Sample Solution for Exercise Communication Networks I

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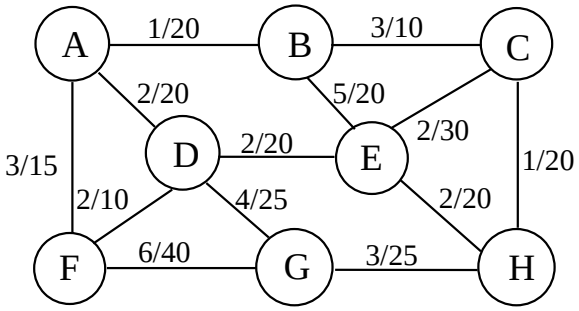
General Remarks

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 - Flow based Routing

Use the following network topology for tasks a-c:



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

a) The following traffic is given :

Source \ Target	A	B	C	D	E	F	G	H
A		3 AB	7 ABC	4 AD	2 ADE	5 AF	2 ADG	5 ADEH
B	3 BA		3 BC	7 BAD	3 BE	4 BAF	3 BADG	4 BCH
C	7 CBA	3 CB		7 CED	5 CE	3 CEDF	5 CHG	3 CH
D	4 DA	7 DAB	7 DEC		2 DE	9 DF	2 DG	9 DEH
E	2 EDA	3 EB	5 EC	2 ED		3 EDF	1 EHG	2 EH
F	5 FA	4 FAB	3 FDEC	9 FD	3 FDE		1 FG	9 FDEH
G	2 GDA	3 GDAB	5 GHC	2 GD	1 GHE	1 GF		1 GH
H	5 HEDA	4 HCB	3 HC	9 HED	2 HE	9 HEDF	1 HG	

Note: The paths for the message transmissions shown in the matrix have been already selected to achieve the shortest distances by applying a different routing algorithm.

I) Is it essential to consider the entire matrix for the calculation of the total delay or is the half sufficient? Why?

Solution: Half is enough due to the symmetry of the paths.

II) Calculate the mean total delay of this network. The mean packet size is 400 bit.

Solution:

i	Line	λ_i(pkts/sec)	μC_i	T_i	Weight	T_i*Weight
1	AB	24	50	38	0,117	4,446
2	AD	23	50	37	0,112	4,144
3	AF	9	37,5	35	0,044	1,54
4	BC	14	25	91	0,068	6,188
5	BE	3	50	21	0,015	0,315
6	CE	15	75	17	0,073	1,241
7	CH	12	50	26	0,059	1,534
8	DE	40	50	100	0,195	19,5
9	DF	24	25	1000	0,117	117
10	DG	7	62,5	18	0,034	0,612
11	EH	26	50	42	0,127	5,334
12	FG	1	100	10	0,005	0,05
13	GH	7	62,5	18	0,034	0,612

Calculation: Total packets: 205
mean total delay: approx. $162,5$ msec

III) How could the underlying routing table be changed so that a significant improvement of the mean total delay is achieved. What can be inferred from this regarding the optimized routing table?

Solution: e.g. Route D → F replaced by D → G → F
New (implied) calculation of the mean total delay:
Total number of packets: 229

9	DF	0	––	––	––	––
10	DG	31	62,5	32	0,135	4,32
12	FG	25	100	13	0,109	1,417

Difference: $(117 - 5,737)$
Difference even larger since remaining weight are reduced. (Total number of packet rises).
$\Rightarrow$ mean total delay < 61 msec
Inference: The simple metric that is used for routing (here: distance) is not sufficient to obtain a globally optimized routing table.

b) Briefly state how a calculation of the mean delay can be used for routing.

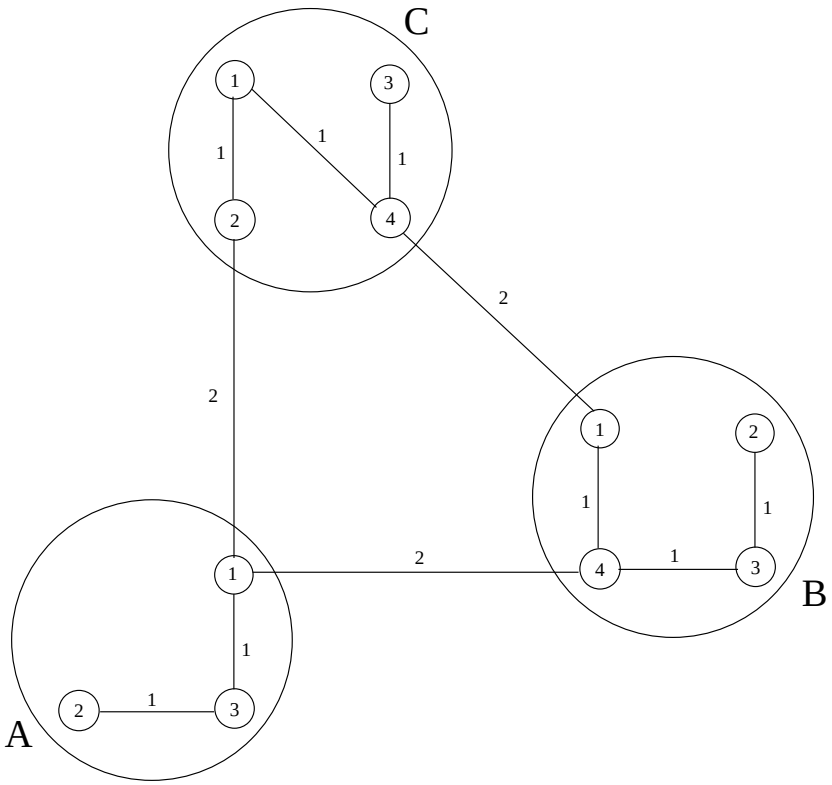
Solution: For a global evaluation of routing alternatives.

