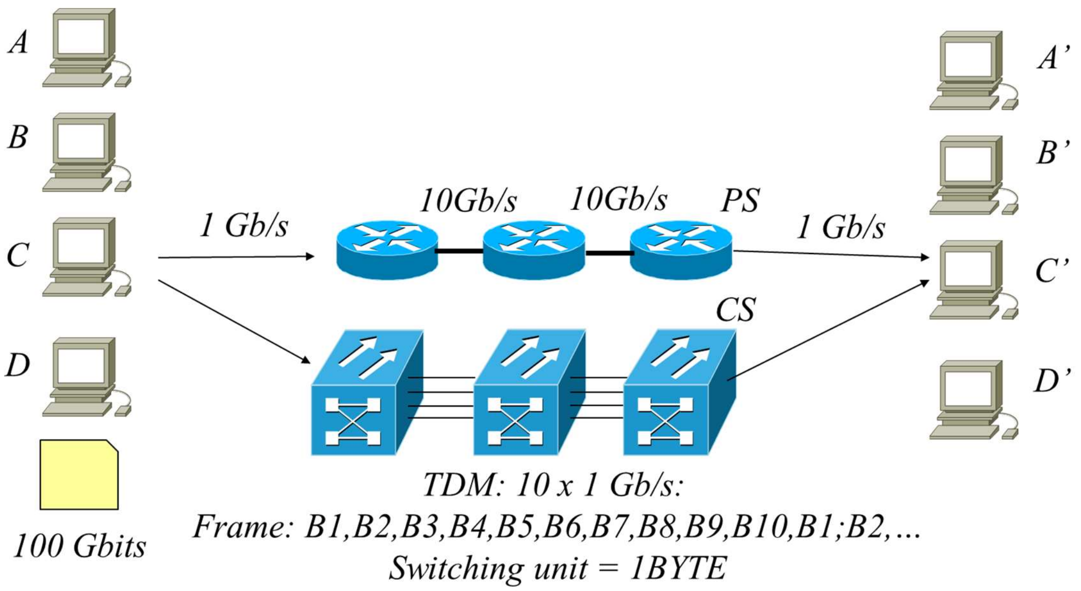
Exercise Switching Techniques

We want to compare the performance of two switching technologies in as-fair-as-possible conditions. To this end, we build the network set up of the Figure.
Each of the end-systems A,B,C,D needs to send concurrently a 100Gbit file to end-systems A',B',C',D' respectively. For this purpose, they have two 1Gb/s line cards (connected to point-to-point dedicated links), each of them interfacing a different type of network technology: a Packet Switching network (in the middle) and a Circuit Switching network (bottom). For the sake of simplicity, the Figure only shows the links of end systems C and C'.



We'd like to make a simple comparison of the two technologies by analyzing the file transfer time when all use the same technology at the same time.

Assumptions:

- There is no other traffic in the network.
- BER=0 (bit error rate) in the links.
- Propagation delay=0 (remember that normally it is 5microsec/Km in a fiber).
- No protocol overhead at all. Only file bytes are sent in all cases, not headers.
- Switching time=0 in switches (remember that normally this time is a few microsecs). That is, in this exercise we only consider queuing delay (when there is such delay) and transmission delay.
- For PS:
    - Assume packets of size 10000 bits, sent back-to-back (i.e. no gap between them), infinite buffers, and packets are served in round-robin fashion. This means that if packets A,B,C,D arrive simultaneously at the input ports of a router destined to the same output port, then the router would write the packets to the output buffer in this order: A,B,C,D,A,B,C,..

- For CS:
  - Assume that the switches are connected by a 10Gb/s link, which is channelised into 10 x 1Gb/s-TDM channels. The switching unit is 1 BYTE. In other words, the bytes from the ten channels are sent like this: B1,B2,B3,B4,B5,B6,B7,B8,B9,B10,B1,B2,B3,… and there isn't any additional framing overhead (no control bytes, OAM bytes, frame alignment sequence, checksum, etc).

