Scarlett Jones
CSCE 3530
Homework #5
Due 11/21/2016, 11:55 PM

1. Briefly explain TCP's additive increase multiplicative decrease (AIMD) approach to congestion.
   a. The sender increases their transmission rate (window size) in order to use the most available bandwidth, until a loss occurs.
   b. The additive increase increases the window size by 1 MSS every round trip time until a loss is detected.
   c. The multiplicative decrease cuts the window size in half after a loss is detected.
2. Differentiate (at least two differences) between TCP Reno and TCP Tahoe.
   a. TCP Reno
      i. After a loss is detected, the window size is cut in half.
      ii. After a loss, the window continues to grow linearly.
   b. TCP Tahoe
      i. After a loss is detected, the window size is set to 1 MSS.
      ii. After a loss, the window continues to grow exponentially (in the slow start region) until it reaches the threshold. Then it grows linearly.
3. Plot a single graph with congestion window on y-axis and transmission rounds on x-axis for TCP Tahoe and TCP Reno. On the plot, show TCP Tahoe's and TCP Reno's congestion window for 15 transmission rounds. Assume ssthresh is initially set to 16 segments and the maximum window size is 20 segments.


TCP Congestion Window vs Transmission Rounds
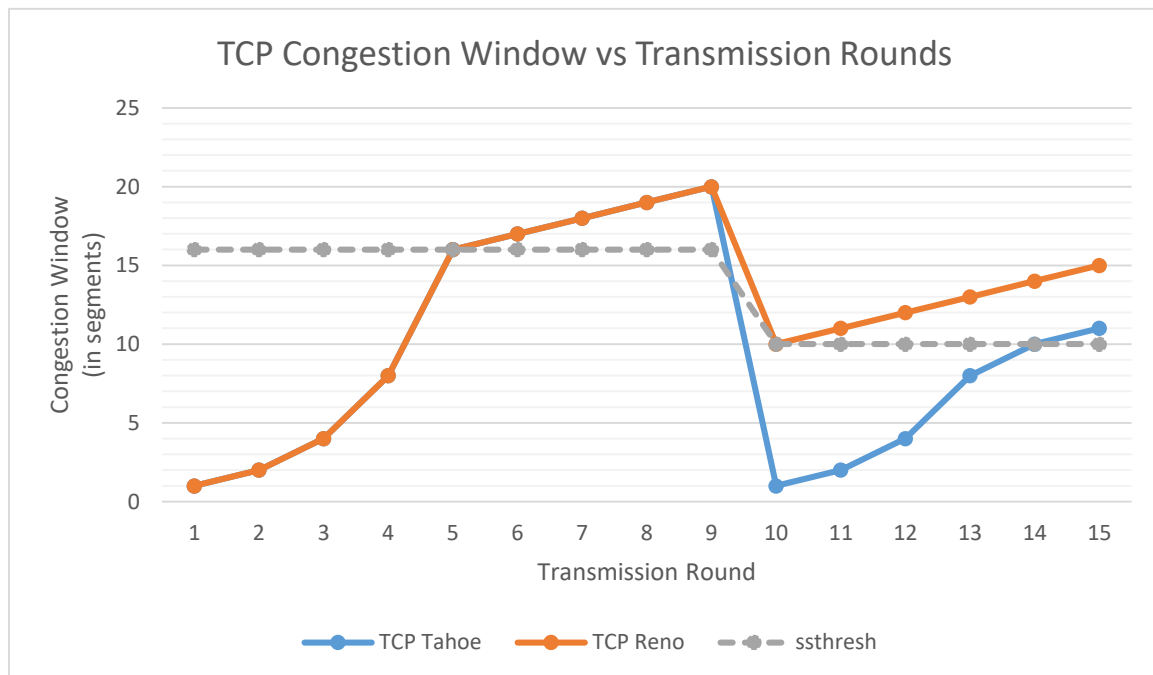
4. Briefly explain why is TCP fair?
   a. If there are N TCP sessions sharing the same bottleneck link of bandwidth R, then each TCP connection should have an average rate of R/N.
   b. Whenever there is a loss, multiplicative decrease decreases the window by a factor of 2.
   c. Then additive increase increases by 1 to avoid congestion.
5. What are the two key functions of a router? Explain each function.

a. Routing
   i. Determine the route to be taken by packets from source to destination. This is done with a routing algorithm.
b. Forwarding
   i. Move packets from router's input to appropriate router output. This follows the local forwarding table that was determined by the routing algorithm.

