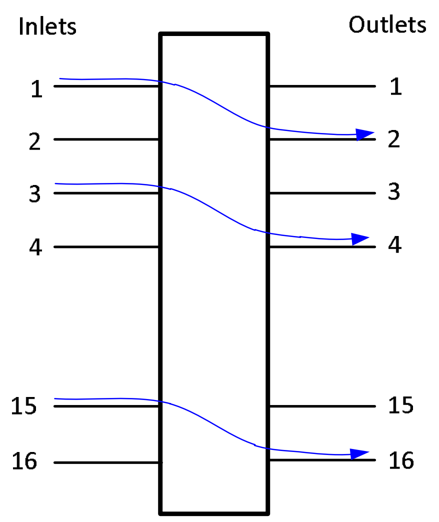
Sheet 2 Solution

Problem (1):

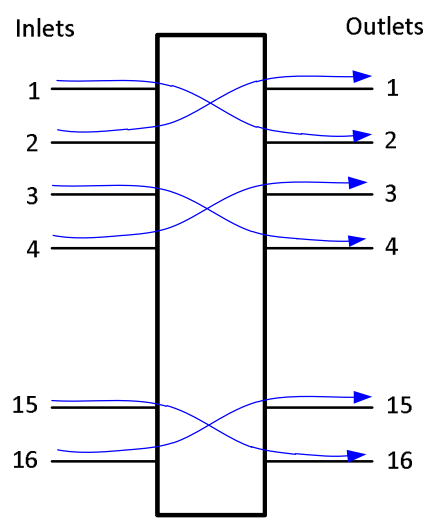
	Hub	Switch	Router
Cost	Least expensive	Low	High
Processing Capabilities	Least intelligent	Intelligent	Smartest
Routing Rules	No routing: incoming frame is broadcast to all ports except incoming port	Routing is based on MAC address of destination: If MAC address exists in Routing Table, send incoming frame to output port that leads to destination. Otherwise, incoming frame is broadcast to all ports except incoming port	Routing is based on network address of destination: send incoming packet to output port that leads to destination.
Range of coverage	Shared LANs	Switched LANs	LANs, WANs
OSI layer	Physical	Data Link	Network

Problem (2):

a)

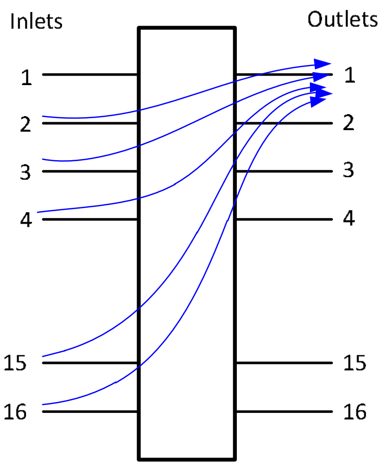


In half-duplex, a port can either transmit or receive:
➔ max. throughput = 8x10 Mbps = 80 Mbps

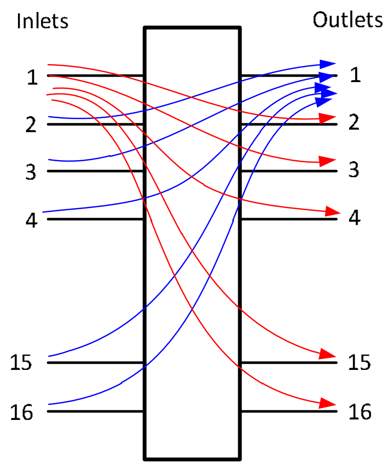


In full-duplex, a port can both transmit or receive:
➔ max. throughput = 16x10 Mbps = 160 Mbps

b)



In half-duplex, a port can either transmit or receive:
➔ min. throughput = 10 Mbps
(All the (15) stations target the same destination.)



In full-duplex, a port can both transmit and receive:
➔ min. throughput = 2x10 Mbps = 20 Mbps
(All the (15) stations target the same destination & all the (15) stations receive from the same source.)

