ESD5 – Fall 2024
Problem Set 4 – Solutions

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Problem 1 – Bellman Ford Algorithm

(a) Max. number of iterations required = num. of nodes - 1 = 4.

(b) The Bellman algorithm (one of the possible solutions)

Initial

Node	S	A	B	C	D
Cost	0	∞	∞	∞	∞
Pre-Node	-	-	-	-	-

Iteration 1

Node	S	A	B	C	D
Cost	0	4	∞	∞	5
Pre-Node	-	S	-	-	S

Iteration 2

Node	S	A	B	C	D
Cost	0	4	7	6	5
Pre-Node	-	S	A	D	S

Converged here: we did not need the 4 iterations at all.

Iteration 3

Node	S	A	B	C	D
Cost	0	4	7	6	5
Pre-Node	-	S	A	D	S

Iteration 4

Node	S	A	B	C	D
Cost	0	4	7	6	5
Pre-Node	-	S	A	D	S

Then, the shortest path tree: S-D-A-B-C

Path	Shortest Path	Distance
S-A	S-A	4
S-B	S-A-B	7
S-C	S-D-C	6
S-D	S-D	5

Challenge:

Initial

Node	S	A	B	C	D
Cost	0	∞	∞	∞	∞
Pre-Node	-	-	-	-	-

Iteration 1

Node	S	A	B	C	D
Cost	0	4	∞	∞	5
Pre-Node	-	S	-	-	S

Iteration 2

Node	S	A	B	C	D
Cost	0	1	7	6	5
Pre-Node	-	D	A	D	S

Iteration 3

Node	S	A	B	C	D
Cost	0	1	4	5	5
Pre-Node	-	D	A	B	S

Iteration 4

Node	S	A	B	C	D
Cost	0	1	4	5	5
Pre-Node	-	D	A	D	S

Then the shorstest path tree: S-D-A-B-C

Path	Shortest Path	Distance
S-A	S-D-A	1
S-B	S-D-A-B	4
S-C	S-D-A-B-C	5
S-D	S-D	5

(c) Checking negative weight cycle

Path	Condition	Checking
A-B	$d_{\mathrm{B}} \leq d_{\mathrm{A}} + c(\mathrm{A,B})$	$4 \leq 1 + 3$
A-C	$d_{\mathrm{C}} \leq d_{\mathrm{A}} + c(\mathrm{A,C})$	$5 \leq 1 + 6$
B-C	$d_{\mathrm{C}} \leq d_{\mathrm{B}} + c(\mathrm{B,C})$	$5 \leq 4 + 1$
D-B	$d_{\mathrm{B}} \leq d_{\mathrm{D}} + c(\mathrm{D,B})$	$4 \leq 5 + 3$
D-C	$d_{\mathrm{C}} \leq d_{\mathrm{D}} + c(\mathrm{D,C})$	$5 \leq 5 + 1$
D-A	$d_{\mathrm{A}} \leq d_{\mathrm{D}} + c(\mathrm{D,A})$	$1 \leq 5 + (-4)$
S-D	$d_{\mathrm{D}} \leq d_{\mathrm{S}} + c(\mathrm{S,D})$	$5 \leq 0 + 5$
S-A	$d_{\mathrm{A}} \leq d_{\mathrm{S}} + c(\mathrm{S,A})$	$1 \leq 0 + 4$

$\rightarrow$ All conditions are satisfied, and the graph has no negative cycle.

Problem 2 – Routing

(a,b)
Going from C via B to all the other nodes gives (11, 6, 14, 18, 12, 8).
Going from C via D to all the other nodes gives (19, 15, 9, 3, 9, 10).
Going from C via E to all the other nodes gives (12, 11, 8, 14, 5, 9).
Taking the minimum for each destination except C gives C's new routing table as

Destination	A	B	C	D	E	F
Distance	11	6	0	3	5	8
Outgoing line	B	B	-	D	E	B

Problem 3 – Flow control

Each packet consumes 10 instructions. With 4 copies, we end up with 40 instructions. The CPU can process 40 instructions in 40 nanoseconds. Thus, a byte (8 bits) requires 5 nanoseconds of CPU time. Thus, the system can handle 200 megabytes/second, 1600 megabits/second, or 1.6 gigabits/second. Therefore, the answer is yes: the system can handle a transmission line of 1 gigabit/second.

Problem 4 – TCP-IP

(a) IP is a network-level protocol, while TCP is an end-to-end transport-level protocol. Any change in the protocol specification of IP must be incorporated on all routers on the Internet. On the other hand, TCP can work fine as long as the two endpoints are running compatible versions. Thus, it is possible to have many different versions of TCP running at the same time on different hosts, but not this is not the case with IP.

(b) The ACK bit is used to tell whether the 32-bit field is used. But if it were not there, the 32-bit field would always have to be used, if necessary, acknowledging a byte that had already been acknowledged. In short, it is not essential for normal data traffic. However, it plays a crucial role during connection establishment, where it is used in the second and third messages of the three-way handshake.