6. Discuss the working of virtual circuits and the working of datagram networks.
   a. Virtual Circuits
      i. Network provides network layer connection service.
      ii. There is a path from source to destination.
      iii. There are VC numbers, one number for each link along the path.
      iv. There are entries in forwarding tables in routers along the path.
      v. The packet belonging to VC carries VC number, rather than the destination address.
      vi. VC number can be changed on each link.
      vii. New VC number comes from forwarding table.
   b. Datagram Networks
      i. Network provides network layer connectionless service.
      ii. No call setup at network layer.
      iii. Routers don't have a state about end to end connections.
      iv. There is no network level concept of connection.
      v. Packets are forwarded using destination host address.

7. Draw the router architecture. Label and describe all the blocks in the architecture.
   a. Here is a picture of the router architecture.
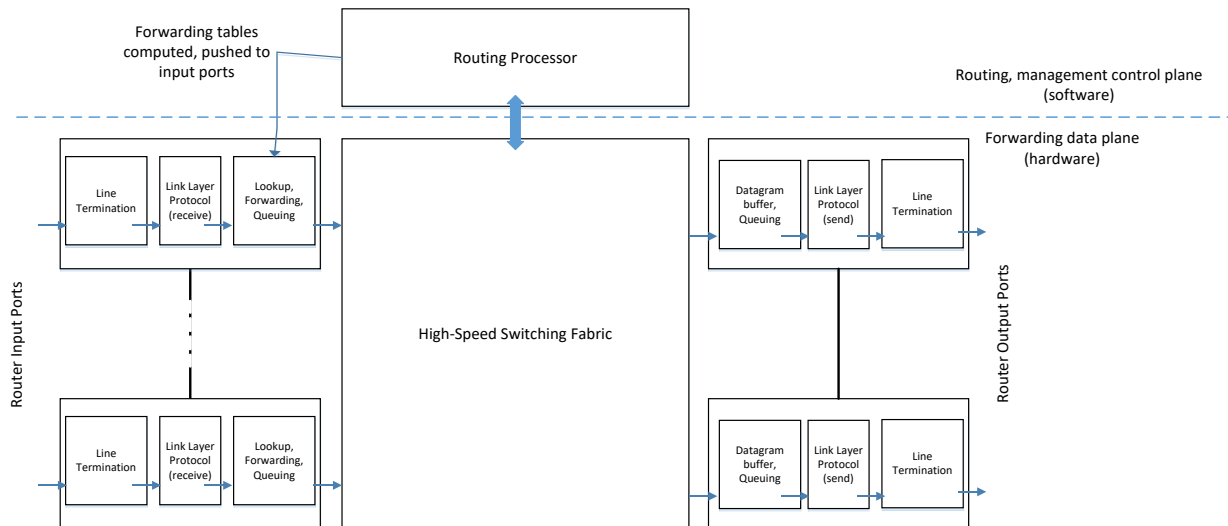
   b. Router input ports
      i. Line Termination is done on the physical layer. It receives bits.
      ii. Link Layer Protocol (receive) is done on the data link layer.

iii. Lookup, forwarding, queueing is done with decentralized switching. Given a datagram destination, it will lookup the output port using the forwarding table in the input port memory. If datagrams arrive faster than forwarding rate into switch fabric, then it will be queued. Head of the line (HOL) blocking will prevent other datagrams in the queue from moving forward if there is a queued datagram waiting at the front of the queue.

iv. There is a close-up of an input port below.
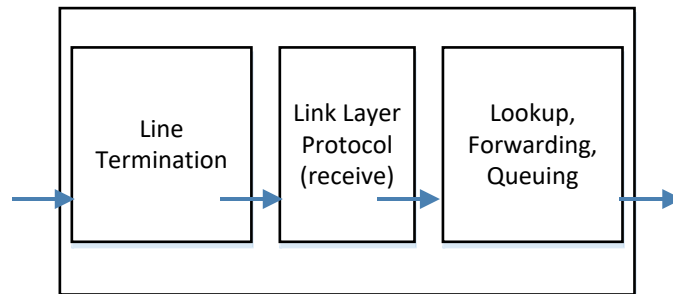
c. Routing processor
   i. This computes the forwarding tables with a routing algorithm.
   ii. This pushes the forwarding tables to the router input ports.