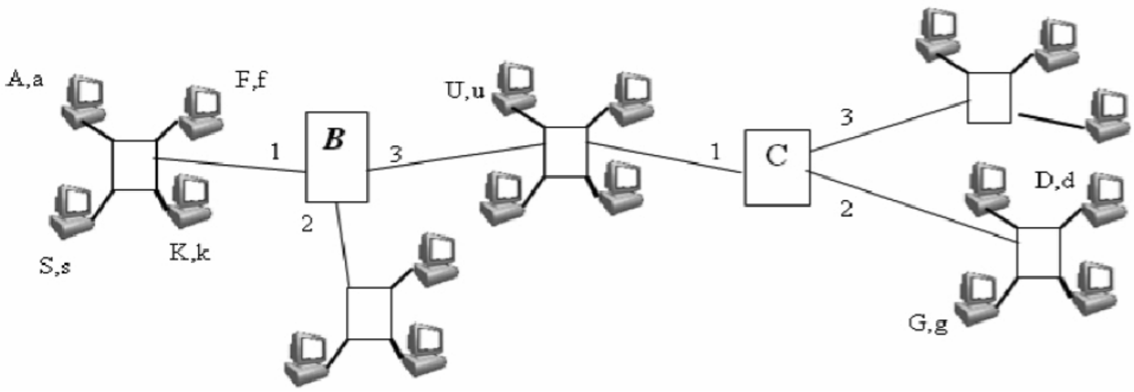
c) Max transmission rate = 100 Mbps + 2*10 Mbps = 120 Mbps (half-duplex)

= 2*120 Mbps (full-duplex)

This rate is attained under the condition that (10) stations with 10 Mbps links are communicating with the station with 100 Mbps link and there remains (5) stations. (2) Of them are talking to another (2) stations and (1) idle station.

Min transmission rate is same as b) as all stations are targeting the same destination that has a 10 Mbps link.

Problem (3):



a)

	Packet format	Switch (B)		Switch (C)	
		Out ports	Table	Out ports	Table
S → D	ARP request: [s,1…1|who is D?]	2, 3	s 1	2,3	s 1
	ARP reply: [d,s| I am D]	1	s 1 d 3	1	s 1 d 2
	Packet: [s,d | S,D | data]	3		2	
G → K	ARP request: [g,1…1|who is K?]	1,2	s 1 d 3 g 3	1,3	s 1 d 2 g 2
	ARP reply: [k,g| I am K]	3	s 1 d 3 g 3 k 1	2	s 1 d 2 g 2 k 1
	Packet: [g,k | G,K | data]	1		1	
U → G	ARP request: [u,1…1|who is G?]	1,2	s 1 d 3 g 3 k 1 u 3	2,3	s 1 d 2 g 2 k 1 u 1
	ARP reply: [g,u| I am G]	-		1	
	Packet: [u,g | U,G| data]	-		3	
D → K	ARP request: [d,1…1|who is K?]	1,2	s 1 d 3 g 3 k 1 u 3	1,3	s 1 d 2 g 2 k 1 u 1
	ARP reply: [k,d| I am K]	3		2	
	Packet: [d,k | D,K | data]	1		1	

b)

	Packet Format	Router (B)		Router (C)	
		input	output	Input	Output
S → D	ARP request: [s,1…1|who is D?] No reply → Send pkt to B	[s,b_1 | S,D | data]	[b_3,c_1|S,D|data]	[b_3,c_1|S,D|data]	[c_2,d |S,D |data]
G → K	ARP request: [g,1…1|who is K?] No reply → Send pkt to C	[c_1,b_3| G,K | data]	[b_1,k |G,K|data]	[g, c_2|G,K|data]	[c_1,b_3|G,K|data]
U → G	ARP request: [u,1…1|who is G?] No reply → Send pkt to B & C	[u,b_3|U,G|data]	----------	[u,c_1|U,G|data]	[c_2,g|U,G|data]
D → K	ARP request: [d,1…1|who is K?] No reply → Send pkt to C	[c_1,b_3| D,K | data]	[b_1,k | D,K | data]	[d,c_2|D,K|data]	[c_1,b_3|D,K|data]

