1 2000 KB file RTT = 160 ms PS = 1 KB ACK = 2×RTT

a) BW = 1.5 Mbps

$$\text{TrasferTime} = 2\times 160 + {}^{82{,}000(1024)\,b}/_{1.5\times 10^6\,\frac{b}{s}}$$
$$= 320\text{ms} + 10.9227\text{s}$$
$$= 0.32\text{s} + 10.9227\text{s}$$
$$= 11.243\text{s}$$

b) $$\text{TrasferTime} = 0.32\text{s} + 2000\left(0.16\text{s} + {}^{8(1024)b}/_{1.5\times 10^6\,\frac{b}{s}}\right)$$
$$= 0.32\text{s} + 2000(0.16546\text{s})$$
$$= 0.32\text{s} + 330.92267$$
$$= 331.243\text{s}$$

c) $$\text{TrasferTime} = 0.32\text{s} + {}^{2000}/_{50}(0.16\text{s})$$
$$= 0.32\text{s} + 40(0.16\text{s})$$
$$= 0.32\text{s} + 6.4\text{s}$$
$$= 6.72\text{s}$$

d) $$\text{TrasferTime} = 0.32\text{s} + \sum_{n=1}^{11} 2^{n-1}\left({}^{8\times 1024\,b}/_{10^6\,b/s}\right)$$
$$= 0.32 + \left({}^{8\times 1024b}/_{10^6 b/s}\right)\cdot \sum_{i=1}^{11} 2^{n-1} + 0.16\text{s}\times 11$$
$$= 0.32 + \left({}^{8\times 1024b}/_{10^6 b/s}\right)\times 2047 + 1.76\text{s}$$
$$= 0.32 + (0.008192)\times 2047$$
$$= 0.32 + 16.769024 + 1.76$$
$$= 18.849\text{ s} \leftarrow \text{If has to send last } 2^{10} \text{ (1024 PACKETS)}$$

$$= 0.32s + \left(8\times1024b / 10^6 b/s\right)\sum_{n=1}^{10} 2^{n-1} + 977\left(8\times1024b / 10^6 b/s\right) + 1.76s$$

($977 = 2000 - \sum_{n=1}^{10} 2^{n-1}$)

$$= 0.32s + 8.380416 + 8.003584 + 1.76$$

$$= 18.464$$ ← If can send less than last 2^{16} bits

e) $331.243 / 2 = 165.6215s$

$$162.6215 = 0.32 + 2000\left(0.16s + 8(1024)b / x\times10^6 b/s\right)$$

$$162.6215 - 0.32 = 2000(0.16 + 0.008192/x)$$

No Solution 2000×0.16 is already 320s

2 50Mbps $d = 385{,}000\,km$ $v = 3\times10^8\,m/s$

a) RTT assuming packet is 1 bit and 0s delay at ends

$\pm\frac{d}{v}$

$$RTT = 2\times\left(385{,}000\times1000m / 3\times10^8\,m/s\right)$$

$$RTT = 2\times\left(3.85\times10^8\,m / 3\times10^8\,m/s\right)$$

$$RTT = 2\times\left(3.85/3\right)$$

$$RTT = 2.56s$$

b) BDP assuming packet size is 1 bit

$BDP = 50 \times 10^6 \text{ b/s} \times 2.56\text{s}$

$BDP = 1.28 \times 10^8 \text{ bits} = 128 \text{ Mb}$

c) 25 MB file

Transfer Time assuming packet size is 128 Mb

$TT = (128 \times 10^6 \text{ b} / 50 \times 10^6 \text{ b/s}) + (72 \times 10^6 \text{ b} / 50 \times 10^6 \text{ b/s}) + r$

(first 128 Mb; 25 MB − 128 Mb; r: Request packet size is 1 bit)

$TT = 128/50 + 72/50 + \text{requestTime}$

$= 4 + 1.28\text{s}$

$= 5.28\text{s}$

d) $1 \times 10^6 \text{ b/s} \times 1\text{s} = 10^6 \text{ b}$ ← Case A

$1 \times 10^9 \text{ b/s} \times 10^{-3}\text{s} = 10^6 \text{ b}$ ← Case B

This is due to the length of the link. Case A will have a longer link so that it can store the same number of bits as Case B

3

a) Time = $1b / 10 \times 10^6$ b/s + L (length of wire (m)) $/ 2 \times 10^8$ m/s