d. Switching fabric
   i. There are 3 different types of switching fabrics: memory, bus, and crossbar.
   ii. Switching fabrics transfer the packet from the input buffer to the appropriate output buffer.
   iii. The switching rate is the rate at which packets can be transferred from input ports to output ports.

e. Router output ports
   i. Buffering is required when datagrams arrive from the switching fabric faster than the transmission rate. Scheduling discipline chooses among queued datagrams for transmission.
   ii. Link layer protocol (send) is done on the data link layer.
   iii. Line termination is done on the physical layer. It sends out bits.
   iv. There is a close-up of an output port below.
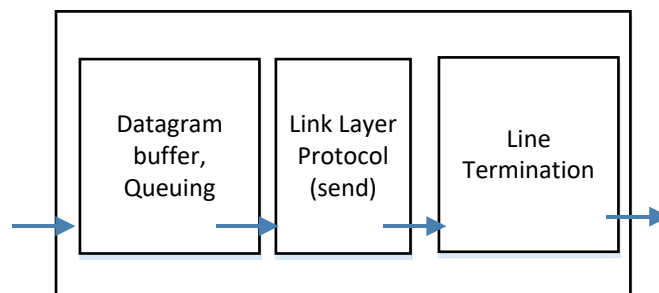
8. Explain the three different types of switching fabrics used in a router. Draw the architecture for each type of switching fabric.

a. Memory
 i. Switching is under the direct control of the CPU.
 ii. Packets are copied to the system's memory.
 iii. The speed is limited by memory bandwidth.
 iv. Here is a picture of switching via memory.

