By Whichway

> updated P22 P25 P6 Tue Apr 20 updated U6 May 20th

U1 P5

- P5. Tollbooths are 75 km apart, Review the car-caravan analogy in Section 1.4. Assume a propagation speed of 100 km/hour.
- Suppose the caravan travels 150km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third toll- booth. What is the end-to-end delay?
- Repeat(a),now assuming that there are eight cars in the caravan instead of ten.

Answer

- Tollbooths are 75 km apart, and the cars propagate at 100km/hr.
- A tollbooth services a car at a rate of one car every 12 seconds.
- a)

$$10 * 12 = 120s = 2mins \tag{1}$$

- There are ten cars. It takes 120 seconds, or 2 minutes, for the first tollbooth to service the 10 cars.

$$75/100 = 45mins \tag{2}$$

- Each of these cars has a propagation delay of 45 minutes (travel 75 km) before arriving at the second tollbooth.

$$2 + 45 = 47mins \tag{3}$$

- Thus, all the cars are lined up before the second tollbooth after 47 minutes.
- The whole process repeats itself for traveling between the second and third tollbooths.

$$2 + 45 + 2 + 45 + 2 = 96mins \tag{4}$$

- It also takes 2 minutes for the third tollbooth to service the 10 cars. Thus the total delay is 96 minutes.
- b)

$$8 * 12 * 3 + 45 * 2 = 94mins - and - 48s \tag{5}$$

- Delay between tollbooths is 8*12 seconds plus 45 minutes, i.e., 46 minutes and 36 seconds. *
- *The total delay is twice this amount plus 8*12 seconds, i.e., 94 minutes and 48 seconds.

U1 P6

- P6. This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking.
- Consider two hosts, A and B, connected by a single link of rate *R* bps.

- Suppose that the two hosts are separated by *m* meters, and suppose the propagation speed along the link is *s* meters/sec.
- Host A is to send a packet of size *L* bits to Host B.

1. Expressthepropagationdelay,*d*prop,intermsof*m*and*s*.
2. Determine the transmission time of the packet, *d*trans, in terms of *L*

   and *R*.
3. Ignoringprocessingandqueuingdelays,obtainanexpressionfortheend-

   to-end delay.
4. Suppose HostA begins to transmit the packet at time *t*=0 .At time *t*=*d*trans, where is the last bit of the packet?
5. Suppose *d*prop is greater than *d*trans. At time *t*=*d*trans,where is the first bit of the packet?
6. Suppose *d*prop is less than *d*trans. At time *t* = *d*trans, where is the first bit of the packet?
7. Suppose $s = 2.5 \cdot 10^8$, *L* = 120 bits, and *R* = 56 kbps. Find the distance *m* so that *d*prop equals *d*trans.

Answer:

a)

$$\frac{m}{s} \tag{6}$$

*d**prop = m/s* seconds.

b)

$$\frac{L}{R} \tag{7}$$

*d**trans = L/R* seconds.

c)

$$\frac{m}{s} + \frac{L}{R} \tag{8}$$

*d**endtoend* = (*m/s* + *L/R*)seconds.

d)

*d*prop is greater than *d*trans

The bit is just leaving Host A.

e)

*d*prop is fewer than *d*trans

The first bit is in the link and has not reached Host B.

f) The first bit has reached Host B.

g) Want

$$d_{trans} = \frac{L}{R} = d_{prop} = \frac{m}{s} \tag{9}$$

$$m = \frac{L}{R} \cdot s = \frac{120bits}{56 * 1000bps} \cdot 2.5 * 10^8 = 536km \tag{10}$$

U1 P25

P25.

- Suppose two hosts,A and B,are separated by 20,000 kilometers and are connected by a direct link of *R* = 2 Mbps.

- Suppose the propagation speed over the link is $2.5 * 10^8$ meters/sec.

1. Calculate the bandwidth-delay product, *R*, d_{prop}.
2. Consider sending a file of 800,000bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?
3. Provide an interpretation of the bandwidth-delay product.
4. Whatisthewidth(inmeters)ofabitinthelink?Isitlongerthanafoot- ball field?
5. Derive a general expression for the width of a bit in terms of the propagation speed *s,* the transmission rate *R,* and the length of the link *m*.

Answer

a) 160,000 bits

$$Bandwidth - delay - product = R \cdot t_{prop} \tag{11}$$

$$= 2Mbps \cdot \frac{20\ 000\ 000m}{2.5 \times 10^8 meters/sec} = 1.6 \times 10^5 bits \tag{12}$$

b)

160,000 bits

$$80\ 0000 > 160,000 \tag{13}$$

$$Max = R \cdot t_{prop} = 2Mbps \cdot \frac{20\ 000\ 000m}{2.5 \times 10^8 meters/sec} = 1.6 \times 10^5 bits \tag{14}$$

c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

d)

the width of a bit [比特宽度] = length of link / bandwidth-delay product,

so 1 bit is 125 meters long, which is longer than a football field

$$the-width-of-a-bit[\text{比特宽度}] = \frac{length-of-link}{bandwidth-delay-product} \tag{15}$$

e)

$$the-width-of-a-bit[\text{比特宽度}] = \frac{length-of-link}{bandwidth-delay-product} \tag{16}$$

$$the-width-of-a-bit[\text{比特宽度}] = \frac{m}{R \cdot t_{prop}} \tag{17}$$

$$the-width-of-a-bit[\text{比特宽度}] = \frac{s \cdot t_{prop}}{R \cdot t_{prop}} \tag{18}$$

$$the-width-of-a-bit[\text{比特宽度}] = \frac{s}{R} \tag{19}$$

⭐ U2 P22

> 向N个对等方分发 File = 15GB
>
> 上载 u_s = 30Mbps, 对等方 d_i = 2Mbps
>
> N = 10, 100, 1000; u = 300kbps, 700kbps, 2Mbps
>
> 对于N和u绘制出最小分发时间图表
>
> 针对 Client-Server 和 P2P 分发制作