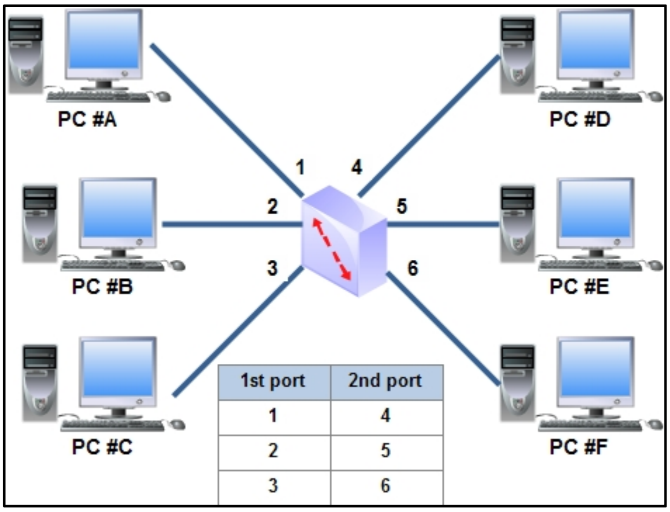
Suggested routing tables:

Router (B)			Router (C)		
destination	O/P port	Next Hop	destination	O/P port	Next Hop
A	1	--	A	1	B
D	3	C	D	2	--
F	1	--	F	1	B
G	3	C	G	2	--
K	1	--	K	1	B
S	1	--	S	1	B
U	3	--	U	1	--

Problem (4):

Scenario [1]:

a)



b) Message format: [data]

c) Call setup is performed first, so resources are reserved for connection. Then, message is passed through the circuit.

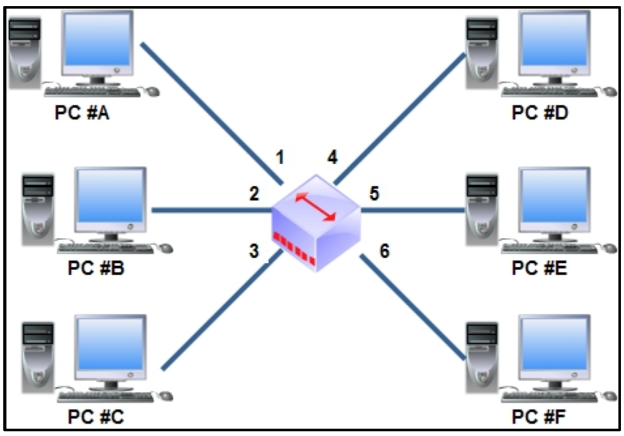
d) Factors that affects delay are: Message size (P), Source rate (R), Distance between source and destination (L).
Delay = P/R + L/v, where v is speed of propagation through link.

e) Link speed (rate) = burst size / burst duration = 2560 bits / 40 ms = 64 Kbps
Switching speed = link speed x # of connections = 192 Kbps

f) Maximum throughput = Av. Source rate x # of connections
= 2560bits/100ms x 3 = 76.8 Kbps. (half-duplex)
This throughput is under the condition that 3 PC's are talking to different PC's at the same time.

Scenario [2]:

a)



b) Message format: [src, dest | data].

c) Message is passed to the switching box that broadcasts it to all ports except the port it comes from. Each PC checks the destination address contained in the message and if the address belongs to the PC, it continues in processing the message. If not it ignores the message.