Input port	Memory	Output port

System Bus
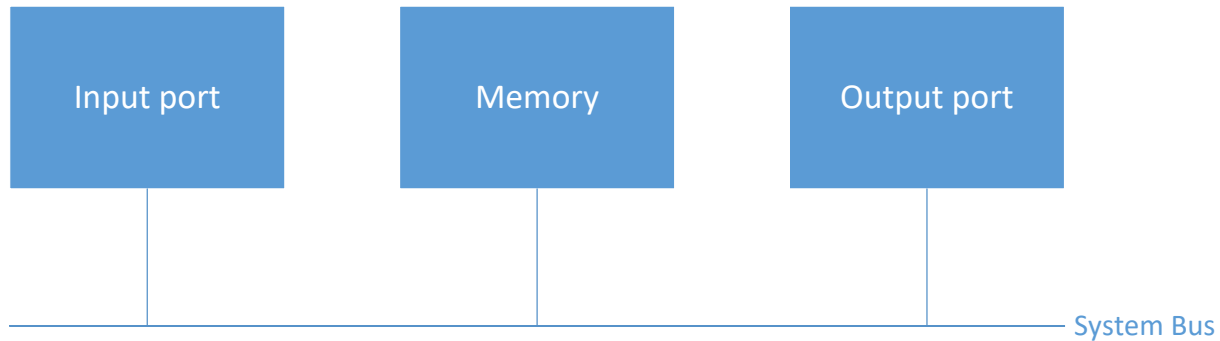
b. Bus
 i. Datagram is transferred from input port memory to output port memory via a shared bus.
 ii. Only one can access the bus at a time. This leads to bus contention.
 iii. The speed is limited by bus bandwidth.
 iv. Here is a picture of switching via a bus.
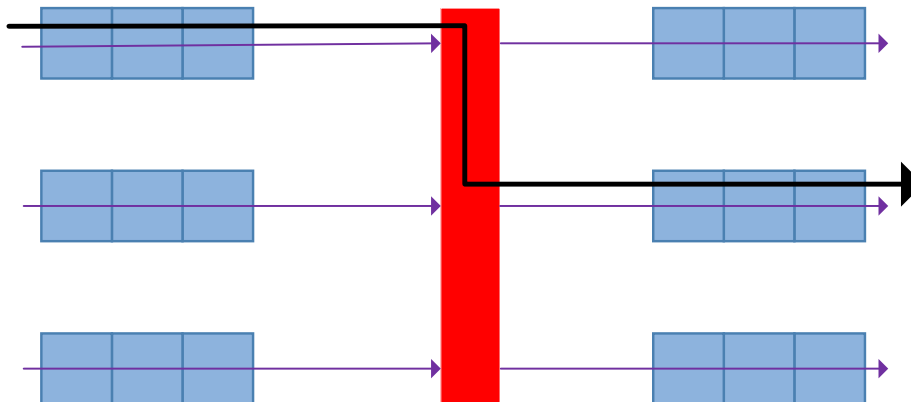
c. Crossbar
 i. Created to overcome bus bandwidth limitations.
 ii. Interconnection nets were initially developed to connect processors in multiprocessor.
 iii. Advanced design: fragments datagrams into fixed length cells and switches these cells through the switching fabric.
 iv. Here is a picture of switching via interconnection network.
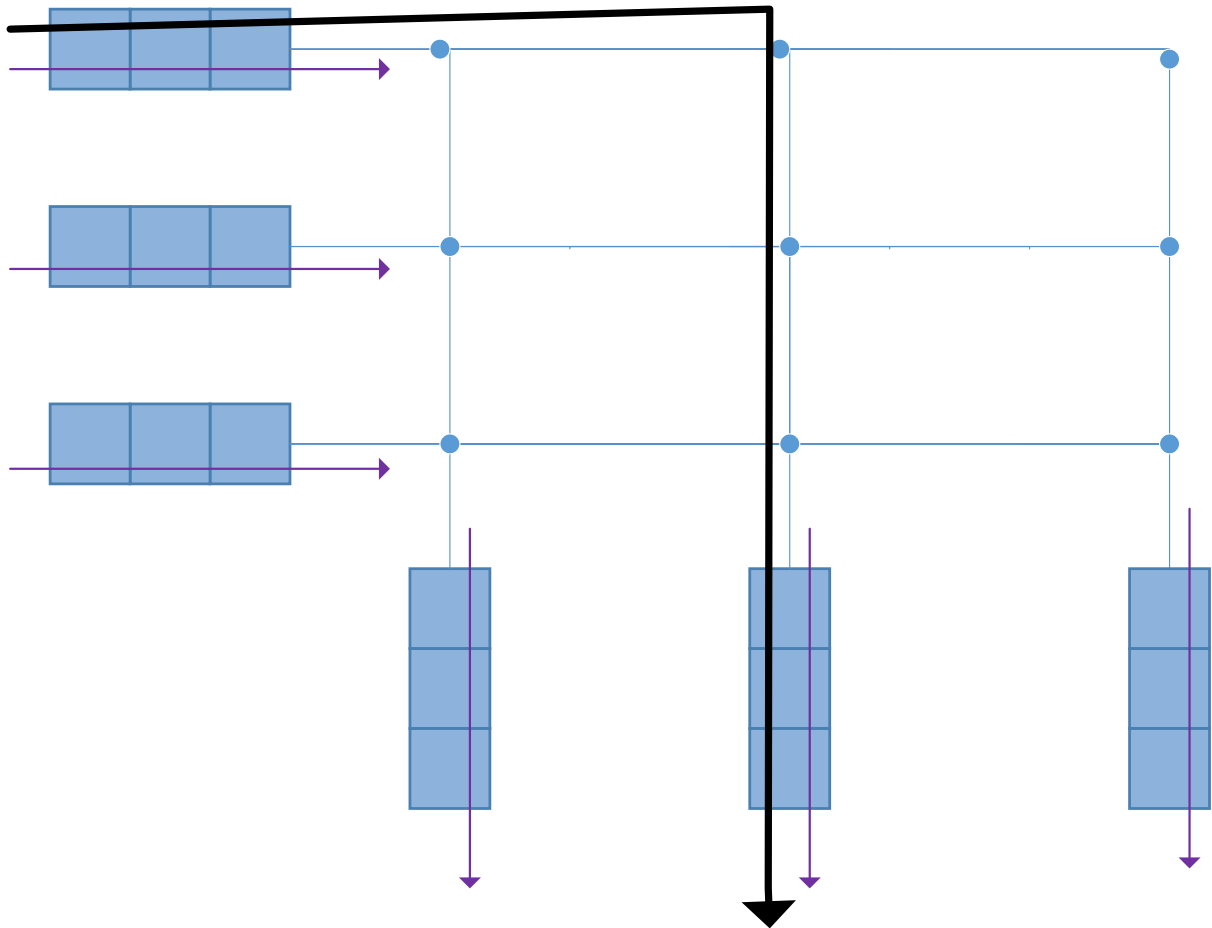
9. A 5000 byte datagram is to be sent through a router that has a MTU (Maximum Transmission Unit) of 1000 bytes. How many fragments are generated and what are the values of the various fields in the IP datagrams generated related to fragmentation. Assume an ID number 123 for the actual datagram.

