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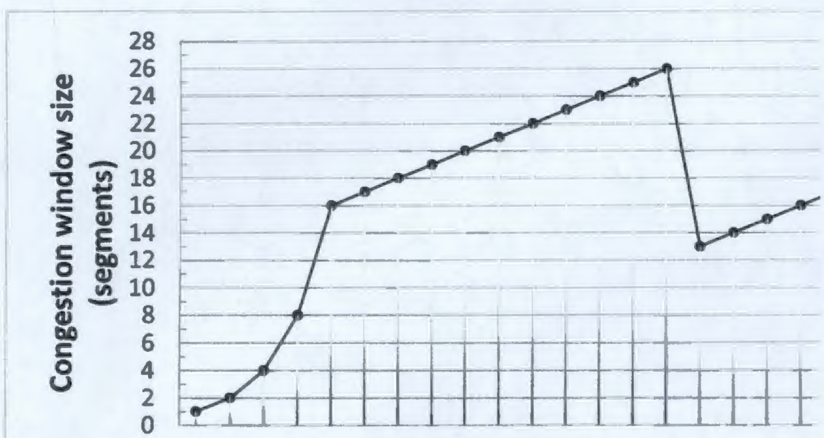
Introduction to Computer Networks

Midterm-2, Fall 2014

1. (4%) What mechanisms can be used to handle packet losses in a reliable transfer protocol?
2. (8%) (a) What are the drawbacks of the Go-Back-N protocol? (b) What mechanisms are used in the Selective-Repeat protocol to remedy the drawbacks?
3. (6%) What are the mechanisms in the TCP for reliable data transfer that are different from the selective repeat protocol?
4. (6%) Describe the TCP connection set-up procedure.
5. (4%) (a) How does a TCP sender detect congestion? (b) How does a TCP sender adjust send rate? MSS
6. (4%) (a) How does TCP sender increase send rate exponentially? (b) How does TCP sender increase send rate linearly?
7. (4%) Describe the additive-increase and multiplicative-decrease algorithm in the TCP congestion control mechanism.
8. (4%) Describe the difference between TCP Tahoe and TCP Reno.
9. (10%) Consider the following plot of window size as a function of transmission round. Assuming TCP Reno is the protocol experiencing the behavior shown below.



   a) Identify the intervals of time when TCP slow start is operating.
   b) Identify the intervals of time when TCP congestion avoidance is operating.
   c) After the 15th transmission round, is segment loss detected by a triple duplicate ACK or by a time out?
   d) After the 21st transmission round, is segment loss detected by a triple duplicate ACK or by a time out?
   e) During what transmission round is the 25th segment sent?

10. (16%) Explain the following terms.
    a) Head-of-line blocking
    b) Prefix
    c) Dynamic Host Configuration Protocol
    d) Network Address Translation Protocol
    e) Link-state algorithm
    f) Gateway router
    g) Autonomous system
    h) Hot-potato routing
11. (8%) Consider two hosts A and B that are connected by two routers with links x, y, and z. Assume that the maximum transmission unit (MTU) of link x, y and z are 2000 bytes, 1000 bytes and 800 bytes, respectively. Suppose that host A

sends a 2000-byte IP datagram (with 20 bytes of IP header plus 1980 bytes of IP payload) to host B. Fragmentation will take place in router R and router Q. Assume that routers R and Q attempt to produce the least number of fragments by using the MTU of the output link as much as possible.

a) The original IP datagram sent by host A will be fragmented by router R. How many fragments will router R produce from the datagram? What are the flags and fragmentation offsets of these fragments?

b) The IP datagrams corresponding to the fragments produced by router R will be fragmented again by router Q. How many fragments will router Q produce? What are the identifications, flags and fragmentation offsets of these fragments?

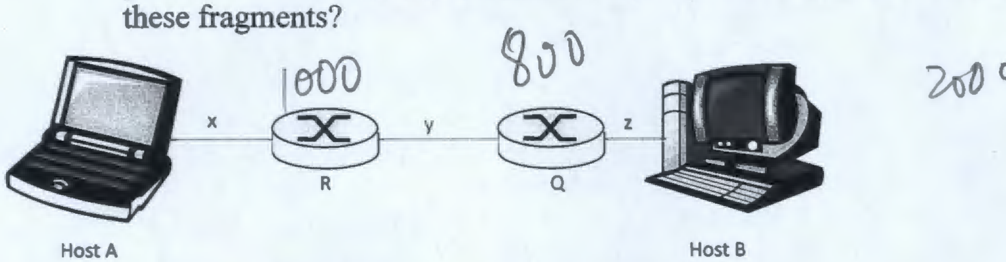


Fig. 1 Two hosts connected by three links.