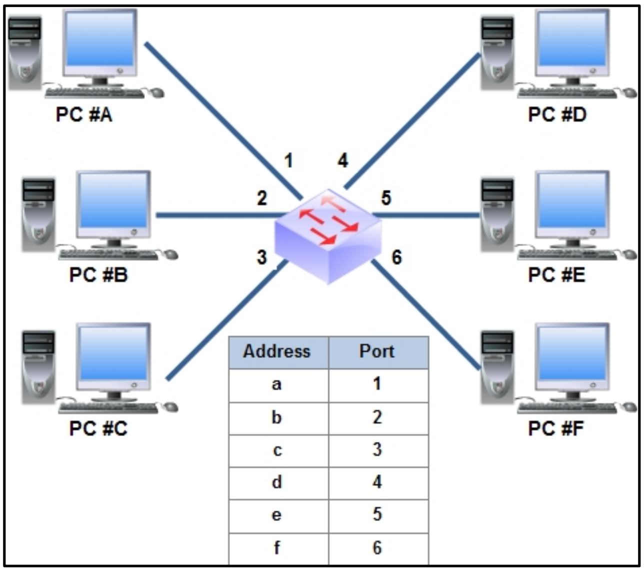
d) Factors the affects delay are:Message size (P), Source rate (R), Distance between source and destination (L), Processing time at switching box (t_s), Collision delay (t_c), Waiting time(t_w).
Delay = $P/R + L/v + t_s + t_c + t_w$.

e) Link speed (rate) = burst size / burst duration = 2560 bits / 40 ms = 64 Kbps.
Switching speed = 64 Kbps

f) Maximum throughput = 25.6 Kbps (half-duplex)
This speed is the maximum as there is only one source that can communicate with another one as switching works by broadcasting the message.

Scenario [3]:

a)



Address	Port
a	1
b	2
c	3
d	4
e	5
f	6

b) Message format: [src, dest | data].

c) Message is passed to switching box that checks the destination MAC address and decides which port it should pass the message to according its routing table.

d) Factors that affect delay are: Message size (P), Source rate (R), Distance between source and destination (L), Processing time at switching box (ts).
Delay = $2*(P/R + L/v)+t_s$.

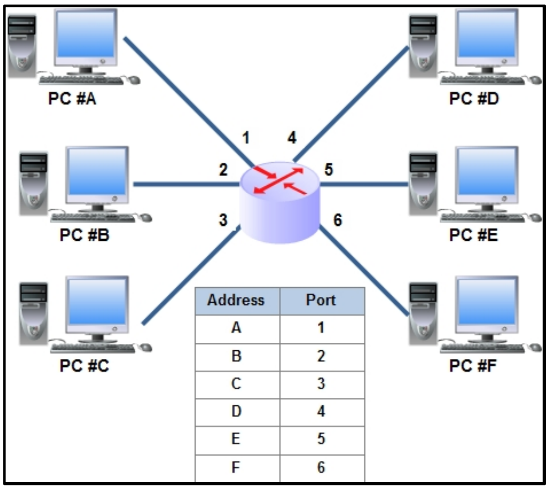
e) Link speed (rate) = burst size / burst duration = 2560 bits / 40 ms = 64 Kbps

f) Switching speed = link speed x # of connections = 192 Kbps

g) Maximum throughput = 3*25.6 Kbps (half-duplex)
= 2 x 3*25.6 Kbps (full-duplex)
This throughput is under the condition that 3 PC's are talking to different PC's at the same time.

Scenario [4]:

a)



Address	Port
A	1
B	2
C	3
D	4
E	5
F	6

b) Message format: [src, r_x | SRC, DEST | data] → [r_y,dest | SRC,DEST | data].

c) When message is passed to the switching box, it checks the network address of the destination and then decides the port to pass the message according to routing table. Then, it changes the source physical address and retransmits the message.

d) Factors that affect delay are: Message size (P), Source rate (R), Distance between source and destination (L), Processing time at switching box (t_s), and queuing delay in router (t_q).
Delay = $2*(P/R + L/v) + t_s + t_q$.

e) Link speed (rate) = burst size / burst duration = 2560 bits / 40 ms = 64 Kbps
Switching speed = 3 x 64 Kbps = 192 Kbps

f) Maximum throughput = 3*25.6 Kbps (half-duplex)
This throughput is under the condition that 3 PC's are talking to different PC's at the same time.

