CSEE 4119: Computer Networks

Homework 4 **Due: 04/15**

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 a crossbar?

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

2. a. A router typically consists of input ports, output ports, a switching fabric and a routing processor. Which of these are implemented in hardware and which are implemented in software? why?

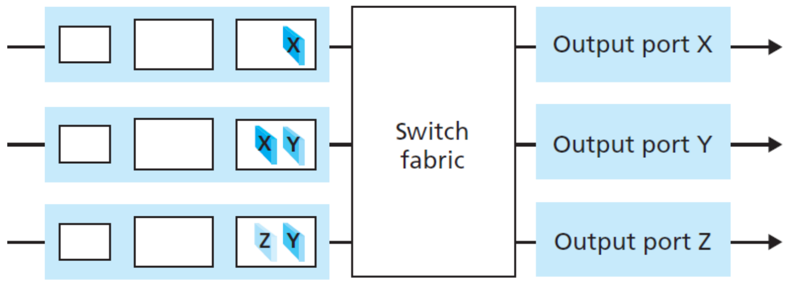
   b. Assuming input and output line speeds are the same, describe how packet loss can occur at output ports. Can this loss be prevented by increasing the switch fabric speed?

   c. What is the 32-bit binary equivalent of the IP address 223.1.3.27?

3. a. Suppose there are three routers between a source host and a destination host. Ignoring fragmentation, an IP datagram sent from the source host to the destination host will travel over how many interfaces? How many forwarding tables will be indexed to move the datagram from the source to the destination?

   b. Suppose you purchase a wireless router and connect it to your cable modem. Also suppose that your ISP dynamically assigns your connected device (that is, your wireless router) one IP address. Also suppose that you have five PCs at home that use 802.11 to wirelessly connect to your wireless router. How are IP addresses assigned to the five PCs? Does the wireless router use NAT? Why or why not?

4. Consider the switch shown below. Suppose that all datagrams have the same fixed length, that the switch operates in a slotted, synchronous manner, and that in one time slot a datagram can be transferred from an input port to an output port. The switch fabric is a crossbar so that at most one datagram can be transferred to a given output port in a time slot, but different output ports can receive datagrams from different input ports in a single time slot. What is the minimal number of time slots needed to transfer the packets shown from input ports to their output ports, assuming any input queue scheduling order you want (i.e., it need not have HOL blocking)? What is the largest number of slots needed, assuming the worst-case scheduling order you can devise (assuming that a non-empty input queue that can be scheduled, it is never idle)?



5. Consider a subnet with prefix 128.119.40.128/26. Give an example of one IP address (of form xxx.xxx.xxx.xxx) that can be assigned to this network. Suppose an ISP owns the block of addresses of the form 128.119.40.64/26. Suppose it wants to create four subnets from this block, with each block having the same number of IP addresses. What are the prefixes (of form a.b.c.d/x) for the four subnets?

6. Consider sending a 2400-byte datagram into a link that has an MTU of 700 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? What are the values in the offset and flag fields in the IP datagram(s) generated related to fragmentation?

Solution 4

1.

a) No, you can only transmit one packet at a time over a shared bus.

b) Yes, the crossbar switch can forward these two packets at the same time.

c) No, in this case the two packets would have to be sent to the same output port at the same time, which is not possible.

2.

a) Input port, switching fabric, and output ports are implemented in hardware, because their datagram-processing functionality is far too fast for software implementation. A routing processor inside a traditional router uses software for executing routing protocols, maintaining routing tables and attached link state information, and computing the forwarding table of a router. In addition, a routing processor in a SDN router also relies on software for communication with a remote controller in order to receive forwarding table entries and install them in the router's input ports.

Data plane is usually implemented in hardware due to the requirement of fast processing, e.g., at nanosecond time scale. Control plane is usually implemented in software and operates at the millisecond or second timescale, for example, for

b) Assuming input and output line speeds are the same, packet loss can still occur if the rate at which packets arrive to a single output port exceeds the line speed. If this rate mismatch persists, the queues will get larger and larger and eventually overflow the output port buffers, causing packet loss. Note that increasing switch fabric speed cannot prevent this problem from occurring.

c) 11011111 00000001 00000011 00011100

3.

a) 8 interfaces; 3 forwarding tables

b) Typically the wireless router includes a DHCP server. DHCP is used to assign IP addresses to the 5 PCs and to the router interface. Yes, the wireless router also uses NAT as it obtains only one IP address from the ISP.

4.

The minimal number of time slots needed is 2. The scheduling is as follows.

Slot 1: send X in top input queue, send Y in middle input queue, send Z in bottom input queue.

Slot 2: send X in middle input queue, send Y in bottom input queue

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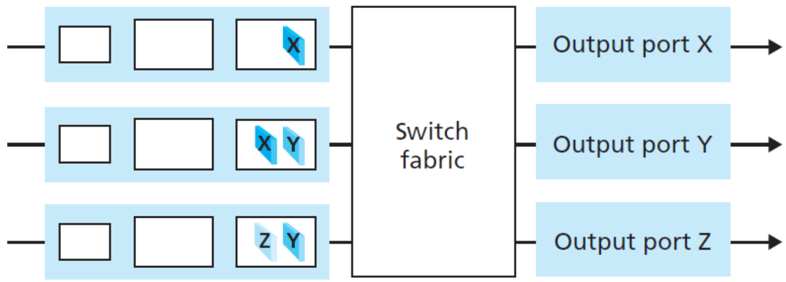

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Largest number of slots is 3 under FIFO. Based on the assumption that a non-empty input queue is never idle, we see that the first time slot always consists of sending X in the top input queue and Y in either middle or bottom input queue, and in the second time slot, we can always send two more datagram, and the last datagram can be sent in third time slot.

NOTE: If the first datagram in the bottom input queue was X, then the worst case would require 4 time slots.

5.

Any IP address in range 128.119.40.128 to 128.119.40.191

Four equal size subnets: 128.119.40.64/28, 128.119.40.80/28, 128.119.40.96/28, 128.119.40.112/28

6.

The maximum size of data field in each fragment = 680 (because there are 20 bytes IP header). Thus the number of required fragments $= \left\lceil \frac{2400-20}{680} \right\rceil = 4$

Each fragment will have Identification number 422. Each fragment except the last one will be of size 700 bytes (including IP header). The last datagram will be of size 360 bytes (including IP header). The offsets of the 4 fragments will be 0, 85, 170, 255. Each of the first 3 fragments will have flag=1; the last fragment will have flag=0.