Questions:

1) **In the worst case** for the end system D (i.e. D is always the last to be served in the round robin, etc), how long would it take each technology to transfer the **whole file for D**?
2) Which technology would deliver the first byte of the file first? Give an estimation of latency for that byte, in the worst case for D, for each technology.
3) Now imagine that instead of a file, the data corresponds to a live videoconference. Do you think that the latency estimated in question 2 is low enough in the two technologies? Which one is the best?
4) Now imagine there are N=20 end-systems on each side of the picture sending one file each. How many simultaneous file transfers can be supported by the CS network?
5) Same assumption as 4). How many simultaneous file transfers could be supported by the PS network?

Exercise 1:

A router has 3 inputs (In1, In2, In3) and 3 outputs (OutA, OutB, OutC). VOQ is used in input lines to route input packets to their outputs. Let's suppose the following data flows in input lines:

- In1: Flow1 to OutA and Flow2 to OutC
- In2: Flow3 to OutB and Flow4 to OutC
- In3: Flow5 to OutA

Flows have the same packet size and their rate is the same.

Q1: What are the possible connection patterns that can occur if is used PIM algorithm?
Q2: For the patterns found previously, what is the probability of each pattern running PIM? To do it, run PIM algorithm step by step and show the probabilities in each step.
Q3: Does PIM algorithm assign a fair internal bandwidth distribution of the 5 flows? To answer, use the Q2 result to calculate the probability of each flow and show their relationship
Q4: What would happen using RRM? To answer it, run RRM algorithm and obtain the different connection patterns.

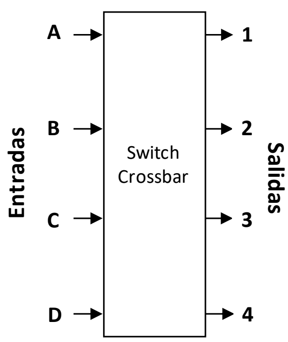
NOTE: Initial Accept Pointers: In1: a1=2; In2: a2=1; In3: a3=2
Initial Grant Pointers: OutA: g1=1; OutB: g2=3; OutC: g3=3

Exercise 2

A router has a crossbar switch with 4 input (ingress) ports and 4 output (egress) ports as shown in the figure. Input ports have the following packets waiting to be switched

	1st packet	2nd packet	3rd packet
Port A	1	2	3
Port B	1	3	4
Port C	1	3	4
Port D	2	4	3

In the table, 1 means a packet for output 1, 3 a packet for output 3, etc.

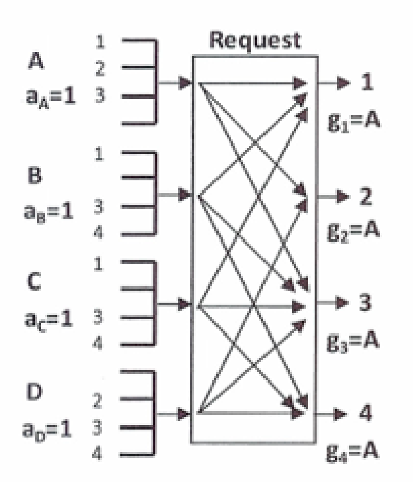


VOQ (Virtual Output Queing) is used

How many times will the crossbar switch to transfer all the packets to the output ports using iSLIP ? Which are those packets? Which is the order?

To take into account: Initial pointers are the following ones where:

- aA=1: input port pointer A is output 1
- g1=A : output port pointer 1 is input A



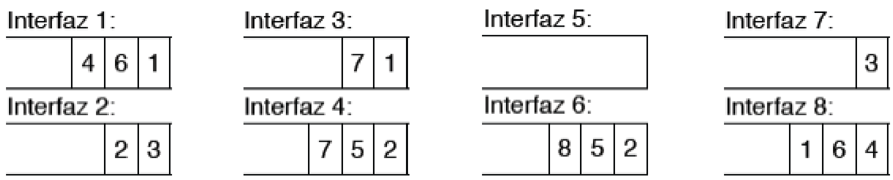
Answer in the table below.

Note: Use only the required Lumber of packet switching.