- P22. Consider distributing a file of *F*=15Gbits to *N* peers.The server has an upload rate of *u***s* = 30 Mbps, and each peer has a download rate of *d***i* = 2 Mbps and an upload rate of *u*. For *N* = 10, 100, and 1,000 and u_i = 300 Kbps, 700 Kbps, and 2 Mbps, prepare a chart giving the minimum distribution time for each of the combinations of *N* and *u* for both client-server distribution and P2P distribution.

Answer

- For calculating the minimum distribution time for client-server distribution, we use the following formula:

$$D_{cs} \geq max\{N \cdot F/u_s, F/d_{min}\} \tag{20}$$

- Similarly, for calculating the minimum distribution time for P2P distribution, we use the following formula:

$$D_{p2p} \geq max\{F/u_s, F/d_{min}, N \cdot F/(u_s + \sum_{i=1}^{N} u_i)\} \tag{21}$$

- Where,

$$F = 15Gbits = 15 * 1024Mbits \tag{22}$$

$$u_s = 30Mbps \tag{23}$$

$$d_{min} = d_i = 2Mbps \tag{24}$$

- Note, 300Kbps = 300/1024 Mbps.

Client Server

> 求2项中的最大值

$$D_{cs} = max\{N \cdot F/u_s, F/d_{min}\} \tag{25}$$

$$\frac{F}{d_{min}} = \frac{15 * 1024Mbits}{2Mbps} = \frac{15360}{2} = 7680 \tag{26}$$

N = 10

$$N\frac{F}{u_s} = 10 \cdot \frac{15 * 1024Mbits}{30Mbps} = 5120 \tag{27}$$

$$7680 > 5120 \tag{28}$$

$$Thus, 7680 \tag{29}$$

N = 100

$$N\frac{F}{u_s} = 100 \cdot \frac{15 * 1024Mbits}{30Mbps} = 51200 \tag{30}$$

$$51200 > 7680 \tag{31}$$

$$Thus, 51200 \tag{32}$$

N = 1000

$$N\frac{F}{u_s} = 1000 \cdot \frac{15 * 1024Mbits}{30Mbps} = 512000 \tag{33}$$

$$512000 > 7680 \tag{34}$$

$$Thus, 512000 \tag{35}$$

	10	**100**	**1000**
300 Kbps	7680	51200	512000
700 Kbps	7680	51200	512000
2 Mbps	7680	51200	512000

Peer to Peer

> 求3个中的最大值

$$D_{p2p} = max\{F/u_s, F/d_{min}, N \cdot F/(u_s + \sum_{i=1}^{N} u_i)\} \tag{36}$$

$$\frac{F}{d_{min}} = \frac{15 * 1024Mbits}{2Mbps} = \frac{15360}{2} = 7680 \tag{37}$$

$$\frac{F}{u_s} = \frac{15 * 1024Mbits}{30Mbps} = 512 \tag{38}$$

N = 10

u_i = 300 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 10 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{10} 300/1024Mbps} \tag{39}$$

$$= 10 \cdot \frac{15 * 1024Mbps}{30Mbps + 2.93Mbps} = 4664 \tag{40}$$

$$7680 > 4664 > 512 \tag{41}$$

u_i = 700 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 10 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{10} 700/1024Mbps} \tag{42}$$

$$= 10 \cdot \frac{15 * 1024Mbps}{30Mbps + 6.84Mbps} = 4169 \tag{43}$$

$$7680 > 4169 > 512 \tag{44}$$

u_i = 2Mbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 10 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{10} 2Mbps} \tag{45}$$

$$= 10 \cdot \frac{15 * 1024Mbps}{30Mbps + 20Mbps} = 3072 \tag{46}$$

$$7680 > 3072 > 512 \tag{47}$$

N = 100

300 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 100 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{100} 300/1024Mbps} \tag{48}$$

$$= 100 \cdot \frac{15 * 1024Mbps}{30Mbps + 29.30Mbps} = 25902 \tag{49}$$

$$25902 > 7680 > 512 \tag{50}$$

700 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 100 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{100} 700/1024Mbps} \tag{51}$$

$$= 100 \cdot \frac{15 * 1024Mbps}{30Mbps + 68.36Mbps} = 15616 \tag{52}$$

$$15616 > 7680 > 512 \tag{53}$$

2Mbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 100 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_1^{100} 2Mbps} \tag{54}$$

$$= 100 \cdot \frac{15 * 1024Mbps}{30Mbps + 200Mbps} = 6678 \tag{55}$$

$$7680 > 6678 > 512 \tag{56}$$

N = 1000

300 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 1000 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_{1}^{1000} 300/1024Mbps} \tag{57}$$