    a. There are 6 fragments generated.

    b. There is a diagram of the fragments with each field filled below.

4980 bytes in data field

Length = 5000	ID = 123	Frag flag = 0	Offset = 0

5000 byte datagram
MTU = 1000 bytes
Header is 20 bytes

980 bytes in data field

Length = 1000	ID = 123	Frag flag = 1	Offset = 0

980 bytes in data field

Length = 1000	ID = 123	Frag flag = 1	Offset = 122.5

5000 − 980 = 4020
980/8 = 122.5

980 bytes in data field

Length = 1000	ID = 123	Frag flag = 1	Offset = 245

4020 − 980 = 3040
980*2/8 = 245

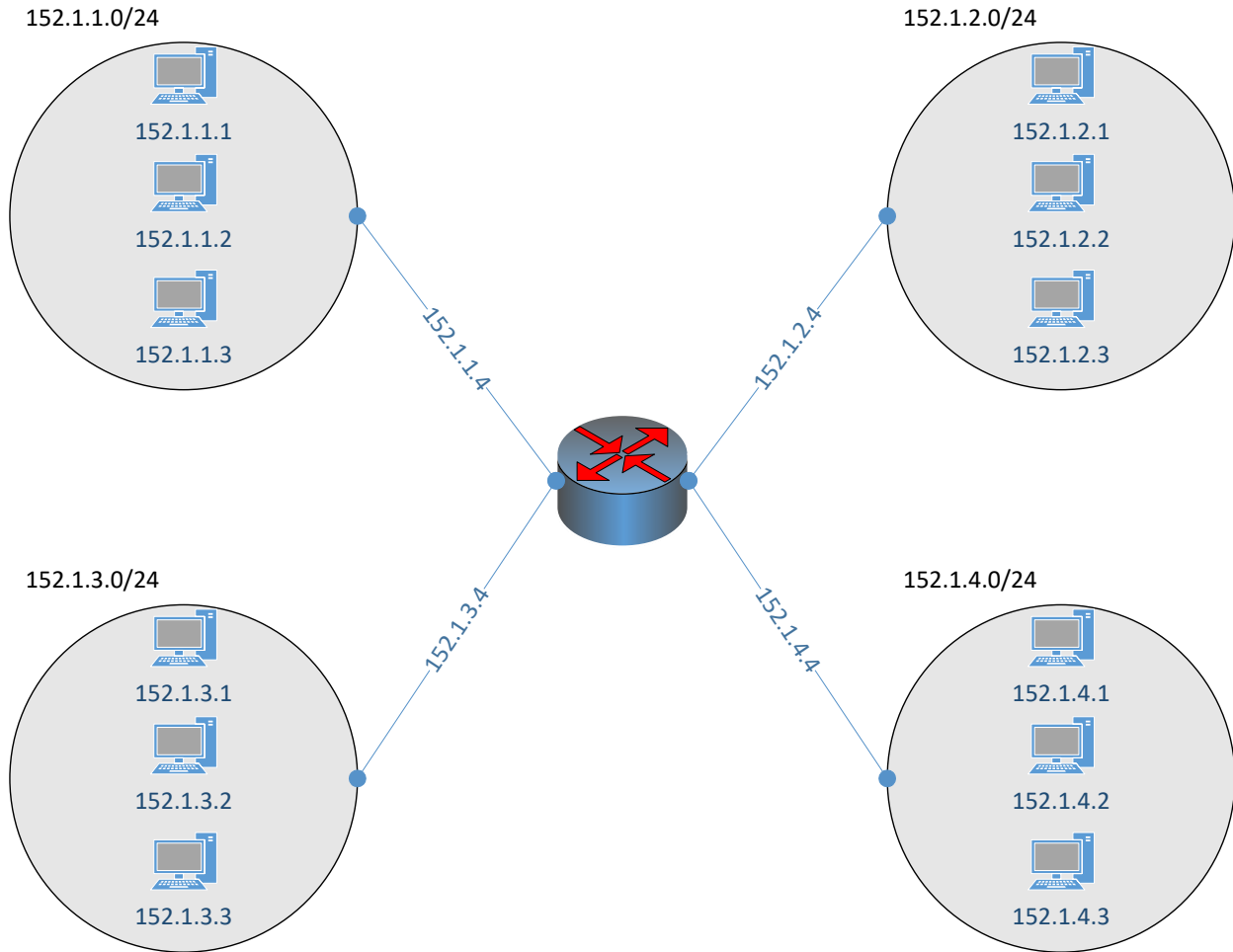980 bytes in data field

Length = 1000	ID = 123	Frag flag = 1	Offset = 367.5

3040 − 980 = 2060
980*3/8 = 367.5

980 bytes in data field

Length = 1000	ID = 123	Frag flag = 1	Offset = 490

2060 − 980 = 1080
980*4/8 = 490

80 bytes in data field

Length = 100	ID = 123	Frag flag = 0	Offset = 612.5

1080 − 980 = 100
980*5/8 = 612.5

10. What is a subnet and how are subnets created? Draw a configuration with four subnets.
   a. A subnet is basically a way to split up a network. If you detach each interface from its host or router, you will see islands of isolated networks. These isolated networks are the subnets. Device interfaces with same subnet part of IP address. The devices in the subnet can physically reach each other without intervening router.
   b. Classless InterDomain Routing (CIDR) is how IP addressing is done. The subnet part of an IP address is the higher order bits while the host part of an IP address is the lower order bits. The subnet portion of the IP address is of an arbitrary length. The format of the IP addresses is a.b.c.d/x, where x is the number of bits in the subnet portion of the address. The subnet mask is /x.

