Prof. Athina Markopoulou | Intro to Computer Networks
Fall 2013 | EECS148

Homework 4

Topic: Network Layer

Posted on Friday 5/22, due on Monday 6/1 (by 2pm, in class or online)

1. *(20 Points)* **IP Addressing.**

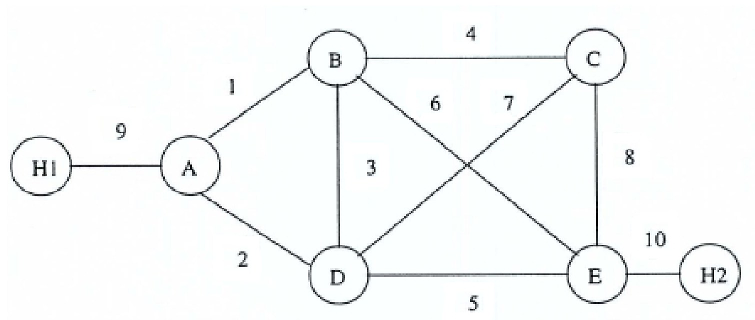
   Chapter 4, Problems 13, 21.

2. *(20 Points)* **BGP.**

   Chapter 4, Problem 40.

3. *(60 Points)* **Routing Algorithms.**

   The following figure shows a network with 2 hosts (H_1 and H_2), 5 routers (A, B, C, D, E).



There are 10 bi-directional links, labeled from 1 to 10, with their transmission bandwidth and propagation delay as follows:

Link #	Trans. BW (100 kb/s)	Propagation delay (ms)
1	4	5
2	1	30
3	1	20
4	2	10
5	1	20
6	0.5	40
7	5	6
8	0.5	20
9	4	5
10	4	5

Packets are sent in the network in a stored-and-forward manner. Suppose that the network is initially empty and processing delay is negligible, *i.e.*, the only delays relevant here are packet transmission time and propagation delay. Now H_1 wants to send a packet of 2000 bits to H_2.

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128 64 32 16 8 4 2 1
1 0 1 0 0 0 1 1

IP Addressing

Ch.4 - 13: 223.1.17/24

Subnet 1: 223.1.17.0 /26 0 → 63

Subnet 2: 223.1.17.64/25 64 → 191

Subnet 3: 227.1.17.192/28 192 → 207

Ch.4 - 21: a) ROUTER : 192.168.1.1

COMPUTER 1: 192.168.1.2

COMPUTER 2: 192.168.1.3

COMPUTER 3: 192.168.1.4

b) NETWORK ADDRESS TRANSLATION TABLEE

WAN = 24.34.112.235, 1 LAN = 192.168.1.2,1

WAN = 24.34.112.235, 2 LAN = 192.168.1.2,2

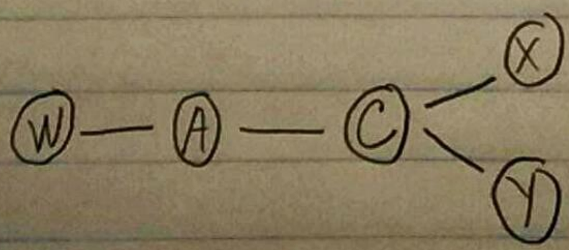
WAN = 24.34.112.235, 3 LAN = 192.168.1.3,1

WAN = 24.34.112.235, 4 LAN = 192.168.1.3,2

WAN = 24.34.112.235, 5 LAN = 192.168.1.4,1

WAN = 24.34.112.235, 6 LAN = 192.168.1.4,2

Ch.4 - 40: W AND X HAS A NETWORK VIEW THAT IS EXACTLY LIKE Y. UNLESS A OR B ADVERTISES AN ALTERNATE ROUTE.



