Section #5: The Transport Layer & Router Architecture

1) **Transport Layer: Sliding Windows and ACKs**

Alice and Bob are designing an experimental transport protocol. Alice controls the sending host, and Bob controls the receiving host; their computers are connected by a direct link (*ie*., there are no routers in between them – just a direct cable).

i) Suppose Alice and Bob use the Stop & Wait algorithm: Alice only sends a new packet once the previous packet has been acknowledged. Bob responds to Alice's packets with individual ACKs. Alice sends 5 packets, but the 3rd one is lost. Show the timing diagram for the transfer between Alice and Bob.

See slides for the diagram

ii) Let's say none of Alice's packets are lost and Bob uses cumulative ACKs. Transmission delay is 2ms for both Alice's packets and Bob's ACKs, and propagation delay is 30 ms. How long does it take for Alice to transmit all five packets and receive an ACK back from Bob for the last packet?

Each packet takes 2+30 ms. 10 packets (including ACKs) are sent, therefore 320ms.

iii) Realizing that this is rather slow, Alice upgrades to using a "sliding window" algorithm with a window size of 3. Bob continues sending cumulative ACKs. No packets are lost. How long does it take (using the parameters from (ii)) for Alice to transmit all five packets and receive an ACK back from Bob for the last packet?

It takes 64ms for Alice to receive the ACK for the 1st packet.

Upon receiving that ACK, Alice sends the 4th packet, and it takes another 64ms to receive the ACK.

After 2ms, the ACK for the 5th packet also arrives.

64 + 64 + 2 = 130ms

iv) Alice and Bob's link is lossy again. Alice's 4^{th} packet is lost while Alice is using her new, more efficient sliding window algorithm with a window of 3. Alice and Bob use the Go-Back-N sliding window algorithm with cumulative ACKs. Assume Alice's retransmission timer is 100ms and the same parameters as above.. How long does it take for Alice to transmit all five packets and receive an ACK back from Bob for the last packet?

It takes 64ms for Alice to receive the ACK for the 1st packet.

Upon receiving that ACK, Alice sends the 4th packet, but the packet is lost. Alice waits for 100ms to retransmit the 4th packet.

After the retransmission, it takes 64ms for Alice to receive the ACK for the 4th packet.

After 2ms, the ACK for the 5th packet also arrives.

64 + 100 + 64 + 2 = 230ms

v) Alice and Bob's link is still lossy. Alice's 4th packet is lost while Alice is transmitting just as before, only now Alice and Bob use the Selective Repeat sliding window algorithm with individual ACKs. Assume the same parameters as above. How long does it take for Alice to transmit all five packets and receive an ACK back from Bob?

Again, tt takes 64ms for Alice to receive the ACK for the 1st packet.

Upon receiving that ACK, Alice sends the 4th packet, but the packet is lost. Alice waits for 100ms to retransmit the 4th packet. In the meantime, Alice sends the 5th packet after sending the 4th packet. The 5th packet then gets acknowledged during the 100ms timeout.

After the retransmission, it takes 64ms for Alice to receive the ACK for the 4th packet.

64 + 100 + 64 =228ms

2) **Router Architecture: Longest Prefix Match**

A router R has the following routing table:

If packets arriving for the following IP addresses arrive, what port do they go out?

Prefix	**Port**
8.0.0.0/8	1
9.0.0.0/8	2
8.192.192.0/18	2
8.192.128.0/18	1
8.128.0.0/16	3
8.192.0.0/16	4
Default	5

List the binary representation of routing prefixes in decreasing order of prefix lengths:

8.192.192.0/18	00001000 11000000 11000000 00000000
8.192.128.0/18	00001000 11000000 10000000 00000000
8.128.0.0/16	00001000 10000000 00000000 00000000
8.192.0.0/16	00001000 11000000 00000000 00000000
8.0.0.0/8	00001000 00000000 00000000 00000000
9.0.0.0/8	00001001 00000000 00000000 00000000

i) 9.8.4.56
00001001 000011000 00000100 00111000
Port 2 (9.0.0.0/8)

ii) 7.63.23.5
00000111 00111111 00010111 00000101
Port 5 (Default)