$$= 1000 \cdot \frac{15 * 1024Mbps}{30Mbps + 293Mbps} = 47554 \tag{58}$$

$$47554 > 7680 > 512 \tag{59}$$

700 Kbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 1000 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_{1}^{1000} 700/1024Mbps} \tag{60}$$

$$= 1000 \cdot \frac{15 * 1024Mbps}{30Mbps + 683.6Mbps} = 21525 \tag{61}$$

$$21525 > 7680 > 512 \tag{62}$$

2Mbps

$$N \cdot F/(u_s + \sum_{i=1}^{N} u_i) = 1000 \cdot \frac{15 * 1024Mbps}{30Mbps + \sum_{1}^{1000} 2Mbps} \tag{63}$$

$$= 100 \cdot \frac{15 * 1024Mbps}{30Mbps + 2000Mbps} = 757 \tag{64}$$

$$7680 > 757 > 512 \tag{65}$$

	10	**100**	**1000**
300 Kbps	7680	25902	47554
700 Kbps	7680	15616	21525
2 Mbps	7680	7680	7680

U3 P3

- P3. UDP and TCP use 1s complement for their checksums. Suppose you have the following three 8-bit bytes: 01010011, 01100110, 01110100.
- What is the 1s complement of the sum of these 8-bit bytes? (Note that although UDP and TCP use 16-bit words in computing the checksum, for this problem you are being asked to consider 8-bit sums.) Show all work.
- Why is it that UDP takes the 1s complement of the sum; that is, why not just use the sum?
- With the 1s complement scheme, how does the receiver detect errors?
- Is it possible that a 1-bit error will go undetected?
- How about a 2-bit error?

Answer

$$01010011 \tag{66}$$

$$+ \tag{67}$$

$$01100110 \tag{68}$$

$$= \tag{69}$$

$$10111001 \tag{70}$$

no overflow

$$10111001 \tag{71}$$

$$+ \tag{72}$$

$$01110100 \tag{73}$$

$$= \tag{74}$$

$$1\ 00101101 \tag{75}$$

warp out the first to the last

$$00101110 \tag{76}$$

One's complement = 1 1 0 1 0 0 0 1.

1. To detect errors, the receiver adds the four words (the three original words and the checksum). If the sum contains a zero, the receiver knows there has been an error.
2. All one-bit errors will be detected, but two-bit errors can be undetected (e.g., if the last digit of the first word is converted to a 0 and the last digit of the second word is converted to a 1).

U3 P7 – ACK no sequence numbers

- P7. In protocol rdt3.0, the ACK packets flowing from the receiver to the sender do not have sequence numbers (although they do have an ACK field that contains the sequence number of the packet they are acknowledging).
- Why is it that our ACK packets do not require sequence numbers?

Answer

1. [sequence numbers] To best answer this question, consider why we needed sequence numbers in the first place.
2. [receiver tells a data packet is duplicateWe saw that the sender needs sequence numbers so that the receiver can tell if a data packet is a duplicate of an already received data packet.
3. [ACKs not need]In the case of ACKs, the sender does not need this info (i.e., a sequence number on an ACK) to tell detect a duplicate ACK.
4. [rdt3.0 receiver, next state]A duplicate ACK is obvious to the rdt3.0 receiver, since when it has received the original ACK it transitioned to the next state.
5. [ignored]The duplicate ACK is not the ACK that the sender needs and hence is ignored by the rdt3.0 sender.

U3 P24

P24.

- Consider the **GBN and SR** protocols. **Suppose** the **sequence number space** is of size ***k***. What is the **largest allowable sender window** that will avoid the **occurrence of problems** such as that in Figure 3.27 for each of these protocols?

Answer true or false to the following questions and briefly justify your answer:

1. [SR, sender receive an ACK, falls outside of the window]With the **SR protocol**,it is possible for the **sender to receive an ACK** for a packet that **falls outside of its current window**.
2. [GBN, sender receive ACK, falls outside of the current window]With **GBN**,it is possible for the sender to **receive an ACK for a packet** that **falls outside of its current window.**
3. [alternating-bit protocol, window size of 1]The alternating-bit protocol is the same as the SR protocol with a sender and receiver window size of 1.
4. [alternating-bit protocol, window size of 1]The alternating-bit protocol is the same as the GBN protocol with a sender and receiver window size of 1.

Answer

Problem 24

1. a) True. Suppose the sender has a window size of 3 and sends packets 1, 2, 3 at *t*0. At *t*1 (*t*1, *t*0) the receiver ACKS 1, 2, 3. At *t*2 (*t*2 *t*1) the sender times out and resends 1, 2, 3. At *t*3 the receiver receives the duplicates and re-acknowledges 1, 2, 3. At *t*4 the sender receives the ACKs that the receiver sent at *t*1 and advances its window to 4, 5, 6. At *t*5 the sender receives the ACKs 1, 2, 3 the receiver sent at *t*2 . These ACKs are outside its window.
2. b) True. By essentially the same scenario as in (a).
3. c) True.

4. d) True. Note that with a window size of 1, SR, GBN, and the alternating bit protocol are functionally equivalent. The window size of 1 precludes the possibility of out-of- order packets (within the window). A cumulative ACK is just an ordinary ACK in this situation, since it can only refer to the single packet within the window.