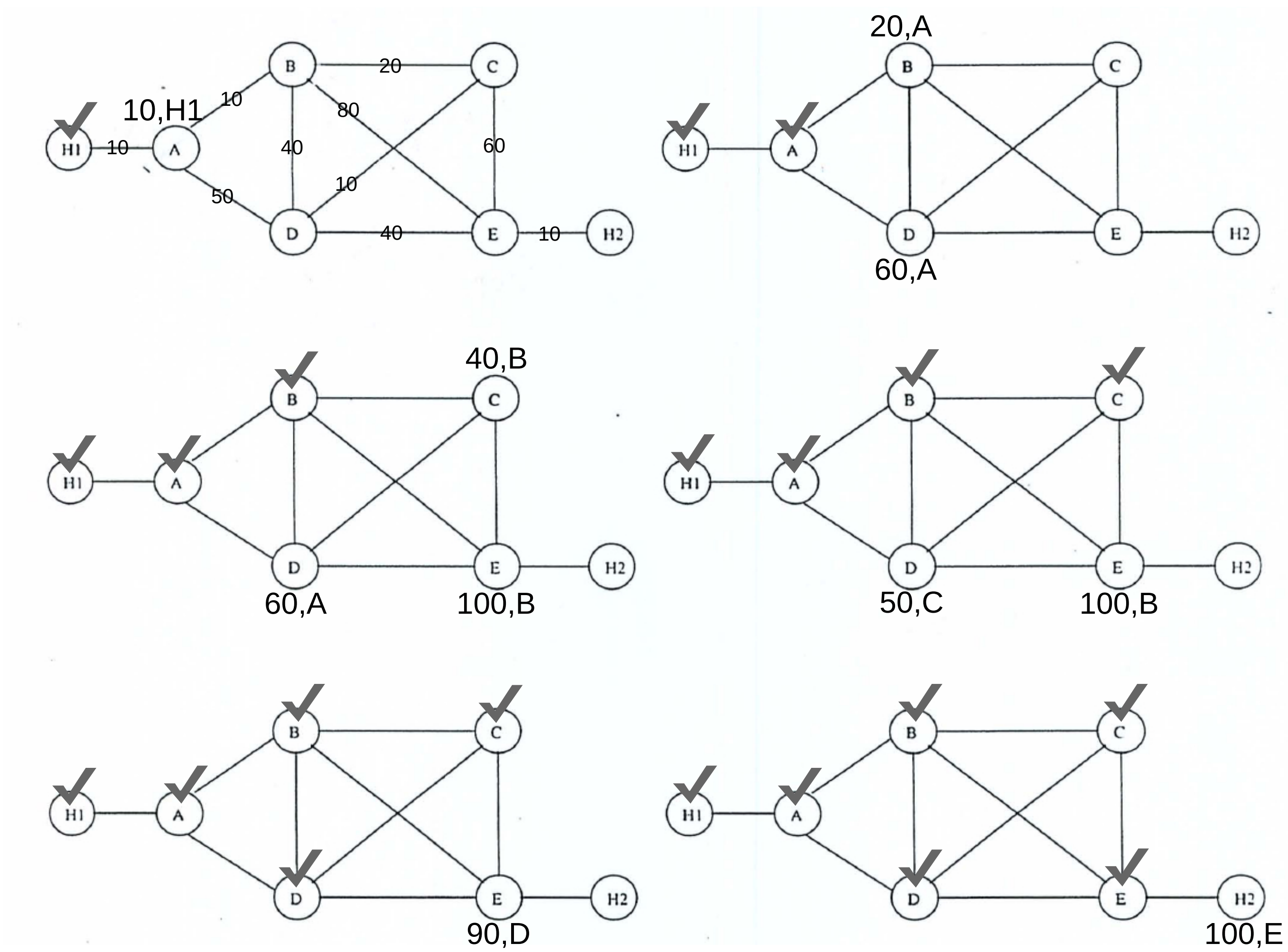


Figure 1: Run Dijkstra's algorithm to find the shortest path from H1 to H2 (question (a)).

Initial tables

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	-	∞
C	-	∞
D	-	∞
E	-	∞

Node B (A, C, D, E)		
Dest.	Via	Delay
A	-	∞
B	B	0
C	-	∞
D	-	∞
E	-	∞

Node C (B, D, E)		
Dest.	Via	Delay
A	-	∞
B	-	∞
C	C	0
D	-	∞
E	-	∞

Node D (A, B, C, E)		
Dest.	Via	Delay
A	-	∞
B	-	∞
C	-	∞
D	D	0
E	-	∞

Node E (B, C, D)		
Dest.	Via	Delay
A	-	∞
B	-	∞
C	-	∞
D	-	∞
E	E	0

Tables after first exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	B	10
C		
D	D	50
E		

Node B (A, C, D, E)		
Dest.	Via	Delay
A	A	10
B	B	0
C	C	20
D	D	40
E	E	80

Node C (B, D, E)		
Dest.	Via	Delay
A		
B	B	20
C	C	0
D	D	10
E	E	60

Node D (A, B, C, E)		
Dest.	Via	Delay
A	A	50
B	B	40
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A		
B	A	80
C	C	60
D	D	40
E	E	0

Tables after second exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	B	10
C	B	30
D	D	50
E	B	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	A	10
B	B	0
C	C	20
D	C	30
E	E	80

Node C (B, D, E)		
Dest.	Via	Delay
A	B	30
B	B	20
C	C	0
D	D	10
E	D	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	A	50
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	90
B	A	80
C	D	50
D	D	40
E	E	0

Tables after third exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	B	10
C	B	30
D	B	40
E	C	80