12. (12%) Consider the 4-node network shown in Fig. 2.

a) Assume that A is the source node. In the initialization phase of Dijkstra's algorithm, what is N'? What is D(v), where v=B, C, and D?

b) Apply Dijkstra's algorithm to find the least-cost paths from source node A to all other nodes.

c) Construct a forwarding table for node A using the results obtained from Dijkstra's algorithm in part b).

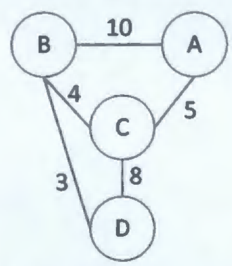


Fig. 2 A 4-node network with 5 links. The link costs are shown next to the corresponding links.

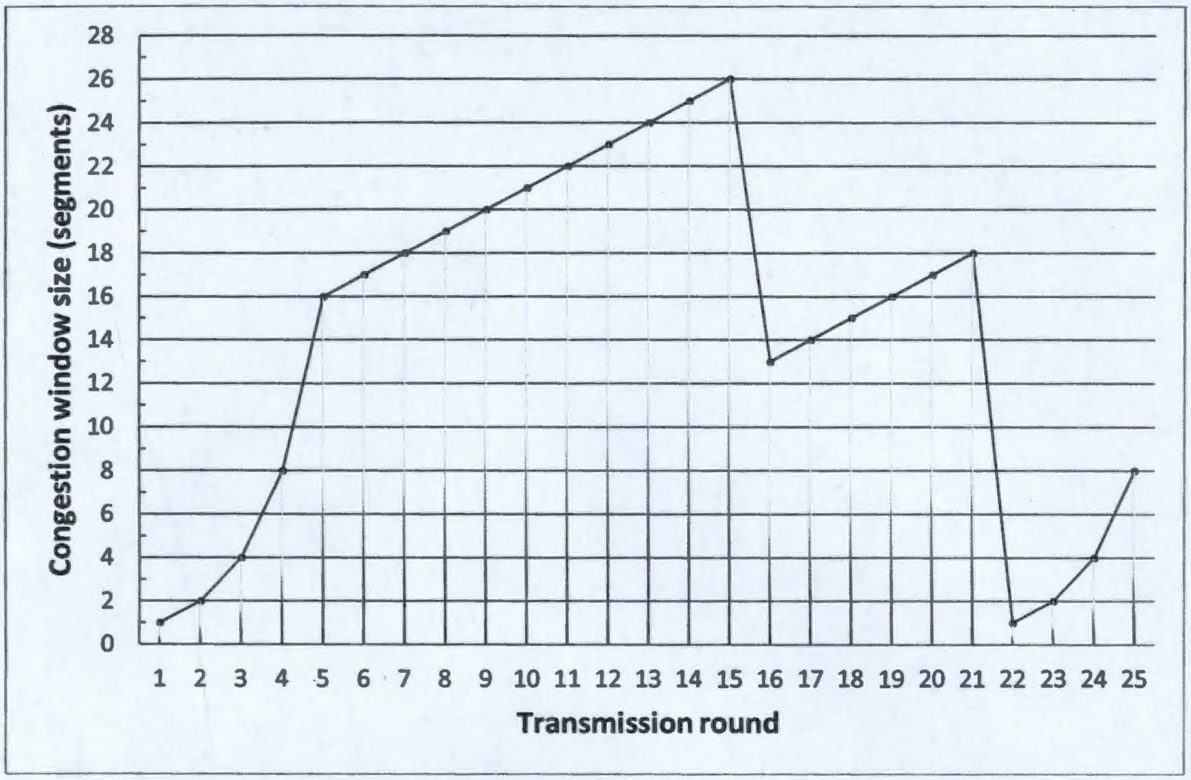
13. (4%) Let c(x,v) be the cost of the link that connects node x and node v. Let $d_x(y)$ be the cost of the cost of the least-cost path form node x to node y. Write down the Bellman-Ford equation that relates $d_x(y)$ and $d_v(y)$, where v is a neighbor of x.