$= 1/10^7$ s + $L(\frac{1}{2} \times 10^{-8})$

$= 10^{-7}$ s + $\frac{L}{2} \times 10^{-8}$ s

b) 10 km link 10 Gbps Assume $s_{prop} = 2.3 \times 10^8$ m/s

TransferTime = 10×10^3 m / 2.3×10^8 m/s

BDP = $(1/2.3 \times 10^4)$ s $\times$ 10×10^9 b/s

$= 10^{10} / 2.3 \times 10^4$

$= 10^6 / 2.3$ bits

$= 434782$ bits

4

a) It is not necessary to include "sequence numbers" because A is only sending 1 packet at a time. A will wait until he receives an Ack so B does not need to worry about the order of transmitted packets

b) A 2 bit sequence number is enough for the receiver to tell whether or not a frame is a duplicate. For example, the sender could include a 1 or 0 which could distinguish a frame as an original or duplicate

c) As long as all the packets arive within the minute. The sequence number would have to be: SN = Bandwidth * (60s/Packet_Size)

5

a) $PropDelay = 40 \times 10^3 m / 2 \times 10^8 m/s$

$= 20 \times 10^{-5} s$

b) $SuitableTimout = 2 \times PropDelay + ProcessingTime$

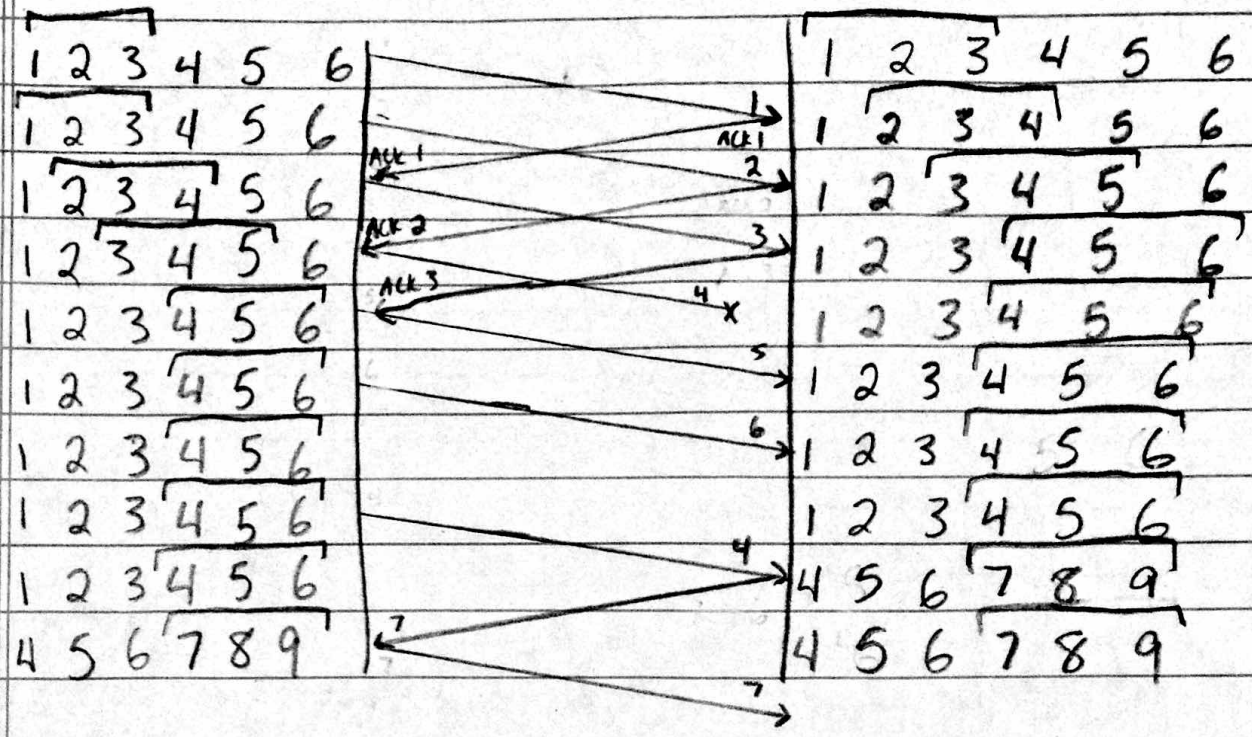
$= 2 \times 20 \times 10^{-5} s + 100 ms$