Node B (A, C, D, E)		
Dest.	Via	Delay
A	A	10
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	B	30
B	B	20
C	C	0
D	D	10
E	D	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	C	40
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	C	80
B	D	70
C	D	50
D	D	40
E	E	0

Tables after fourth exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	B	10
C	B	30
D	B	40
E	B	80

Node B (A, C, D, E)		
Dest.	Via	Delay
A	A	10
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	B	30
B	B	20
C	C	0
D	D	10
E	D	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	C	40
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	80
B	D	70
C	D	50
D	D	40
E	E	0

Figure 2: Show the exchange of routing tables for the Bellman-Ford algorithm in (c). (In a router's table, the nodes in parenthesis are its neighbors. "Via" is the next hop towards destination "Dest.")

(a) *(20 Points)* Use **Dijkstra**'s algorithm to determine the route the packet should take in order to achieve minimal delay. Show your work on Figure 1.

(b) *(10 Points)* Is this route the same as the route with the minimum number of hops?

(c) *(20 Points)* Now suppose that the network employs a **distributed but synchronous version of the Bellman-Ford** routing algorithm (to find the path of minimum delay for each 2000bits packet). Fill in Figure 2 to show the exchanges of routing tables until the final result. (You may ignore the entries for hosts H_1 and H_2, and focus only on the routers.) In each router's table, the routers in parenthesis are its neighbors.

(d) *(10 Points)* Now assume that links AB and BE fail. Run Bellman-Ford algorithm, starting from the steady state achieved in question (c) above. Show your calculations similarly to (or on a copy of) Fig. 2. Does the algorithm converge?

4. *(Optional +50 Points)* **Programming Assignment.** In this programming assignment you will be writing a distributed set of procedures that implement a distributed asynchronous distance-vector routing protocol for the small network shown in the figure (p.429 in v6 of your book). The full programming assignment can be found in the following URL:

`http://media.pearsoncmg.com/aw/aw_kurose_network_3/labs/lab6/lab6.html`

You are only asked to do only the **basic** assignment. You can do it in C or java version, or you can skip it without penalty(it is optional).

Initial tables

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	B	10
C	B	30
D	B	40
E	B	80

Node B (A, C, D, E)		
Dest.	Via	Delay
A	A	10
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	B	30
B	B	20
C	C	0
D	D	10
E	D	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	C	40
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	80
B	D	70
C	D	50
D	D	40
E	E	0

Tables after first exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	D	80
C	D	60
D	D	50
E	D	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	C	50
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	B	30
B	B	20
C	C	0
D	D	10
E	E	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	C	40
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	80
B	D	70
C	D	50
D	D	40
E	E	0

Tables after second exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	D	80
C	D	60
D	D	50
E	D	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	C	50
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	D	50
B	B	20
C	C	0
D	D	10
E	E	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	C	40
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	80
B	D	70
C	D	50
D	D	40
E	E	0

Tables after third exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	D	80
C	D	60
D	D	50
E	D	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	C	70
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	D	50
B	B	20
C	C	0
D	D	10
E	E	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	A	50
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	80
B	D	70
C	D	50
D	D	40
E	E	0

Tables after fourth exchange

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	D	80
C	D	60
D	D	50
E	D	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	C	70
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	D	60
B	B	20
C	C	0
D	D	10
E	E	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	D	50
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	90
B	D	70
C	D	50
D	D	40
E	E	0

Node A (B, D)		
Dest.	Via	Delay
A	A	0
B	D	80
C	D	60
D	D	50
E	D	90

Node B (A, C, D, E)		
Dest.	Via	Delay
A	C	80
B	B	0
C	C	20
D	C	30
E	C	70

Node C (B, D, E)		
Dest.	Via	Delay
A	D	60
B	B	20
C	C	0
D	D	10
E	E	50

Node D (A, B, C, E)		
Dest.	Via	Delay
A	D	50
B	C	30
C	C	10
D	D	0
E	E	40

Node E (B, C, D)		
Dest.	Via	Delay
A	D	90
B	D	70
C	D	50
D	D	40
E	E	0

③ **Routing Algorithms**

Dijkstra's Algorithm

Transmitting: 2kb

Cost in ms

Nodes	D(A), P(A)	D(B), P(B)	D(C), P(C)	D(D), P(D)	D(E), P(E)
H1	10, H1	—	—	—	—
H1, A	—	20, A	—	60, A	—
H1, A, B	—	—	40, B	60, A	100, B
H1, A, B, C	—	—	—	50, C	100, B
H1, A, B, C, D	—	—	—	—	90, D

D(H2), P(H2) = 100, E

b) No, the least cost route is not the same as the minimum hops route

d) Yes, the algoritm converges and finds the new shortesst path.