<u>Problem (5):</u>

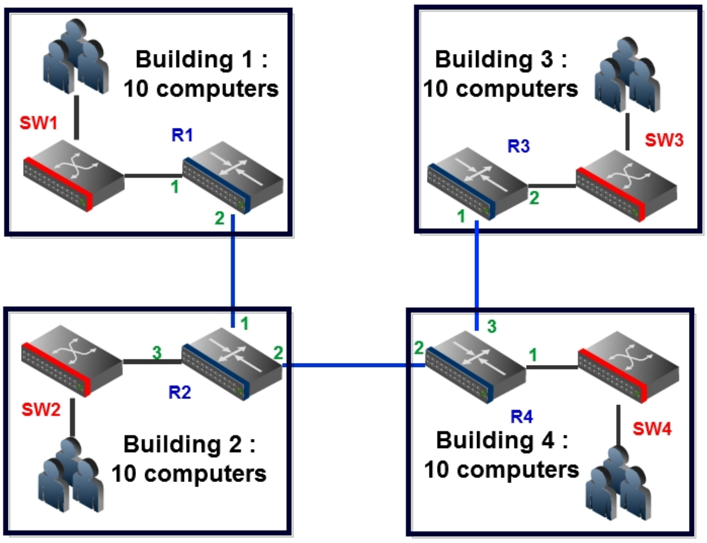
a) i. Maximum distance between 2 end devices = 100m + 50m + 100m = 250m.
ii. Maximum throughput = 10 Mbps

b) i. Maximum distance between 2 end devices = 100m + 100m + 100m = 300 m
(assuming transmission media is unshielded twisted pairs – UTP – copper cable)
ii. Maximum throughput = 3 * 10 Mbps = 30 Mbps (half-duplex).
iii. Maximum throughput = 2 * 30 Mbps = 60 Mbps (full-duplex).
iv. Maximum throughput = 2 * 120 = 240 Mbps.

c) <u>In part a):</u> Maximum throughput = 2 * 10 Mbps = 20 Mbps
The max throughput is doubled as the router divided the network into 2 collision domains. So each hub may broadcast the received message separately and computers in different collision domains can communicate without the need to pass the messages to the other domains.
<u>In part b):</u> No change in throughput will occur when adding the router as switch divides the network into different collision domains unlike hub.

Problem (6):

a) For the network diagram of this problem, see the figure below:



- Blg 1 : 1 switch (16 or 24 ports) +1 Router (1-LAN port + 1-WAN port)
- Blg 2 : 1 switch (16 or 24 ports) +1 Router (1-LAN port + 2-WAN ports)
- Blg 3 : 1 switch (16 or 24 ports) +1 Router (1-LAN port + 2-WAN ports)
- Blg 4 : 1 switch (16 or 24 ports) +1 Router (1-LAN port + 1-WAN port)

b) Routing tables:

R 1

Network Address	Port	Next hop	
C(1,1) – C(10,1)	1	-	C13→C21,C12→C21
C(1,2) – C(10,2)	2	R2	
C(1,3) – C(10,3)	2	R2	
C(1,4) – C(10,4)	2	R2	C11→C14

R 2

Network Address	Port	Next hop	
C(1,1) – C(10,1)	1	R1	C13→C21,C12→C21
C(1,2) – C(10,2)	3	-	
C(1,3) – C(10,3)	2	R4	C22→C13
C(1,4) – C(10,4)	2	R4	C11→C14

R 4

Network Address	Port	Next hop	
C(1,1) – C(10,1)	2	R2	C13→C21
C(1,2) – C(10,2)	2	R2	
C(1,3) – C(10,3)	3	R3	C22→C13
C(1,4) – C(10,4)	1	-	C11→C14