U3 P40

1. P40. Consider Figure 3.58. Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer.
2. IdentifytheintervalsoftimewhenTCPslowstartisoperating.
3. Identify the intervals of time when TCP congestion avoidance is operating.
4. After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
5. Afterthe22ndtransmissionround,issegmentlossdetectedbyatriple duplicate ACK or by a timeout?
6. Whatistheinitialvalueofssthreshatthefirsttransmissionround?
7. What is the value of ssthresh at the 18th transmission round?
8. Whatisthevalueofssthreshatthe24thtransmissionround?
9. Duringwhattransmissionroundisthe70thsegmentsent?
10. Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh?
11. j. Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 16th round. What are the ssthresh and the

congestion window size at the 19th round?

12. k. Again suppose TCP Tahoe is used, and there is a timeout event at 22nd round. How many packets have been sent out from 17th round till 22nd round, inclusive?

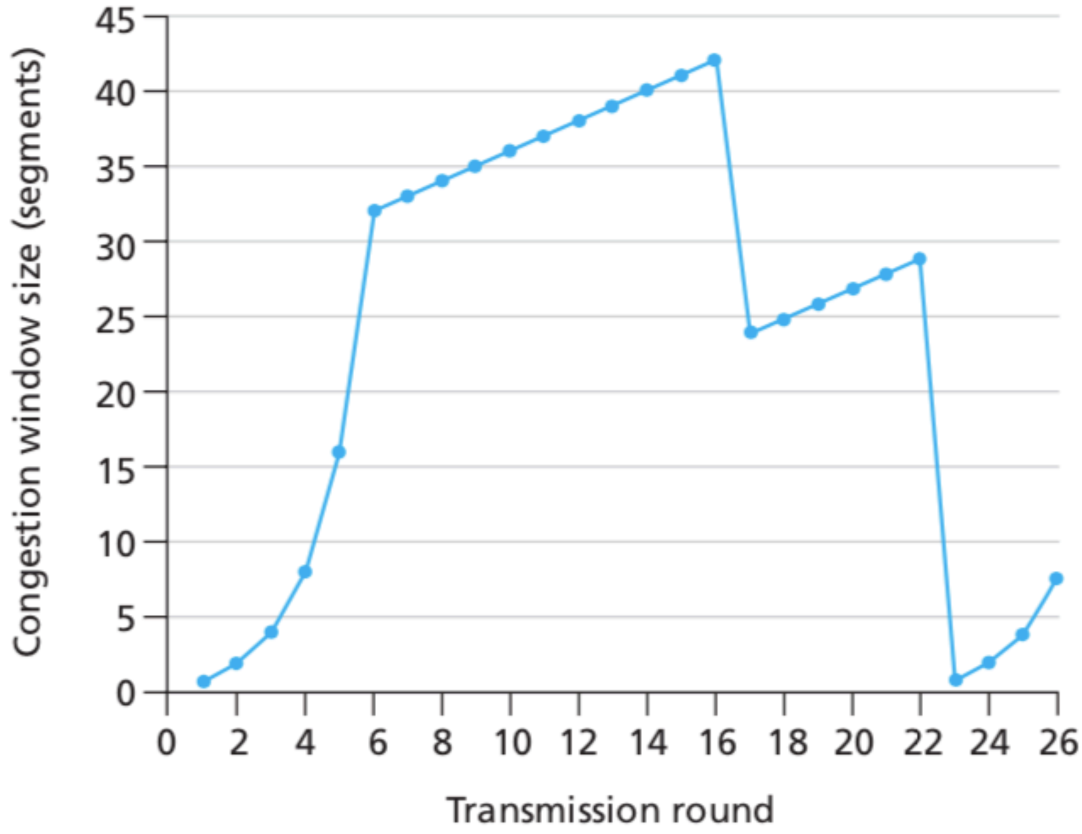
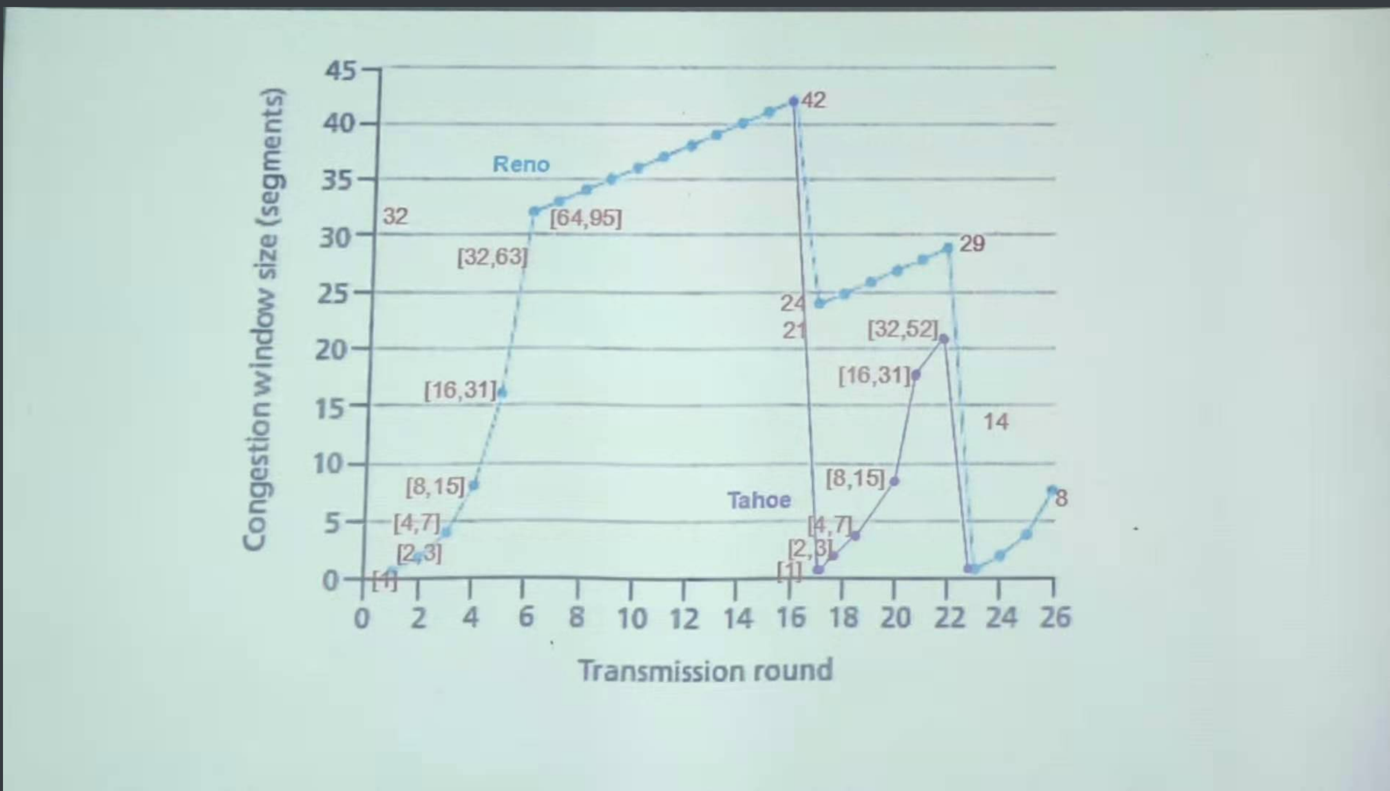


