Toppology Control in Wireless Sensor Networks

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CSC 7701 - Lecture Notes
Overview

What are the tasks to be performed when a sensor network is first activated?

- Infrastructure establishment for collaborative communication
- Communication Issues - neighbor discovery, neighbor selection.
- Power Issues - set radio power for connectivity.
- Clustering
- Timing Issues - nodes must be placed in a common temporal and spatial framework. Why? Reason about events sensed at different locations on different occasions.
Topology Control Problem

- How to set radio range for each node to minimize energy usage while ensuring connectivity and other desirable communication properties.

- Assume *homogenous* topology control settings - ignore multipath, interference effects.

- *Critical Transmitting Range* (CTR) problem: Compute the minimum common transmitting range $r$ such that the network is connected.

- For known node locations,
  1. Compute (distributed) minimum Euclidean spanning tree (MST).
  2. $r$: length of longest edge in MST (Why?)
Probabilistic deployment: If \( n \) points are randomly and uniformly deployed around a unit square:

\[
r = c \sqrt{\frac{\log n}{n}}
\]

for some constant \( c > 0 \).
CTR Problem for Non-homogenous Deployments

- Non-homogenous deployments: variable transmission ranges. Short ranges in high density, long ranges in low density.
- Minimize $\sum_{i=1}^{n} r_i^\alpha$ where $\alpha$ is the power law exponent.
- \(NP\)-Complete in general. 2-approximate solution: Compute MST where $w_{ij} = \delta^\alpha(i, j)$ and $\delta(i, j)$ is Euclidean distance between nodes $i, j$.
- $r_i = \max_{j \in N(i) \subseteq MST} \delta(i, j)$
Clustering

- Clustering allows hierarchical structures to be built on nodes.
- Saves scarce resources such as spectrum, bandwidth and power.
- Simplifies Routing and Broadcasting. Allows frequency reuse across non-interfering clusters.
- *Cluster-heads and Gateways*
Other Problems

- Time Synchronization: Interval Methods and Reference Broadcasts
- Localization - Self-localization via Landmarks, Beacons. Ranging Techniques - Received Signal Strength, Time Difference of Arrival (TDOA).
- Localization Services: A node wants to know the location of a node with a known ID.