c. Here is a picture of a configuration with four subnets.

152.1.1.0/24

152.1.1.1

152.1.1.2

152.1.1.3

152.1.2.0/24

152.1.2.1

152.1.2.2

152.1.2.3

152.1.1.4

152.1.2.4

152.1.3.0/24

152.1.3.1

152.1.3.2

152.1.3.3

152.1.4.0/24

152.1.4.1

152.1.4.2

152.1.4.3

152.1.3.4

152.1.4.4

11. What is DHCP? Using a timeline diagram, show an example of a client getting its IP address from DHCP server.

   a. Dynamic Host Configuration Protocol (DHCP) allows a host to dynamically obtain its IP address from the network server when it joins the network.

   b. Here is a timeline diagram that shows a client getting its IP address from a DHCP server.

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DHCP Server

Arriving Client

New arriving client broadcasts a **DHCP discover** message, looking for a DHCP server.
Source: 0.0.0.0, port 68
Destination: 255.255.255.255, port 67
Your IP address: 0.0.0.0
Transaction ID: 1

DHCP server broadcasts a **DHCP offer**, offering the client an available IP address.
Source: 223.1.2.5, port 67
Destination: 255.255.255.255, port 68
Your IP address: 223.1.2.4
Transaction ID: 1
Lifetime: 3600 seconds

Arriving client broadcasts a **DHCP request**, accepting the IP address offered.
Source: 0.0.0.0, port 68
Destination: 255.255.255.255, port 67
Your IP address: 223.1.2.4
Transaction ID: 2
Lifetime: 3600 seconds

DHCP server broadcasts a **DHCP ACK**, letting the client know that it can still have that IP address.
Source: 223.1.2.5, port 67
Destination: 255.255.255.255, port 68
Your IP address: 223.1.2.4
Transaction ID: 2
Lifetime: 3600 seconds