$= 40 \times 10^{-5} + .1$

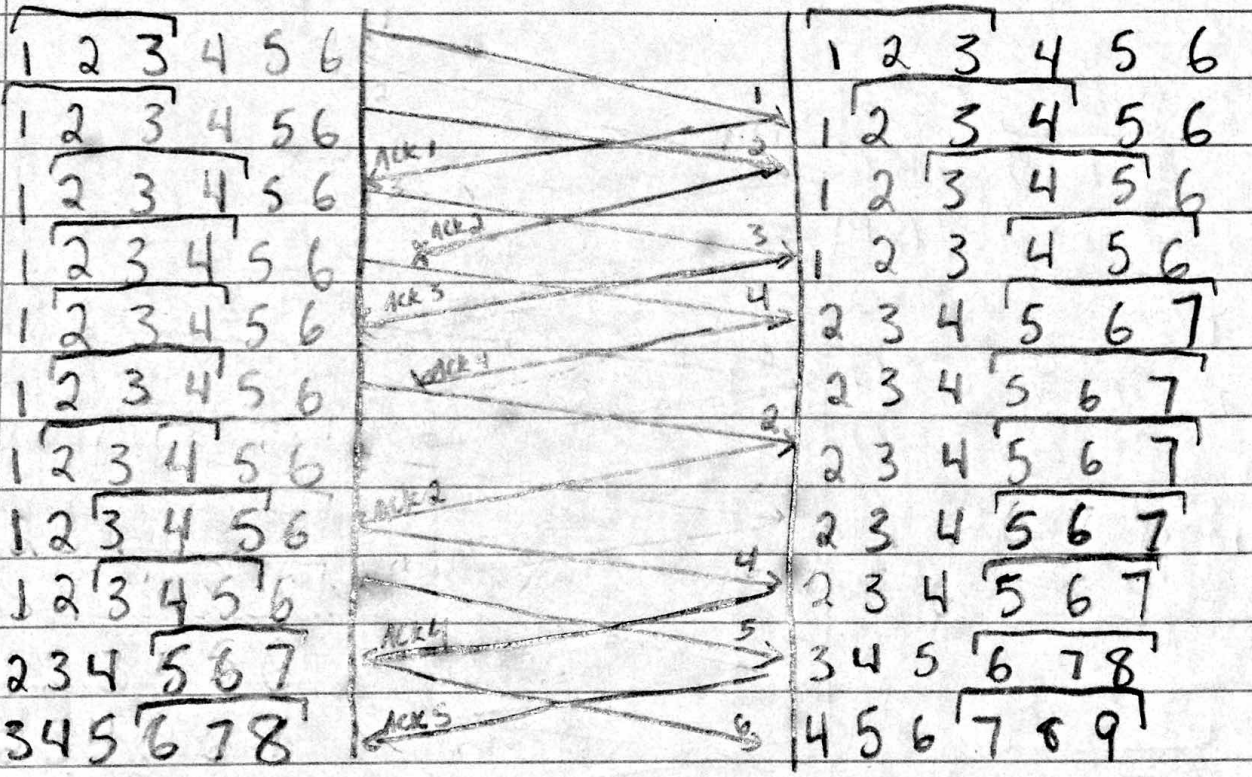
c) It might be possible to time out given this delay if the processing time took longer than 100 ms. For example, if it took 200 ms to process the packet, it would take longer than the timeout value to complete the round trip, hence the server would resend that packet

6)

