Problem Set 2, Part a

Due: Wednesday, March 15, 2006
Problem sets will be collected in class. Please hand in each problem on a separate page, with your name on it.

Reading

Localization	Aspnes *et. al*: Theory of localization
Time Sync	Elson, Girod, Estrin: RBS paper
	Karp *et. al*: Global synchronization in sensornets

Reading for next week

Time sync	Fan, Lynch: Gradient clock sync
	Attiya, Hay, Welch: Optimal clock sync paper
Topology control	Li, *et. al*: Cone-based topology control algorithm
	Bahramgiri *et. al*: Fault tolerant distributed topology control algorithm

Problems

1. The mobile-assisted localization paper describes an algorithm for determining the distances between 2, 3, and 4 points in 3-space, and uses this to determine coordinates for all nodes. Now suppose that we only need these algorithms to work in 2-space.

   (a) State versions of propositions 2 and 4, as needed for use in 2D.

   (b) Describe how a 2D version of MAL would work, using your propositions.

   (c) Describe what a 2D version of AFL would do, based on your new version of MAL.

2. A complete bipartite graph $K_{x,y}$ is a graph whose vertices can be partitioned into two sets S_1 and S_2, such that $|S_1| = x, |S_2| = y$, an edge connects each vertex in S_1 to each vertex in S_2, and there are no edges between vertices in S_1 or between vertices in S_2. Let $G = K_{2,3}$ be a complete bipartite graph.

   (a) Is the graph G generically rigid in two dimensions? Why or why not?

   (b) Provide an example of a rigid formation in two dimensions with graph G.

3. In this problem, we use RBS to compute the velocity of an object tracked by a field of sensors. Consider a simple scenario consisting of four nodes, i, j, k and ℓ, as depicted below. Edges connect nodes which can directly communicate with each other. Suppose that j observes an object when its clock value is 8, and k observes the same object when its clock is 18. After this, node ℓ sends two reference signals. The first signal is heard by i when its clock is 10, by j when its clock is 16, and by k when its clock is 24. The second signal is heard by i at 12, j at 18.2, and k at 25.8. Nodes i, j and k use the signals to synchronize their clocks via RBS. If nodes j and k send i their clock values when they observe the object, and i knows the distance between j and k is 10 meters, then what does i compute for the object's velocity?

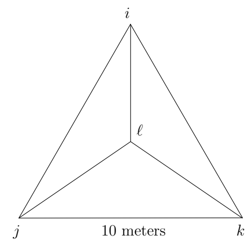

Figure 1: Network for problem 2

4. Consider the method for modeling an execution of RBS as a bipartite graph, as described in the Karp paper. Let the graph shown below be the bipartite graph corresponding to some execution of RBS. Here, each circle represents a node, and each triangle represents a signal. Each edge has a variance of 1. Compute the variance of the minimum variance unbiased estimator of $T_p - T_q$, as described in Section 3.2 of the Karp paper.

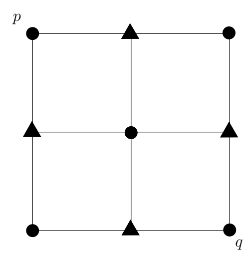

Figure 2: Graph for problem 3