Sample Solution for Exercise Communication Networks I

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General Remarks

Welcome to the exercise for Communication Networks I. Please adhere to the following general remarks regarding the organization of the exercise during this summer term.

- One week before the tutorial, a new exercise will be published at the Exercise area of the KN1 Moodle (`https://moodle.tu-darmstadt.de/course/view.php?id=5268`)
- The exercise serves as your hands-on experience in addition to the lecture and as a preparation for the exam
- The questions in the exercise can be discussed at the tutorial date
- The sample solution for the exercise is available at the Exercise area of KN1 Moodle in addition to the corresponding tutorial. Nevertheless, we encourage students to try to solve the exercise themselves before the tutorial date without looking into the solution as a good practice to understand the subject of the lecture

Problem 1 - Distance Vector Routing

a) Compare Distance-Vector and Link-State Routing, which information is collected, which information is send to whom and what do the nodes calculate themselves?

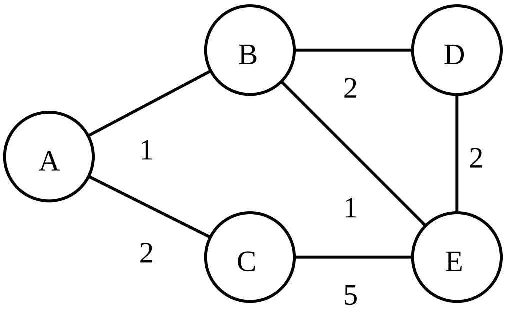
Solution:

Distance-Vector: station ***collects*** information about ***distance to all IS sends*** the information ***to neighbours***

Link-State: station ***collects*** information about ***distance to neighbours sends*** the information ***to all IS***

In Link-State Routing, every station calculates the distances from all the information on its own (because information from all IS is available), whereas in Distance-Vector Routing the stations “rely” on the calculations of their neighbours (because only informations from neighbours are available).

In the following network the numbers indicate a metric for the distance of 2 nodes.



At the moment, however, the routing tables of the nodes A, B, C and E look as follows:

Node A			**Node B**		
Target	Egress	Costs	Target	Egress	Costs
A	-	0	A	A	1
B	B	1	B	-	0
C	C	2	C	E	6
D	B	3	D	D	2
E	B	2	E	E	1

Node C			**Node E**		
Target	Egress	Costs	Target	Egress	Costs
A	A	2	A	B	2
B	A	3	B	B	1
C	-	0	C	E	5
D	E	7	D	D	2
E	E	5	E	-	0

b) What are the vectors, that B and E send to their neighbours? Use the following format:
Sender : Vector

Solution: B: $(1,0,6,2,1)$ E: $(2,1,5,2,0)$

c) D receives the vectors from B and E. Complete D’s routing table:

Solution:

Node D		
Target	Egress	Costs
A	B	3
B	B	2
C	E	7
D	-	0
E	E	2

d) Now the line between A and B is cut. Describe, how the nodes react. For this purpose, specify the first 5 vectors interchanged by the nodes after the cut. Use the following format:
Sender : Vector
A node sends the vector when its routing table has changed.

Solution:

A) A: $(0,*,2,*,*)$ B: $(*,0,6,2,1)$

B) C: $(2,*,0,7,5)$ D: $(*,2,7,0,2)$ E: $(*,1,5,2,0)$

($*$ means infinite distance)

A) When the link between A and B is broken, A sets the distances to all nodes that are reached about Egress B to infinite and sends the vector; so does B with all nodes that are reached about Egress A.

B) C gets the information, that A can not reach B. Because C reaches B via Egress A (and A can not reach B), C sets the distance to B to infinite and sends the vector; so do D and E.

e) After some steps, alle the nodes have updated their routing tables and the network works without the line between A and B. The routing tables of A and C look like this:

Node A			Node C		
Target	Egress	Costs	Target	Egress	Costs
A	-	0	A	A	2
B	C	8	B	E	6
C	C	2	C	-	0
D	C	9	D	E	7
E	C	7	E	E	5

Now also the line between C and E is cut.
Describe which problem occurs, if node A sends its routing information (the vector) to node C (e.g. because of a timer), before node C was able to send its new routing information (containing the cut between C and E) to A.

Solution: "Count to Infinity" - Problem

- A sends $(0,8,2,9,7)$ to C.
- C has detected the broken link to E, the vector from A arrives.
- Now C thinks it can reach nodes B, D, E over the link to A and sends its new routing information to A: $(2,10,0,11,9)$.
- A, who thinks to reach B, D and E over C, updates its routing information and sends a new vector to C: $(0,12,2,13,11)\dots$

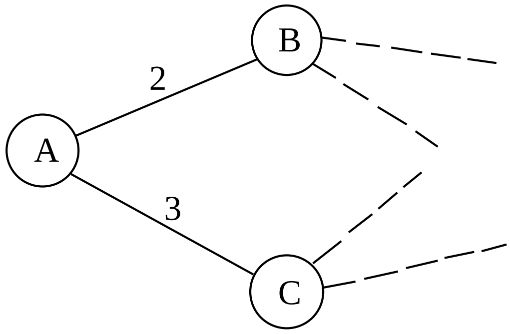
Nodes A and C will count the distance to B, D and E up to infinity in steps of 2.

f) How can this problem be solved?

