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Freiburg, 4 May 2007
Due until 11 May 2007

Exercises of lecture
Mobile Ad Hoc Networks
Summer 2007
Sheet 3

SECTION 1:
Max-Flow problem

1. Consider network of figure-1 with the capacities written over the edges as follows:

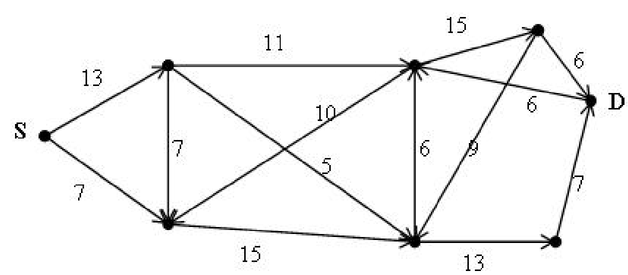


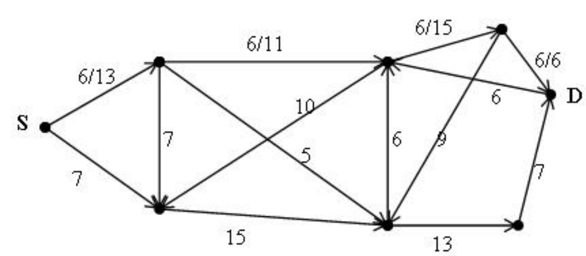
Figure 1:

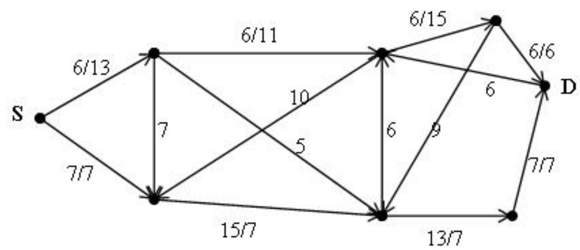
- Apply Edmonds-Karp algorithm to find the max flow from source S to destination D. Show the path found during each step from S to D in separate figure.

- Find min-cut in the network given above.

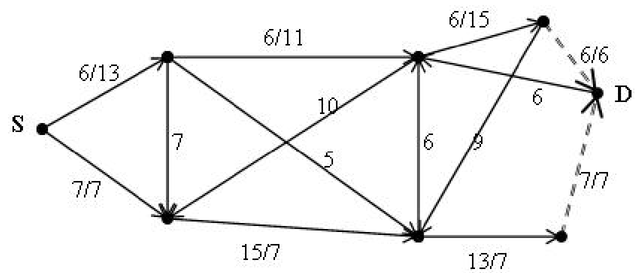
Solution:

- Following is the solution for network-1 and maximum flow is equal to 13. *Note: You could also use applet at http://www.cse.yorku.ca/ aaw/Wang/MaxFlowStart.htm and create more examples.*





- The min-cut involves highlighted edges and is equal to 13. Note that 13 is also the maximum flow.



2. Consider the network of figure-2 with capacities written over the edges as follows:

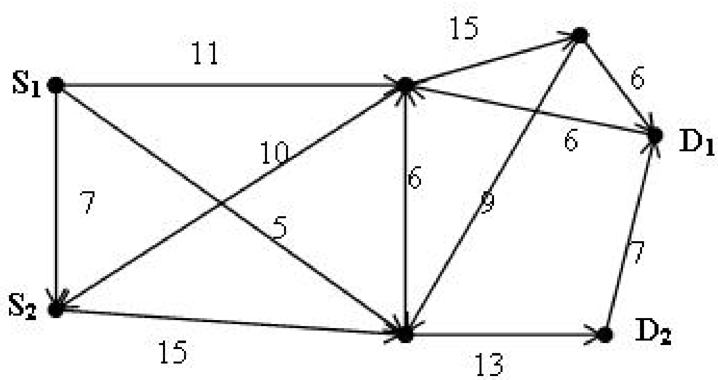
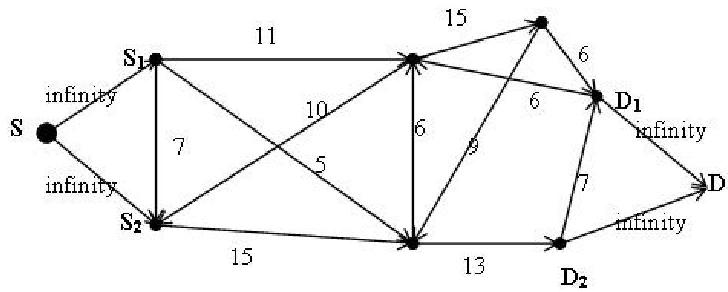


Figure 2:

- Apply Edmonds-Karp algorithm to find max aggregated flow from sources S1, S2 to destination D1, D2.

Solution: *Infinity* indicates the data flow can be unlimited.



The maximum aggregated flow is 19.

SECTION 2:
Random Placement Model

1. According to Figure 3, consider a quadratic area that consists of 16 squares and the size of each square is 5m x 5m. We want to place each sensor randomly and uniformly in each square of the area so that they are connected to each other.

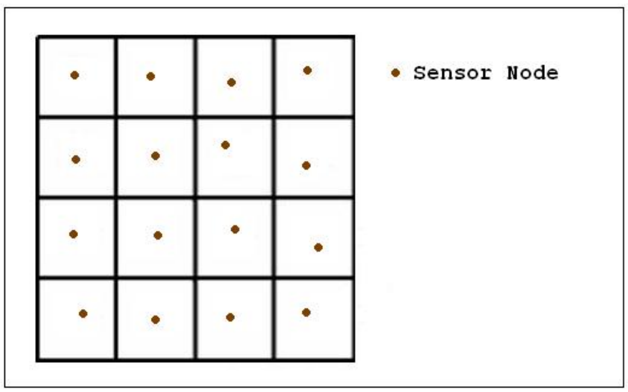


Figure 3:

- Based on the random placement model, if we have 16 sensor nodes, what is the probability that exactly 1 sensor node is placed in one square?
- However, to ensure the desired connectivity of all sensor nodes in the area, how many sensor nodes should be prepared?

Solution:

- We have 16 equal size squares in the area. The probability of placing a sensor node in the square, p is 1/16. Using the formula below, where n = 16 and k=1:

$$P_r[k \text{ } of \text{ } n \text{ } nodes \text{ } fall \text{ } in \text{ } area \text{ } B] = \binom{n}{k} \cdot p^k \cdot (1-p)^{n-k}$$

the probability that exactly 1 sensor node is placed in one square,
P_r[*1 of 16 sensors nodes fall in 1 square*]
$= 16 \cdot (1/16)^1 \cdot (15/16)^{15}$

To get exactly 1 sensor in 1 square for every square on the area (illustrated in Figure 3), the probability is
P_r[*exactly 1 sensor falls in 1 square for all the squares*]
$= 16! \cdot (1/16^{16})$

- Let the sensor nodes construct a connected UDG. We need an overhead of a factor of $O(\log n)$, where n is the number of sensor node needed to form a connected UDG. So, we need a total of $16 \times log 16$ sensor nodes. Please find the proof sketch in the *Lecture #3*.