	1st Switch	2nd Switch	3rd Switch	4th Switch	5th Switch	6th Switch	7th Switch	8th Switch
Port A	Packet=							
Port B	Packet=							
Port C	Packet=							
Port D	Packet=							

Exercise 3:

An 8 port router has the following content in its input buffers:



Note: Each cell represents a packet in the input buffer. The number is the output interface.

VOQ is used to avoid blockings at the switching matrix input by an implementation of algorithm RRM. In which order will all the shown packets be sent (show in each step the pointers values)?

Note: Suppose that initially all the port pointers are set to themselves

Exercise 1

I) Route Lookup Operation

A certain router runs the route lookup before classification. If RL operation takes 15 ns, how much time is allowed for classification to reach a throughput of 40 Gbps (average packet size: 100 bytes)? **Show your calculus.**

II) Binary Tries

a. Build a binary trie for the following prefix set. Taking into account that each node in the binary trie requires a memory access, how many memory accesses are needed for a search in the worst case?

Prefix Label	Prefix Value
P1	0*
P2	00001*
P3	001*
P4	1*
P5	1000*
P6	1001*
P7	1010*
P8	1011*
P9	111*

b. For the previous prefixes, build the path-compressed trie. Show the next bit to compare in the matching nodes. In this trie, how many memory accesses are needed for the search of the following 8-bit addresses: 10011000 and 11100011? .

Exercise 2

I) Route lookup operation

How much time is allowed in a given router for route lookup to reach a throughput of 20 Gbps (Data: average packet size: 200 bytes; Router needs 30 ns per packet in other operations) . **Show your computation.**

II) Multibit Trie

Build a multibit trie of fixed stride size for the following prefix set (the prefixes have been expanded to a equivalent set of length 3 and 5). How many memory accesses are needed for the search of the following 8-bit addresses: 10011000 and 11100011?

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Prefix label	Prefix Value	Expanded Prefixes
P1	**0***	**000*; 010*; 011***
P2	**00001***	**00001***
P3	**001***	**001***
P4	**1***	**100*; 101*; 110***
P5	**1000***	**10000*; 10001***
P6	**1001***	**10010*; 10011***
P7	**1010***	**10100*; 10101***
P8	**1011***	**10110*;10111***
P9	**111***	**111***

Exercise 3

The following table represents a forwarding table.

Prefix	Value
P1	10*
P2	01*
P3	110*
P4	0010
P5	0110
P6	0111

a) Build a binary trie for the following prefix set. Show clearly where the prefixes are.

b) Apply the path-compressed trie to Q1 structure (trie PATRICIA). Re-draw the trie showing the required additional information to make searchs (in other words, the number of bits to skip in the nodes where it would be needed)

Exercise 4

The following table represents a forwarding table.

	Prefix/length
P1	0.0.0.0/1
P2	32.0.0.0/3
P3	0.0.0.0/5
P4	8.0.0.0/5
P5	16.0.0.0/5
P6	24.0.0.0/5
P7	64.0.0.0/2
P8	128.0.0.0/2
P9	192.0.0.0/3
P10	224.0.0.0/3

a) Build a binary trie for the prefix set in the table. How many memory access are required in the worst case? Note: Assume the root node does not imply a memory access.

b) Apply the path-compressed trie). Re-draw the trie showing the required additional information to make searchs (in other words, b = bit to look at; c= bit string to be compared with in case it is required)

c) Build the multibit trie using a fixed stride size equal to 2.

Exercise 5

The following table represents a forwarding table.

	Prefijo/longitud
P0	0.0.0.0/0
P1	116.0.0.0/6
P2	120.0.0.0/6
P3	124.0.0.0/6
P4	224.0.0.0/4
P5	224.0.0.0/6
P6	236.0.0.0/6
P7	252.0.0.0/6

a) Build a binary trie for the prefix set in the table. How many memory access are required in the worst case? Note: Assume the root node does not imply a memory access.

b) Apply the path-compressed trie). Re-draw the trie showing the required additional information to make searchs (in other words, b = bit to look at; c= bit string to be compared with in case it is required)

c) Build the multibit trie using a fixed stride size equal to 3.