Figure 3.58 ♦ TCP window size as a function of time

Answer

1. a) TCP slowstart is operating in the intervals [1,6] and [23,26]
2. b) TCP congestion avoidance is operating in the intervals [6,16] and [17,22]
3. c) After the 16th transmission round, packet loss is recognized by a triple duplicate ACK. If there was a timeout, the congestion window size would have dropped to 1.
4. d) After the 22nd transmission round, segment loss is detected due to timeout, and hence the congestion window size is set to 1.
5. e) The threshold is initially 32, since it is at this window size that slow start stops and congestion avoidance begins.

6. f) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 16, the congestion windows size is 42. Hence the threshold is 21 during the 18th transmission round.
7. g) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 22, the congestion windows size is 29. Hence the threshold is 14 (taking lower floor of 14.5) during the 24th transmission round.
8. h) During the 1st transmission round, packet 1 is sent; packet 2-3 are sent in the 2nd transmission round; packets 4-7 are sent in the 3rd transmission round; packets 8-15 are sent in the 4th transmission round; packets 16-31 are sent in the 5th transmission round; packets 32-63 are sent in the 6th transmission round; packets 64 – 96 are sent in the 7th transmission round. Thus packet 70 is sent in the 7th transmission round.
9. i) The threshold will be set to half the current value of the congestion window (8) when the loss occurred and congestion window will be set to the new threshold value + 3 MSS . Thus the new values of the threshold and window will be 4 and 7 respectively.
10. j) threshold is 21, and congestion window size is 1.
11. k) round 17, 1 packet; round 18, 2 packets; round 19, 4 packets; round 20, 8 packets; round 21, 16 packets; round 22, 21 packets. So, the total number is 52.



> TCP: detecting, reacting to loss
>
> - loss indicated by timeout: " cwnd set to 1 MSS; " window then grows exponentially (as in slow start) to threshold, then grows linearly *loss indicated by 3 duplicate ACKs: TCP RENO " dup ACKs indicate network capable of delivering some segments " cwnd is cut in half window then grows linearly *TCP Tahoe always sets cwnd to 1 (timeout or 3 duplicate acks) Transport Layer

