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SENSOR NETWORKS - 2

Exercise 1 : Routing

1. Present briefly the principal of the Rumor Routing. Propose an example of Rumor Routing on a ring of size 10 with a sink and two generators of events at distance 1 from each other and at least 3 to the sink.
2. Present briefly the principal of the Geographical Routing.
3. Consider a set of sensors located in the nodes of a grid network (5x5). On the upper left and upper right corners are two anchors. Propose a method to associate to each sensor a coordinate in the grid using the two anchors. Propose a routing algorithm for this network.
4. Present briefly the principal of GAF protocol.
5. GAF protocol uses a local leader election in order to decide which node will lead a virtual cell. Propose a simple protocol to elect a local leader.

Exercise 2 : Shortest Path

1. One way of building routing tree in WSNs is based on ETX (expected number of transmissions). The idea is to make a minimum spanning tree (MST) minimizing the expected number of transmissions for each node. This is done based on MAC layer functionalities (e.g., PRR). With PRR for each link between (i, j) nodes have a good estimate of *packet reception rate* from other party and hence can measure the temporal reliability of the link. Having the values of PRR of direct neighbors available at each node, in a recursive fashion nodes can build a routing tree that minimizes the expected number of transmissions to the sink.
   a. Develop a sketch of the algorithm and the required equations to build the routing tree based on ETX metric.
   b. Consider Figure 1 and assume the PRR is bidirectional (links are undirected) where the values of the PRR are given on the arcs. Find the MST based on ETX metric.

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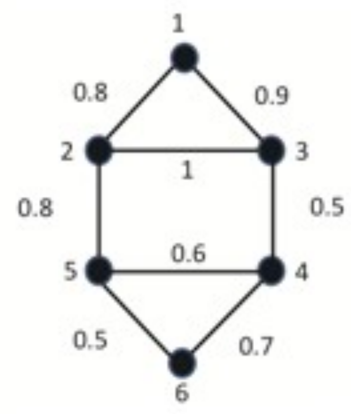

Figure 1

Exercise 3 : Anycast

In WSNs, the expected number of transmissions of a node (ETX) is a routing metric, namely a metric used by a node to take the decision over which path the node routes packets. Denote by ETX[s] the expected number of transmissions required for node s to send a packet to the destination D. Let Ns, Ps and pi be the neighbors set of s, parent set of s and probability of successful transmission from node s to neighboring node i, respectively. Given ETX[i] and pi for all i ∈ Ns, ETX at s is defined as : ETX[s]=**min** $_{i \in Ns}$\{ETX[i] + 1/pi\} and the parent set of s is defined as Ps = {i}, where i is the neighbor that minimizes ETX[s] above. Note that the Ps has one component.

Now we want to extend this scheme to consider multiple parents. Figure 3 illustrates such network. The routing scenario is as follows. Node s looks at its parents set Ps = {1 . . . n} as an ordered set. It broadcasts a packet to all the parents and waits for an acknowledgement (ack) packet. If parent 1 receives the packet (with probability p1) then node 1 will forward the packet to D (with cost ETX[1]). Now if node 1 fails to receive the packet and node 2 receives it, then node 2 will forward it. So within this scheme node i is allowed to forward a packet if 1) it successfully receives the packet from s with probability pi and 2) if all the nodes with higher priority 1, . . . , i − 1 fail to get the packet. Assume that an efficient message passing scheme handles this structure.

a. Calculate the new ETX metric for s and a given ordered set of parents Ps = {1 . . . n}. [hint: first you can calculate the probability that a packet from s is received by at least one of the parents. Then, conditioned on that you are in one of the parents (the first hop transmission is successful), calculate the average ETX from one of the parents to the destination.]
b. In Figure 3, assume that s has 3 neighbors with success probabilities (p1, p2, p3) = (1/2, 1/3, 1) and ETX of (2, 2, 4), respectively. Calculate the ETX[s] for two cases: with single parent and three parents with priority order (1, 2, 3).

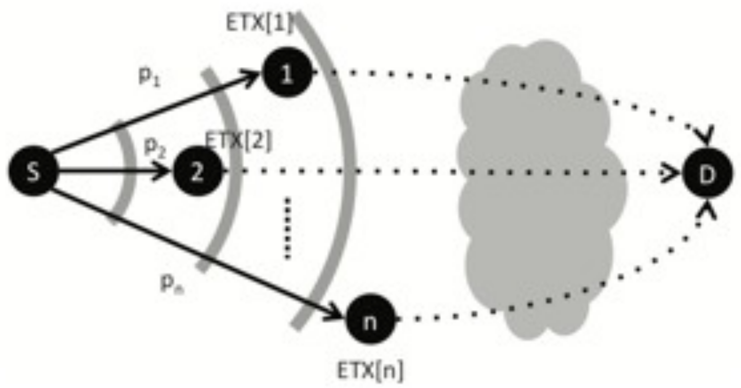

Figure 3

Bibliography

1. G. J. Pottie and W.J. Kaiser «Principals of Embedded Networked Systems Design», Cambridge University Press 2009.
2. E. Ghadimi and Yushe Xu and Carlo Fischione «Principals of wireless sensor networks», KTH 2013.