14. (10%) Consider again the 4-node network in Fig. 2. In this problem we apply the distance-vector algorithm on this network.

a) Initially, what is the distance vector D_x=[$D_x(A)$, $D_x(B)$, $D_x(C)$, $D_x(D)$] stored in node x, where x=A, B, C, and D?

b) What are the routing tables (tables that store distance vectors) stored in nodes A and C at time zero?

c) Assume that the distance-vector algorithm operates in a synchronous manner, i.e., all nodes simultaneously receive distance vectors from their neighbors. What are the routing tables in node A and node C after all nodes exchange their initial distance vectors with neighbors and update? Explain your calculation in detail. Note that in this problem you are asked to manually execute **one iteration** of the distance-vector algorithm only.


Congestion window size (segments)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Transmission round

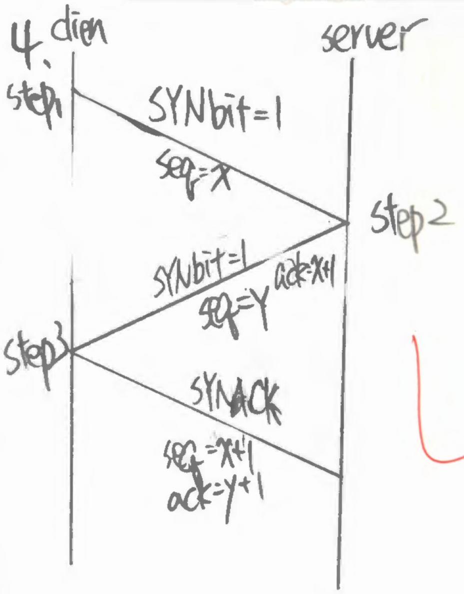
1. timer , sequance number

2. (a) 當 timeout 時重送 window 中所有的資料
只有 window 中最前面的資料有 timer

(b) 每當 window 中的資料有各自的 timer，當 timeout 時重送自己的資料

3. TCP只有一個 timer，SR window中各自有timer
TCP具有快速重送，當收到3個 duplicate ack時即重送
TCP可調整 window 大小，避免 congestion，利用 slow start 及 congestion avoidance

4.



step1：送出 SYNbit=1資料給server
且包含 seq# x

step2: server 回傳 SYN bit=1 and SYNACK
且包含 seq# y ack# x+1

step3: 送出 SYNACK，此時可傳送 data
且包含 seq# x+1 ack# y+1

5. (a) package 丟了或 delay

(b) 調整 window 大小

6. (a) 收到一個 ack，cwnd 增加一個 MSS
一個 RTT cwnd 會變成 2 倍
(b) 收到一個 ack，cwnd 增加 $\frac{MSS}{cwnd}$
一個 RTT cwnd 會增加 1

7. additive-increase：增加時每次加一
multiplicative-decrease：減少時每次變成 $\frac{1}{2}$

8. TCP Tahoe：收到 3 個 duplicate ack，cwnd 直接變 1
TCP Reno：收到 3 個 duplicate ack，cwnd 變成 $\frac{1}{2}$

9. (a) [1,5]，[22,25]
(b) [5,15]，[16,21]
(c) triple duplicat ACK
(d) time out
(e)

Time	segment
1	1
2	2~3
3	4~7
4	8~15
5	16~31

A: 5th transmission round

10、

(a) 在 router 轉送的過程中,會有多個通道,每個通道的第一筆資料未送出前 後面的資料無法送出

(b) 優先選擇

例如:在 Prefix longest 中 ① 0000 會先選擇②
② 00001000
③ 0111

(c) ① host broadcast "DHCP discover"

② DHCP server send respond "DHCP offer"

③ host request "DHCP request"

④ DHCP server send "DHCP address"

(d)

① Local client 送資料到 destination 包含(dest IP, dest port 及 local IP, Local port)

② 會先送到 NAT router 將 (Local IP, Local port)轉成 (NAT IP, NAT port)
並記在 NAT table 中

③ 到達 destination 並回傳資料 包含(dest IP, dest port 及 NAT IP, NAT port)

④ 回傳到 NAT router 利用 NAT table 將 (NAT IP, NAT port)改回(Local IP, Local port)

(e) 需知道所有 link 的 cost，藉由 link cost 計算最小成本，

例如：Dijkstra algorithm

每次選擇最小成本並擴充 link，最後得到最小成本路徑

(f) 連接到其它 AS 的 router

(g) AS中可利用 inter-As routing algorithm 控制 AS 內部的 routing 方式；也可利用 intra-As routing algorithm 與其它As連接 -1

(h) 當 router 傳送資料到其它 AS 有多條路線且其它條件都相同時，router 會選擇離自己最近的 Gateway router

11.