U4 P4

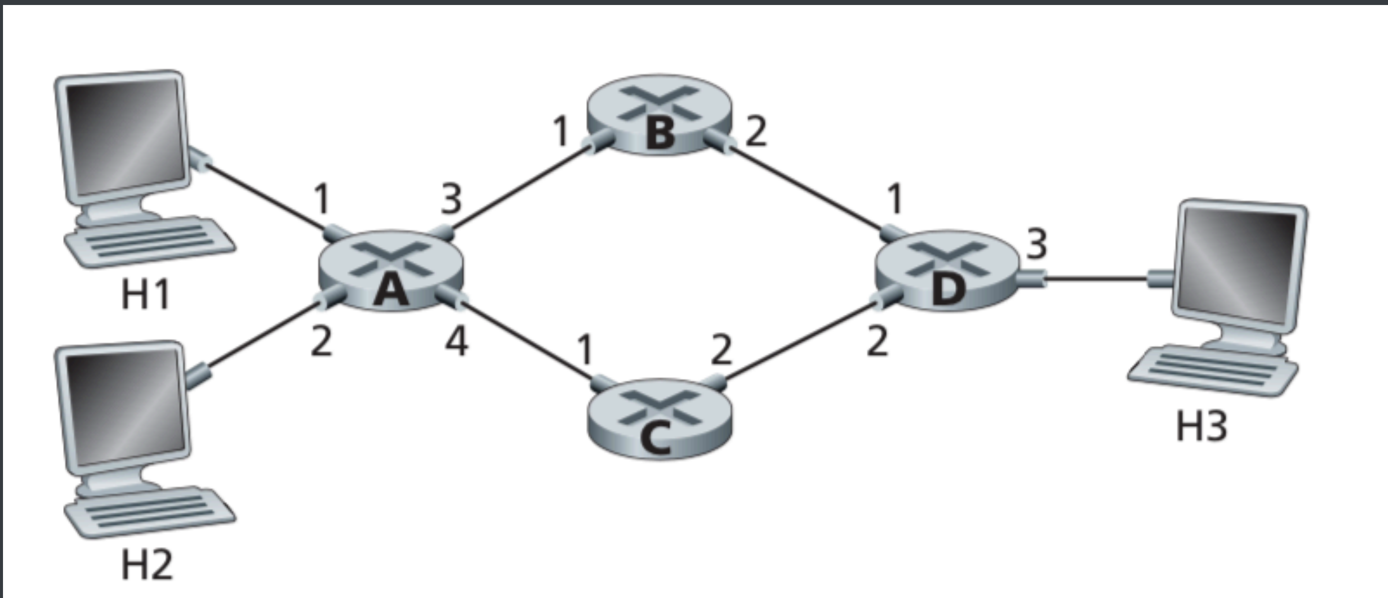
1. P4. Consider the network below.

   a. Suppose that this network is a datagram network. Show the forwarding table in router A, such that all traffic destined to host H3 is forwarded through interface 3.

   b. Suppose that this network is a datagram network. Can you write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4? (Hint: this is a trick question.)

   c. Now suppose that this network is a virtual circuit network and that there is one ongoing call between H1 and H3, and another ongoing call between H2 and H3. Write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4.

   d. Assuming the same scenario as (c), write down the forwarding tables in nodes B, C, and D.



Answer

Problem 4

a) Data destined to host H3 is forwarded through interface 3

Destination Address	Link Interface
H3	3

b) No, because forwarding rule is only based on destination address.

c) One possible configuration is:

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	12	3	22
2	63	4	18

Note, that the two flows could actually have the same VC numbers.

d) One possible configuration is:

Router B.

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	22	2	24

Router C.

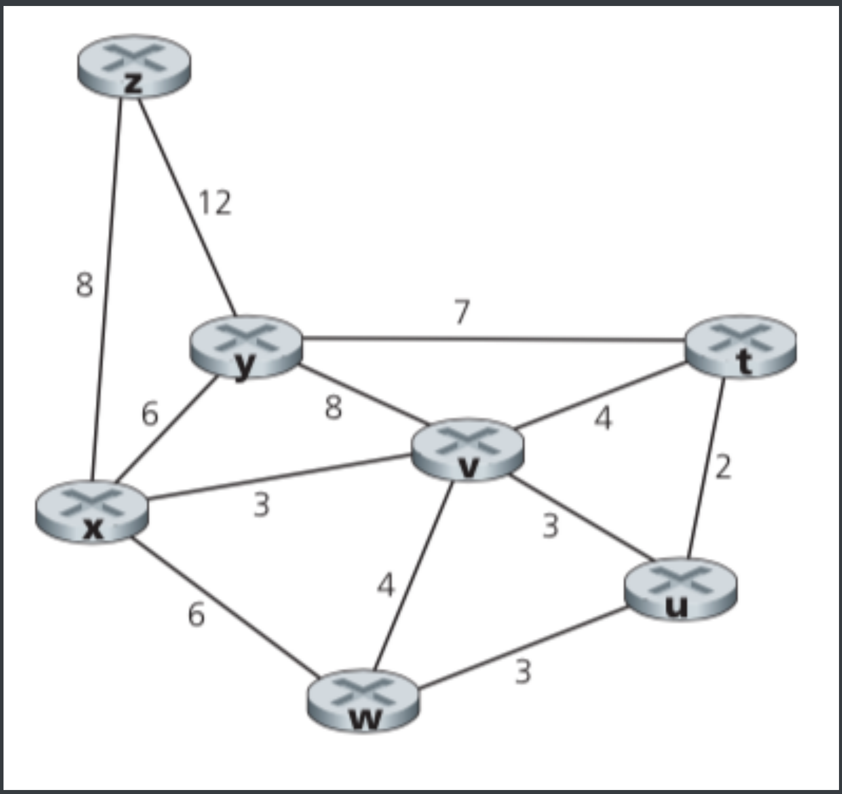
Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	18	2	50

Router D.

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	24	3	70
2	50	**3**	**76**

U4 P26

1. P26. Consider the following network. With the indicated link costs, use Dijkstra's shortest-path algorithm to compute the shortest path from *x* to all network nodes. Show how the algorithm works by computing a table similar to Table 4.3.