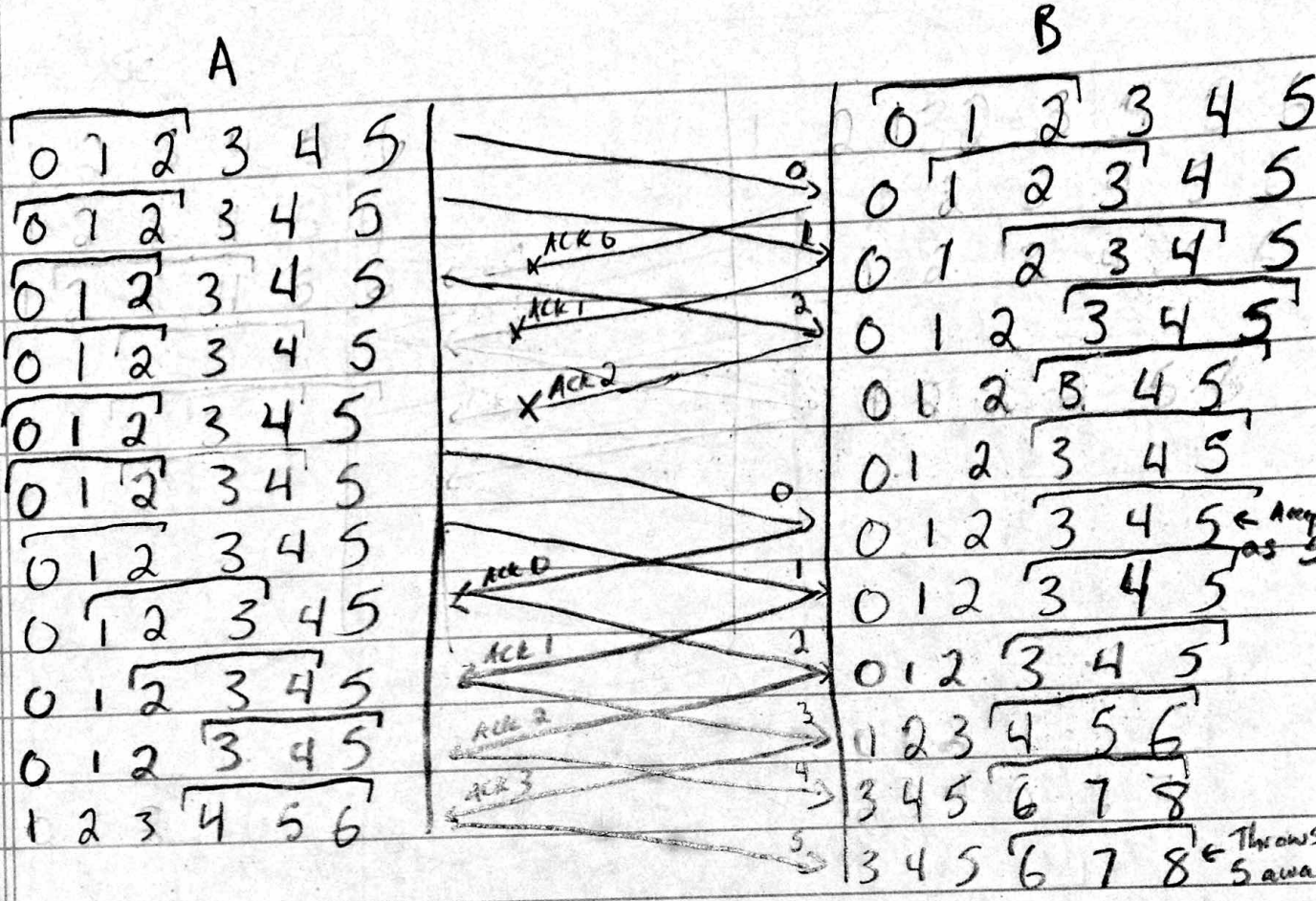
a)


1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
4 5 6 7 8 9
ACK 1
ACK 2
ACK 3
1
2
3
4
X
5
6
4
7
7
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
4 5 6 7 8 9
4 5 6 7 8 9

b)


1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
2 3 4 5 6 7
3 4 5 6 7 8
ACK 1
ACK 2
ACK 3
ACK 1
ACK 2
ACK 4
ACK 5
1
2
3
4
2
4
5
6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
1 2 3 4 5 6
2 3 4 5 6 7
2 3 4 5 6 7
2 3 4 5 6 7
2 3 4 5 6 7
3 4 5 6 7 8
4 5 6 7 8 9

7



In this situation B accidentally throws away 5 because when A retransmitted 0, B thought it was 5.

8

	X		Y	
	Addr	Int	Addr	Int
A to B	B	1	-	-
B to E	E	3	E	2
A to C	C	2	-	-
C to A	A	1	-	-
D to A	-	-	-	-
D to E	-	-	-	-

9)

Ports that are not selected would be:
- B2 - A
- B3 - B
- B3 - F
- B6 - I

10 Ports that are not selected would be:
- B3 - B
- B3 - F
- B6 - I