



Lecture 12

WSNs: Localization

Reading:

- “Wireless Sensor Networks,” in *Ad Hoc Wireless Networks: Architectures and Protocols*, Chapter 12, section 12.6
- N. Bulusu, J. Heidemann and D. Estrin, “GPS-less Low Cost Outdoor Localization for Very Small Devices,” *IEEE Wireless Communications*, Vol 7. No.5, pp. 27-34, Oct 2000.



Localization

- Sensors often must know their location – why?
- Goals for localization algorithm
 - RF-based: reduces added hardware costs
 - Receiver-based: scales better
 - Ad hoc: no existing infrastructure needed
 - Responsive: localize quickly
 - Low energy
 - Adaptive fidelity: better localization with more reference points

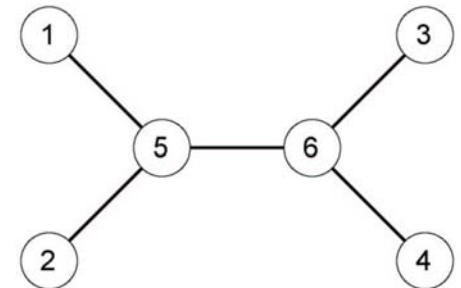
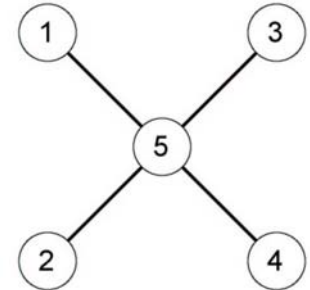


Localization Techniques

- What techniques exist for determining location?
 - GPS
 - Cost/size/power issues
 - Reliability: indoors, dense foliage
 - Beacon nodes
 - Measure signal strength, angle of arrival or time difference of arrival
 - Measure parameters from different beacons
 - Use geometric relationships to calculate local topology
 - Multi-lateration techniques

Multi-lateration (ML)

- Atomic ML
 - Node receives three beacons
 - Use trilateration to position node at intersection points
- Iterative ML
 - For case when all nodes not in range of three beacons
 - Nodes send out their estimates as beacon
 - Enables other nodes to receive three beacons and estimate position
 - Problem: error propagation
- Collaborative ML
 - For case when no node can hear three beacons
 - Collaborate to determine position using all available beacons and relative position between unknown nodes





Other Approaches

- Use connectivity information
 - Create graph using connectivity information between all pairs of nodes
 - Assign locations to nodes to satisfy all constraints
 - Relative positioning
 - Can determine absolute positioning if three nodes in the network know their position



Obtaining Pair-wise Distance Measurements

- Received signal strength indicator (RSSI)
 - Susceptible to errors
 - Problems with multipath
- Time of Arrival (ToA)
 - Used in GPS
 - Requires good clocks for resolving propagation delays
- Time Difference of Arrival (TDoA)
 - RF and IR signals transmitted simultaneously
 - Difference of time when two signals received converted to distance based on difference in speeds
- Angle of Arrival (AoA)
 - Requires antenna arrays
 - Triangulation



Reference Point Centroid Scheme

- Sensors listen for beacons
- Compute location as centroid of locations of reference beacons
 - Does not require RSSI, ToA, etc.
 - Can have large errors
 - Trade-off in resolution/error of location estimate with number of beacon nodes
 - Error increases indoors as propagation not uniform
- Can improve system if know location of all beacon nodes
 - Use position of beacons hear *and* not heard



Discussion