Answer

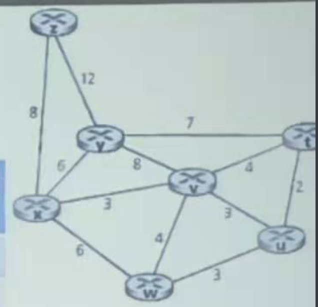
> ❓ no needs D(x), p(x)
>
> 持续下拉填到 N' 有字母的前一个序列

step	N'	D(z),p(z)	D(y),p(y)		D(v),p(v)	D(w),p(w)	D(u),p(u)	D(t),p(t)
0	x	8,x	6,x		3,x	6,x	∞	∞
1	xv	8,x	6,x			6,x	6,v	7,v
2	xvy	8,x				6,x	6,v	7,v
3	xvyu	8,x				6,x		7,v
4	xvyuw	8,x						7,v
5	xvyuwt	8,x						
6	xvyuwtz							

参考答案

- **Problem 26：**

step	N'	D(y), p(y)	D(z), p(z)	D(u), p(u)	D(v), p(v)	D(w), p(w)	D(t), p(t)
0	x	6,x	8,x	∞	3,x	6,x	∞
1	xv	6,x	8,x	6,v		6,x	7,v
2	xvy		8,x	6,v		6,x	7,v
3	xvyu		8,x			6,x	7,v
4	xvyuw		8,x				7,v
5	xvyuwt		8,x				
6	xvyuwtz						

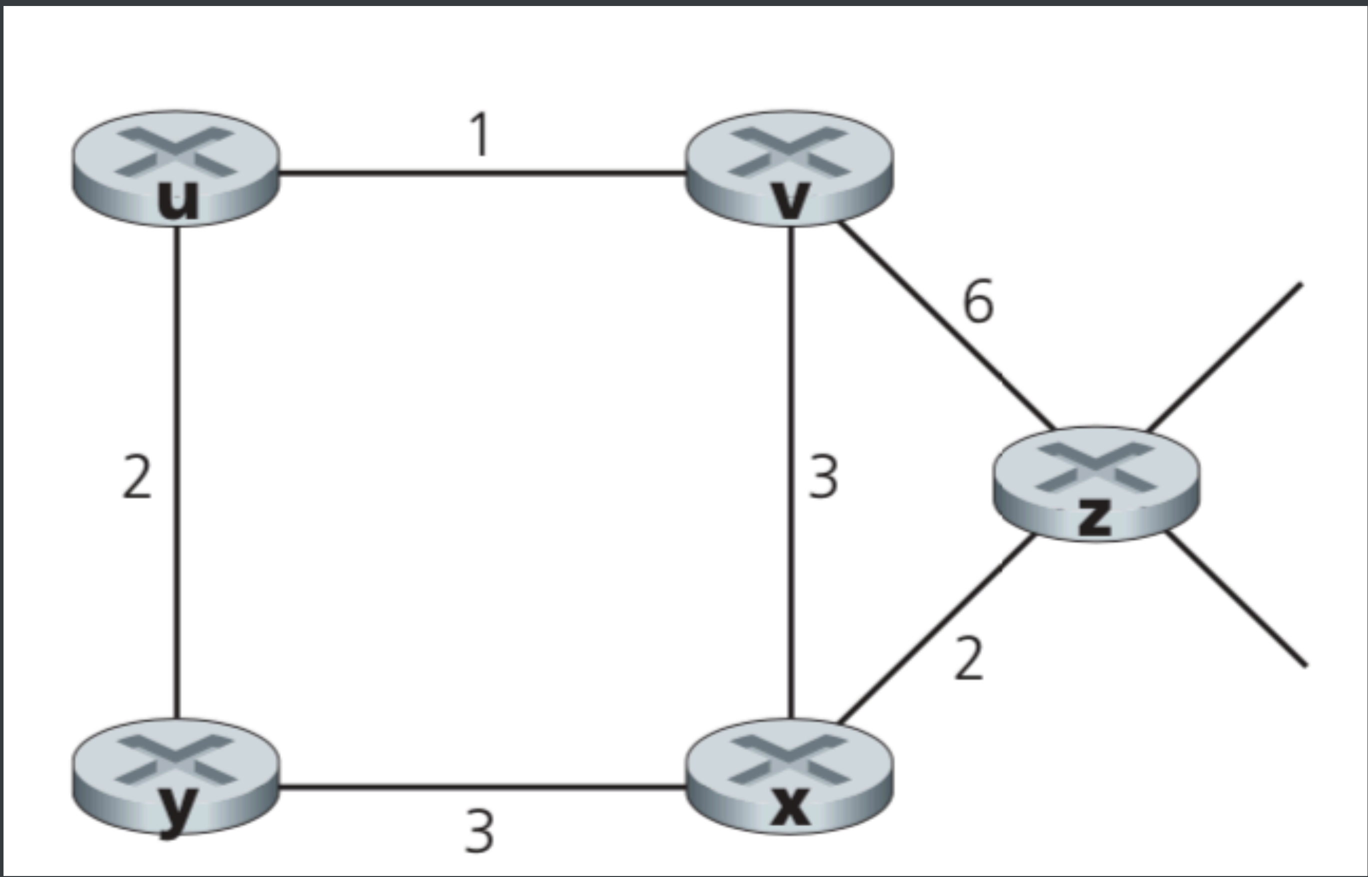


Problem 26

Step	*N'*	*D(t),p(t)*	*D(u),p(u)*	*D(v),p(v)*	*D(w),p(w)*	*D(y),p(y)*	*D(z),p(z)*
0	x	∞	∞	3,x	6,x	6,x	8,x
1	xv	7,v	6,v	3,x	6,x	6,x	8,x
2	xvu	7,v	6,v	3,x	6,x	6,x	8,x
3	xvuw	7,v	6,v	3,x	6,x	6,x	8,x
4	xvuwy	7,v	6,v	3,x	6,x	6,x	8,x
5	xvuwyt	7,v	6,v	3,x	6,x	6,x	8,x
6	xvuwytz	7,v	6,v	3,x	6,x	6,x	8,x

U4 P28 Distance Vector

1. P28. Consider the network shown below, and assume that each node initially knows the costs to each of its neighbors. Consider the distance-vector algorithm and show the distance table entries at node *z*.