R 3

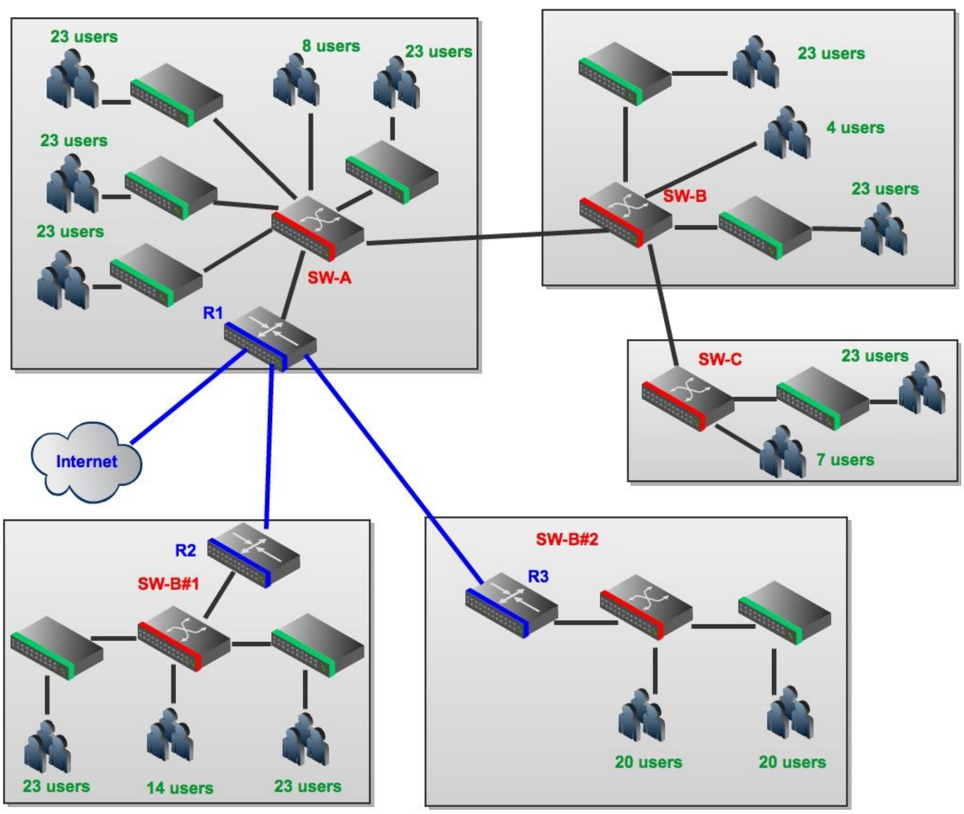
Network Address	Port	Next hop	
C(1,1) – C(10,1)	1	R4	C13→C21
C(1,2) – C(10,2)	1	R4	
C(1,3) – C(10,3)	2	-	C22→C13
C(1,4) – C(10,4)	1	R4	

Problem (7):

a)

- Building A : 4 Hubs (24 ports) + 1 Switch (24 ports) + 1 Router (1 LAN port + 3 WAN ports)
- Building B : 2 Hubs (24 ports) + 1 Switch (24 ports)
- Building C : 1 Hub (24 ports) + 1 Switch (24 ports)
- Branch #1 : 2 Hubs (24 ports) + 1 Switch (24 ports) + 1 Router (1 LAN port + 2 WAN ports)
- Branch #2 : 1 Hub (24 ports) + 1 Switch (24 ports) + 1 Router (1 LAN port + 2 WAN ports)

b)



Problem (8):

Exercise part	Switch	Input		Output	
		Port	VCI	Port	VCI
(a)	1	2	0	1	0
	2	3	0	0	0
	3	0	0	3	0
(b)	1	3	0	1	1
	2	3	1	1	0
	4	3	0	1	0
(c)	2	2	0	0	1
	3	0	1	2	0
(d)	1	0	0	1	2
	2	3	2	0	2
	3	0	2	3	1
(e)	2	1	1	0	3
	3	0	3	1	0
	4	2	0	3	1
(f)	1	1	3	2	1
	2	1	2	3	3
	4	0	0	3	2

Problem (9):

- We have 2 conditions:

1) Rate <= 155 Mbps ➔ N* 2 Mbps <= 155 Mbps ➔ N <= 77.5 ➔ N = 77
2) Buffer size <= 16 Mb ➔ N * 0.2 Mb <= 16 Mb ➔ N <=80 ➔ N = 80

To satisfy the two conditions: N = 77

- Max delay at O/P link = buffer size when 77 sources are waiting/output link rate
  = 0.2 Mb*77/155 Mbps = $0.2*2^{20}*77 / 155*10^{6}$ = 0.104 s