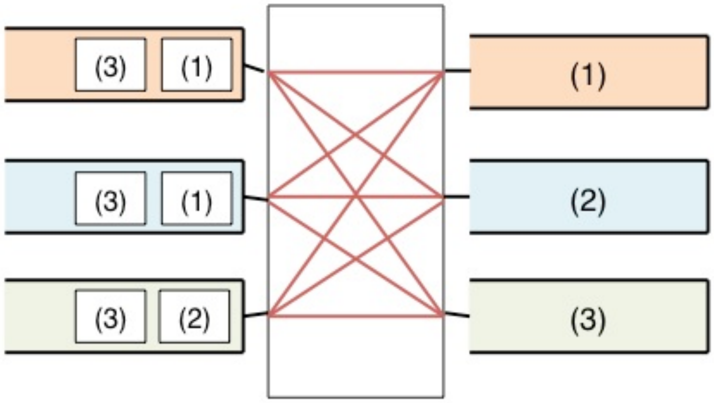
iii) 8.192.130.43
00001000 11000000 10000010 00101011
Port 1 (8.192.128.0/18)

iv) 8.178.54.3
00001000 10110010 00110110 00000011
Port 1 (8.0.0.0/8)

v) 8.192.200.14
00001000 11000000 11010000 00001110
Port 2 (8.192.192.0/18)

vi) 8.0.192.0
00001000 00000000 11000000 00000000
Port 1 (8.0.0.0/8)

3) **Router Architecture: Head of Line Blocking**



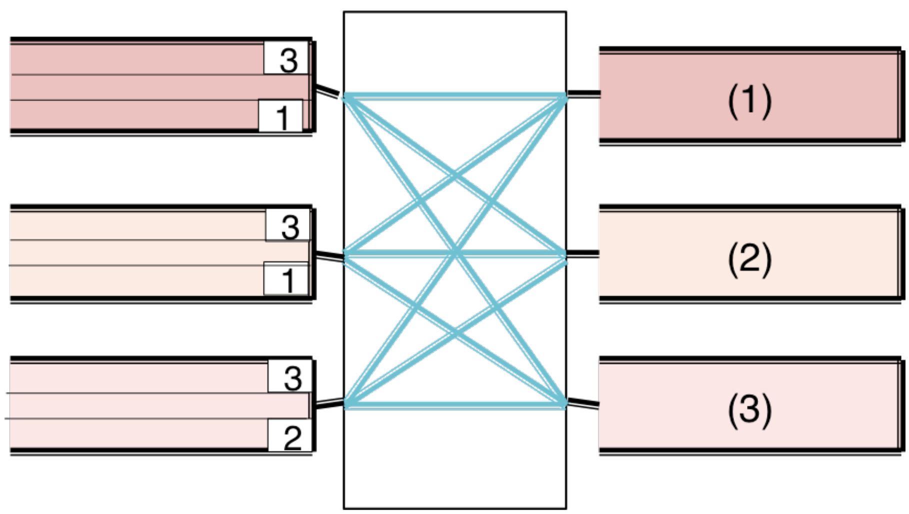
The router to the left receives has three input/output ports and a switched interconnect as described in class ("3rd generation" routers).

Assume all packets are the same size; every interconnect scheduling interval is T seconds; and one packet per port can cross the interconnect per scheduling interval.

(i) How many seconds does it take for all of the input packets to reach their output ports?

4T

(ii) Assume the router uses virtual output queues. Draw the router as it would appear with virtual output queues and the above packets below:



(iii) How many seconds does it take for al of the input packets to reach their output ports using this new router with virtual output queues?

3T