Solution: With the "Split Horizon Algorithm", but not for all network topologies!

Problem 2 - Link State Routing

Look at the following cut-out of a network:



In this network, Link-State Routing is used. System A knows its neighbours (found out via HELLO messages over each L2 channel)
B, distance 2
C, distance 3
and has sent its Link State Packet.

a) Who will receive this packet? Which sending mechanism is used?

Solution: flooding → every station in the network will receive the packet

b) What does this Link State Packet contain? Why?

Solution: own address, sequence number (flooding → to prevent duplicates), age of packet (flooding → inconsistent (= old) information can be on the network), all neighbours and their distance

A	
Seq.#	
Age	
B	2
C	3

c) Station A receives the following Link State Packets:

B		C		D		E		F		G	
Seq.#		Seq.#		Seq.#		Seq.#		Seq.#		Seq.#	
Age		Age		Age		Age		Age		Age	
A	2	A	3	B	1	B	6	E	2	C	4
D	1	D	5	C	5	D	3				
E	6	G	4	E	3	F	2				

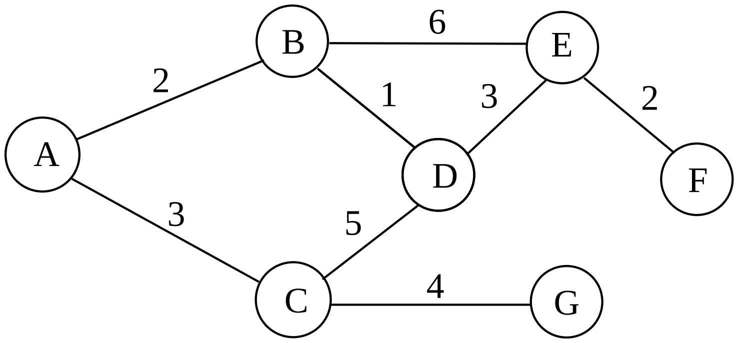
Compute the routing table of A. For every station in the network, the table must have a row of the form (target, egress, distance), e.g. the entry for station B in the routing table of A looks like this:

Target	Egress	Distance
B	B	2

Solution:

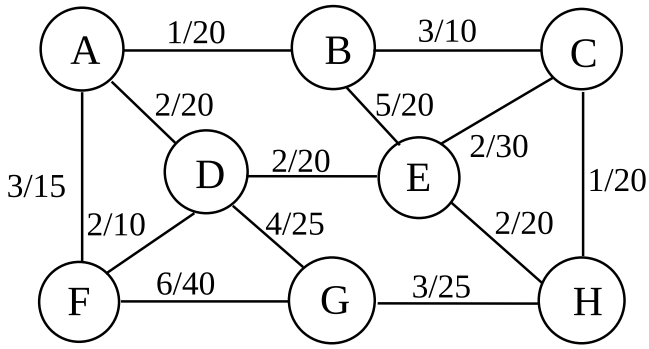
Target	Egress	Distance
B	B	2
C	C	3
D	B	3
E	B	6
F	B	8
G	C	7

The network structure is as follows:



Problem 3 - Multipath Routing

The following network topology is given:



The first number indicates a metric for the distance of 2 nodes. The second number denotes the data rate in Kbits/sec.

State according to the Multipath-Routing Algorithm based on the distance the routing table for node E. Do this by indicating the weight of the two best egress lines. Pick any one in case of several possibilities for the second alternative. The weight should be reciprocally proportional to the total distance over each path. Note that the sum of the weights for every target node must be 1.

Solution:

Target	Egress	Distance	Weight	Egress	Distance	Weight
A	D	4	0,6	B/C	6	0,4
B	B	5	0,5	C/D	5	0,5
C	C	2	0,6	H	3	0,4
D	D	2	0,8	B/C	8	0,2
F	D	4	0,69	B/C	9	0,31
G	H	5	0,55	C/D	6	0,45
H	H	2	0,6	C	3	0,4

Calculation example for A:
Total distance $= 4 + 6 = 10$
Weight(A→D) $= 6/10 = 0,6$
Weight(A→B/C) $= 4/10 = 0,4$ A hint how can we compute the weights in general: We now that the weights should be reciprocally proportinal to the distances (see the task test), i.e., for the path i it holds

$$w_i = \frac{a}{d_i} \quad and \quad \sum_i w_i = 1$$

with some factor a which is to be found.. We can resolve this equation system for a. For a system with only two alternative paths we get:

$$\frac{a}{d_1} + \frac{a}{d_2} = 1$$

and the solution is

$$a = \frac{d_1 d_2}{d_1 + d_2}$$

. Therefore,

$$d_1 = \frac{d_2}{d_1 + d_2} \quad and \quad d_2 = \frac{d_1}{d_1 + d_2}$$

. If we have more than two additional paths then we will get another formulas for weights, e.g. for three paths it holds

$$d_1 = \frac{d_2 d_3}{d_1 d_2 + d_2 d_3 + d_3 d_1}$$

and so on....