ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
Distributed Computing

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Ad Hoc And Sensor Networks
Sample Solution to Exercise 11

Assigned: December 6, 2010
Due: December 13, 2010

1 Routing with Mobility

First we have to identify a network topology which allows us to forward a message to as many relay nodes as possible before reaching the destination. A chain of nodes with the source at one end and the destination at the other fulfills this property. In a line topology of n nodes the message travels $n-1$ hops before reaching its destination. To further prolong the travel time the destination has to change its position when the message reaches one of its direct neighbors. To maximize the path length after this change the source has to move to the other end of the line (to the source).

Such a topology can easily be modeled as a ring with distance 1 between any two neighboring nodes. Source s and destination d are neighboring nodes on this ring. Initially, to prevent the one hop solution d is moved by $\epsilon/2$ away from s to break the (s,t) link. The message travels around the ring and when it reaches d's direct neighbor u, d is moved by ϵ towards s. The link (u,d) breaks and (s,d) is established. The topology remains connected but the message has to travel along the whole ring again to reach d. By always moving d by ϵ when the message comes close we can prevent it from ever reaching d. Hence, we look at a line of $n-1$ reachable nodes and $n-2$ rounds to travel from one end of the line to the other. So every $n-2$ rounds the destination needs to be moved.

2 Pseudo-Geo-Routing with Anchor Nodes

a) Assuming a transmission from node u to v. The label vector of v contains exactly one 0 element since each element represents the hop distance from v to one other node in the network (and only the distance from v to itself can be 0). u finds the index of the 0 element in v's label. It then compares the value at this index in the labels of its neighbors and forwards the message to the neighbor with the smallest value.

   This algorithm works since in its label each node stores its position in the minimum spanning trees (MST) to all other nodes. So routing basically consists of moving along the MST rooted at the destination.

b) The problem sounds pretty simple and it also is, if we know n, the number of nodes in the ring[1]. A routing algorithm requires only two anchors $A1$ and $A2$ which have to be placed directly beside each other.

   Routing a message from node u to v works as follows: The routing algorithm first checks if u, and v have a common closest anchor (i.e. both nodes are closer to $A1$ than $A2$ or vice versa).If this is the case their distance is at most $n/2$ and only the distance to the closest anchor is required to route the message. That is, the message is forwarded to the neighbor which is closer to v on the MST rooted at the closer anchor.

   If u and v have different closest anchors the algorithm needs to decide if it is cheaper to route towards the anchors or away from them. To do so it sums up the distances of u and v

[1]Please note that also a symmetric placement of anchors equals to the knowledge of n, as n can be deduced from the distance to the closest anchors.

to one of the anchors (which one does not matter). If this sum is less than $n/2$ the message is forwarded towards the neighbor of u which is closer to the anchor. If not, the message is forwarded in the other direction.

What if we do not know n? in this case the problem becomes much harder. Convince yourself that a constant number of anchors no longer suffices to route a message along the optimal path. So far we have only found a sketch of a randomized algorithm which works with high probability but requires a large number of anchors. Can you do better? If you find a clever algorithm solving this problem let us know!