Answer

step 1, activiate z(1)

	z	x	v	y	u
z	0	2	6	∞	∞

step 2, z(2), activiate x(1), v(1)

> z--v 5, 5(2+3) < 6, z 限制2跳
>
> z--u 7(1+6), z 限制2跳

> x, v 限制1跳

	z	x	v	y	u
z	0	2	5, 5(2+3) < 6	5	7
x	2	0	3	3	∞
v	6	3	0	∞	1

step 3, z(3), x(2), v(2)，activiate u(1), y(1)

> z---u, 6, 6(2+3+1) < 7, z 限制3跳
>
> v--z, 5, 5(2+3) < 6, v 限制2跳

	z	x	v	y	u
z	0	2	5	5	6, 6(2+3+1) < 7
x	2	0	3	3	4
v	5, 5(2+3) < 6	3	0	3	1
y	∞	3	∞	0	2
u	∞	∞	1	2	0

step 4, z(4), x(3), v(3), u(2), y(2)

> y, u 可以继续优化

	z	**x**	**v**	**y**	**u**
z	0	2	5	5	6
x	2	0	3	3	4
v	5	3	0	3	1
y	5	3	3	0	2
u	7	4	1	2	0

step 4, z(5), x(4), v(4), u(3), y(3)

> 优化的最后结果应该是一个对角对称的表

	z	**x**	**v**	**y**	**u**
z	0	2	5	5	6
x	2	0	3	3	4
v	5	3	0	3	1
y	5	3	3	0	2
u	6	4	1	2	0

Problem 28

		Cost to u	v	x	y	z
From	v	∞	∞	∞	∞	∞
	x	∞	∞	∞	∞	∞
	z	∞	6	2	∞	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	∞	6
	x	∞	3	0	3	2
	z	7	5	2	5	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	3	5
	x	4	3	0	3	2
	z	6	5	2	5	0

		Cost to				
		u	v	x	y	z
From	v	1	0	3	3	5
	x	4	3	0	3	2
	z	6	5	2	5	0

最后是只需要z这一行的结果的

U5 P5

- P5. Consider the 7-bit generator, G=10011, and suppose that D has the value 1010101010. What is the value of R?

Answer

$$10011\sqrt{1010101010} \tag{77}$$

R 有5位，补4个0

$$10011\sqrt{1010101010\ 0000} \tag{78}$$

```
               1
10011\sqrt{1010101010 0000}
           10101
           10011
```

```
               101
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
```

```
               1011
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
             010100
              10011
```

```
               101101
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
             010100
              10011
              0011110
                10011
```

```
               101101 1
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
             010100
              10011
              0011110
                10011
                01101 0
                 1001 1
```

```
               101101 11
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
             010100
              10011
              0011110
                10011
                01101 0
```

```
                 1001 1
                 0100 10
                  100 11
```

最后是 000 0100, 10011是5位，所以R取（5-1）， 4位是0100，上面的商补00，因为没满

```
               101101 1100
10011\sqrt{1010101010 0000}
           10101
           10011
           0011001
             10011
             010100
              10011
              0011110
                10011
                01101 0
                 1001 1
                 0100 10
                  100 11
                  000 0100
                      0100
```

If we divide 10011 into 1010101010 0000, we get 1011011100, with a remainder of R=0100. Note that, G=10011 is CRC-4-ITU standard.

U5 P17

- P17. Recall that with the **CSMA/CD protocol**,the **adapter waits K·512bit times** after a collision, where *K* is drawn randomly. **For *K* = 100, how long** does the adapter wait until returning to **Step 2 for a 10 Mbps** broadcast channel? For a **100 Mbps broadcast channel**?

Answer

Wait for 51,200 bit times, For 10M bps, this wait is

$$\frac{51,200\ bits}{10,000,000\ bps} = 5.12 \times 10^{-3} sec = 5.12\ msec \tag{79}$$

For 100 Mbps

$$\frac{51,200\ bits}{100,000,000\ bps} = 5.12 \times 10^{-4} sec = 0.512\ msec = 512\ \mu sec \tag{80}$$

U6 R10

- R10 Suppose the IEE 802.11 RTS and CTS frams were as long as the standard DATA and ACK frames. Would there be any advantage to using the CTS and RTS frams? Why or why not?

> 假设2种情况
>
> 和DATA一样长，要消耗2个DATA frame碰撞💥的时间

> RTS/CTS小于DATA才是有效的

Answer

1. [No]No, there wouldn't be any advantage.
2. [Suppose two stations RTS/CTS]Suppose there are two stations that want to transmit at the same time, and they both use RTS/CTS.
3. [as long as DATA, wasted for two colliding[碰撞💥] DATA frams]If the RTS frame is as long as a DATA frames, the channel would be wasted for as long as it would have been wasted for two colliding[碰撞💥] DATA frames.
4. [useful, RTS/CTS significantly smaller than DATA]Thus, the RTS/CTS exchange is only useful when the RTS/CTS frames are significantly smaller than the DATA frames.