(a)

$\left\lceil \frac{1980}{980} \right\rceil = 3$ fragments

1st 976 flag=1 offset=0 0

2nd 976 flag=1 offset=122.5 122 122

3rd 48 flag=0 offset=245 2 244

(b)

$\left\lceil \frac{1980}{780} \right\rceil = 3$ fragments

1st ~~200~~ 776 flag=1 offset=0 0 97

2nd ~~200~~ 776 flag=1 offset=97.5 122

3rd 48 flag=0 offset=~~195~~ 244 -2

12. (a) $N = A$ $D(B) = 10$ $D(C) = 5$ $D(D) = \infty$

(b)

	P(B), D(B)	P(C), D(C)	P(D), D(D)
A	A, 10	A, 5	A, ∞
AC	C, 9		C, 13
ACB			C, 13
ACBD			

$A \to B = 9$
$A \to C = 5$
$A \to D = 13$ 12 −2

(c)

destination node	forwarding node
B	~~B~~ C
C	C
D	C

13. $d_v(y) = c(x,v) + d_x(y)$ wrong −1

$d_v(y) = \min_v\{ c(x,v) + d_x(y) \}$

14. (a)

$D_A = \{ D_A(A) = 0, D_A(B) = 10, D_A(C) = 5, D_A(D) = \infty)$

$D_B = (D_B(A) = 10, D_B(B) = 0, D_B(C) = 4, D_B(D) = 3)$

$D_C = (D_C(A) = 5, D_C(B) = 4, D_C(C) = 0, D_C(D) = 8)$

$D_D = (D_D(A) = \infty, D_D(B) = 3, D_D(C) = 8, D_D(D) = 0)$

(b) node A

	A	B	C	D
D A	0	∞ 10	∞ 5	∞
D B	10	∞	∞	∞
D C	5	∞	∞	∞
D D	∞	∞	∞	∞

node C

	A	B	C	D
D A	∞	∞	5	∞
D B	∞	∞	4	∞
D C	∞ 5	∞ 4	0	∞ 8
D D	∞	∞	8	∞

-3

(c)

node A

	A	B	C	D
A	0			
B	10			
C	5			
D	∞			

node B

	A	B	C	D
A		10		
B		0		
C		4		
D		3		

node C

	A	B	C	D
A			5	
B			4	
C			0	
D			8	

node D

	A	B	C	D
A				∞
B				3
C				8
D				0

	A	B	C	D
A	0	10	5	∞
B	10	0	4	3
C	5	4	0	8
D	∞	3	8	0

	A	B	C	D
A	0	10	5	∞
B	10	0	4	3
C	5	4	0	8
D	∞	3	8	0

$\Rightarrow$

	A	B	C	D
A	0	10	5	∞
B	10	0	4	3
C	5	4	0	8
D	∞	3	8	0

	A	B	C	D
A	∞	10	5	∞
B	3	0	4	3
C	8	4	0	8
D	0	3	8	0

node A

	A	B	C	D
A	0	9	5	13
B	9	0	4	3
C	5	4	0	7
D	13	3	7	0

A

	D_A	D_B	D_C	D_D
D A	0	9	5	13
D B	10	0	4	3
D C	5	4	0	8
D D	X	X	X	X

$A \to D = c(A,C) + D_C(D) = 13$

$A \to B = c(A,C) + D_C(B) = 9$

$\Rightarrow C \to D = c(C,B) + D_B(D) = 7$

C

	D_A	D_B	D_C	D_D
A	0	10	5	∞
B	10	0	4	3
C	5	4	0	7
D	∞	3	8	0

node C

	A	B	C	D
A	0	9	5	13
B	9	0	4	3
C	5	4	0	7
D	13	3	7	0