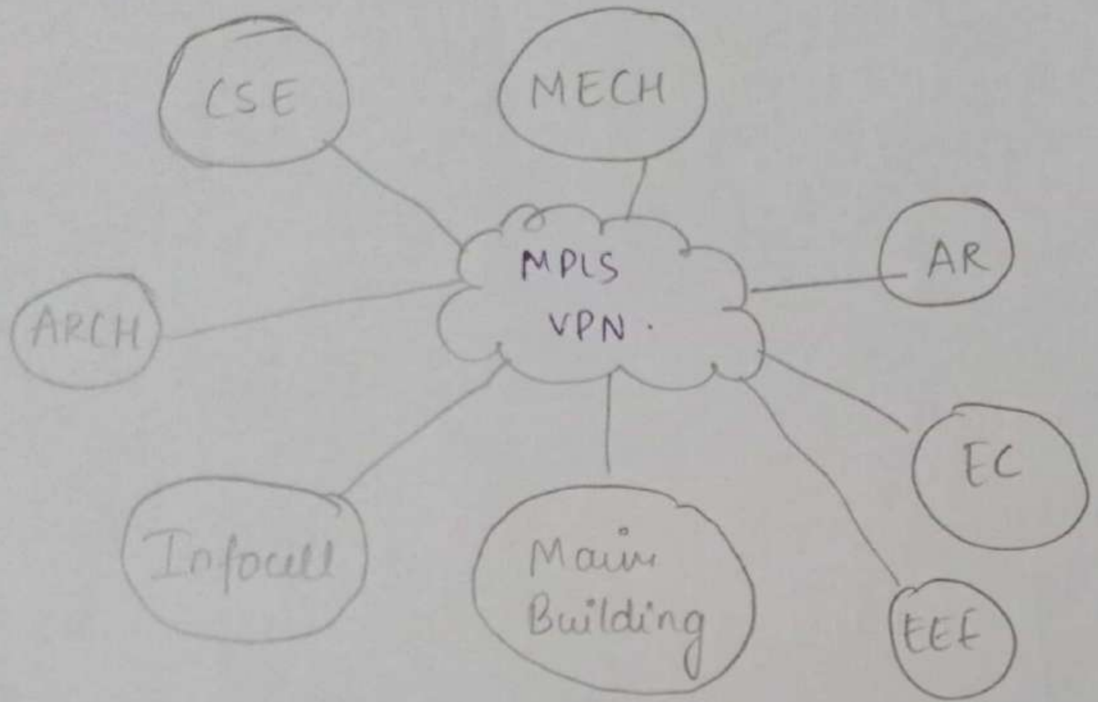
MPLS can be efficient by taking best of both ~~to~~ packet and circuit switching. We have LAN's at our university dedicated for each department.



So it is suitable to interconnect and use them in LAN switches for taking benefits.

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