c) Determine a Multicast-Tree for sender C, with the group being A,F,G,H. Is the tree optimal with regard to the given distances?

Solution: C → B → A, C → H, C → H → G, C → E → D → F
The tree is optimal with regard to each receiver, but not for the network as such. For this it would be sensible to route A via F, or vice versa.

Problem 2 - Hierarchical Routing

Given is the following structured network topology:



The numbers on the lines indicate a metric for the distance of two nodes.

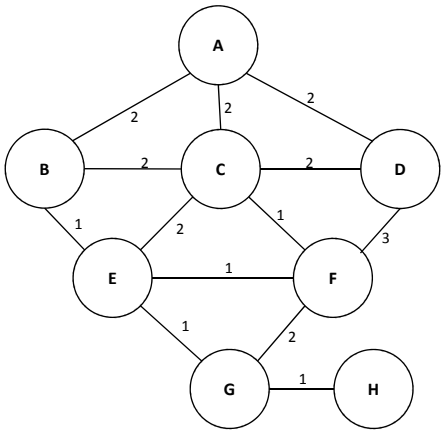
In this network, hierarchical routing is used. How do the routing tables of the nodes C1 and B2 look like?

Solution:

Node	Target	Egress	Dist.	Node	Target	Egress	Dist.
C1	C1	-	0	B2	B1	B3	3
	C2	C2	1		B2	-	0
	C3	C4	2		B3	B3	1
	C4	C4	1		B4	B3	2
	B	C4	3		A	B3	4
	A	C2	3		C	B3	5

Problem 3 - Broadcast and Mulitcast

a) In the following topology vertex A does a broadcast using reverse path forwarding. Name for each message which is sented during the broadcast the sender, the receiver and whether it is forwarded or dropped by the receiver. Use the following notation (sender, receiver, drop) or (sender, receiver, forward). How many messages are sent in total for the broadcast? Assume every IS knows the best possible path to A.



From A: (A, B, forward), (A, C, forward), (A, D, forward)

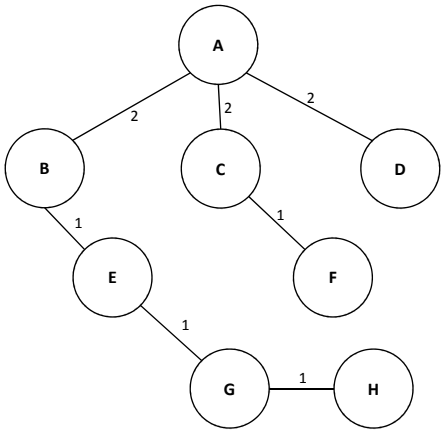
Solution:
From B: (B, C, drop), (B, E, forward)
From C: (C, B, drop), (C, D, drop), (C, E, drop); (C, F, forward)
From D: (D, C, drop), (D, F, drop)
From E: (E, C, drop), (E, F, drop), (E, G, forward)
From F: (F, D, drop), (F, E, drop), (F, G, drop)
From G: (G, F, drop), (G, H, forward)

Because vertex H has only one neighbor from which it got the message, vertex H does not forward the message.

In total 19 messages are sent during the broadcast.

b) How many messages would be needed for a broadcast from vertex A when a spanning tree is used for broadcasting? Draw the spanning tree.

Solution: When a spanning tree is used, a message is sent once per tree edge (number of vertexes minus 1), so that 7 messages are needed.



c) What is the purpose of IGMP and DVMRP?

Solution: IGMP (Internet Group Management Protocol) is used to manage multicast group membership locally (inside a subnet connected to one multicast router). Hosts join a multicast group by sending IGMP messages which are received by their local multicast router.
DVMRP (Distance Vector Multicast Routing Protocol) is used for wide-area multicast routing in one autonomous system consisting of many subnets. DVMRP builds source-specific trees out of the multicast routers using reverse-path forwarding.