Problem 1

Suppose two packets arrive to two different input ports of a router at exactly the same time. Also suppose there are no other packets anywhere in the router.

(a) Suppose the two packets are to be forwarded to two different output ports. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses a shared bus?

(b) Suppose the two packets are to be forwarded to two different output ports. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses switching via memory?

(c) Suppose the two packets are to be forwarded to two different output ports. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses a crossbar?

Write your solution to Problem 1 in this box

(a) No, the bus is shared between the different input and output ports. The bus may allow a single packet through at a time.

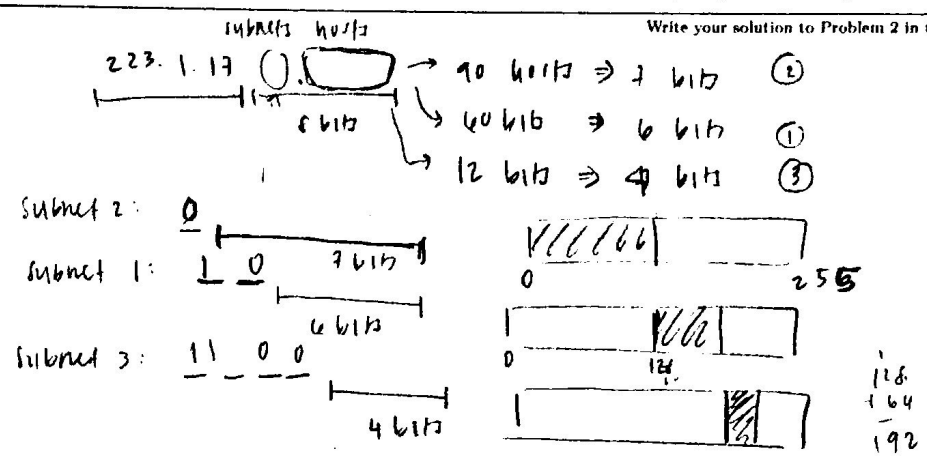
(b) No, the shared memory uses the system bus and the system bus can only move a single packet at a time.

(c) Yes, the crossbar is designed to allow multiple packets to be transmitted simultaneously.

Problem 2

Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, and Subnet 3 is to support at least 12 interfaces. Provide three subnet addresses (of the form a.b.c.d/x) that satisfy the constraints. You may use the following link to help verify your result: `http://jodies.de/ipcalc`.

Write your solution to Problem 2 in this box



Subnet 1: 223.1.17.128/26

Subnet 2: 223.1.17.0/25

Subnet 3: 223.1.17.192/28

Problem 3

Consider sending a 2400 B datagram into a link that has an MTU (maximum transmission unit) of 700 B. Suppose the original datagram is stamped with the identification number 422.

(a) How many fragments are generated?

(b) What are the values in the various fields in the IP datagram(s) generated related to fragmentation?

Write your solution to Problem 3 in this box

(a) 2400 B 700 B

→ 680 B data / datagram

$\lceil \frac{2400}{680} \rceil$ = 4 fragments are generated

(b)

	length	ID	frag flag	offset
original	2400	422	0	0
fragment 1	700	422	1	0
fragment 2	700	422	1	85
fragment 3	700	422	1	170
fragment 4	380	422	0	255

Problem 4

In this problem we will explore the impact of NATs on P2P applications. Suppose a peer with username Arnold discovers through querying that a peer with username Bernard has a file it wants to download. Also suppose that Bernard and Arnold are both behind a NAT. Try to devise a technique that will allow Arnold to establish a TCP connection with Bernard without application-specific NAT configuration. If you have difficulty devising such a technique, discuss why.

Write your solution to Problem 4 in this box

This would be difficult without any application-specific NAT when Arnold tries to establish a connection with Bernard he sends the request to Bernard's NAT's address, not Bernard's actual IP address. The NAT on Bernard's end will not be able to determine which host the data is for and thus the packet will be dropped. This is because the NAT table has not yet been established for Bernard because there were no outgoing connections.

Problem 5

Consider the SDN OpenFlow network shown as follows. Suppose that the desired forwarding behavior for datagrams arriving at s2 is as follows:

- Any datagrams arriving on input port 1 from hosts h5 or h6 that are destined to hosts h1 or h2 should be forwarded over output port 2;
- Any datagrams arriving on input port 2 from hosts h1 or h2 that are destined to hosts h5 or h6 should be forwarded over output port 1;
- Any arriving datagrams on input ports 1 or 2 and destined to hosts h3 or h4 should be delivered to the host specified;
- Host h3 and h4 should be able to send datagram to each other.

Specify the flow table entries in s2 that implement this forwarding behavior.

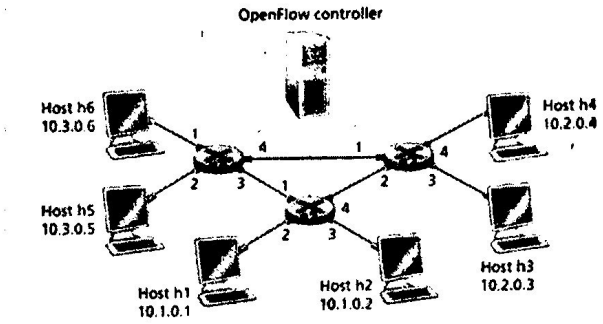


Figure 4.30 • OpenFlow match-plus-action network with three packet switches, 6 hosts, and an OpenFlow controller

Problem 5 continued on next page...

Write your solution to Problem 5 in this box

match	action
IngressPort = 1 IP Src = 10.3.0.* IP Dst = 10.1.0.*	forward (2)
IngressPort = 2 IP Src = 10.1.0.* IP Dst = 10.2.0.*	forward (1)
IngressPort = 1 IP Dst = 10.2.0.4	forward (4)
IngressPort = 1 IP Dst = 10.2.0.3	forward (3)
IngressPort = 2 IP Dst = 10.2.0.4	forward (4)
IngressPort = 2 IP Dst = 10.2.0.3	forward (3)
IP Src = 10.2.0.4 IP Dst = 10.2.0.3	forward (3)
IP Src = 10.2.0.3 IP Dst = 10.2.0.4	forward (4)