Abstract

• Time-varying network topology plays a key role in mobile sensor networks for detection of an event of interest and subsequent awareness propagation within a surveillance framework.
• Feedback control scheme tunes key network topology parameters (e.g., average degree and degree distribution) resulting in a desired network topology.
• The idea is to modify the timelines of the asynchronous belief update protocol depending on the node-level belief/awareness.

Introduction & Motivation

• Wireless sensor networks (WSN) is gaining prominence in the following areas:
  - Process Monitoring
  - Military Reconnaissance
  - Safety Control
  - Resource Operations

• In undersea surveillance, GPS capabilities are limited and long range communications are subject to transmission loss due to the dense fluid medium.
• Optimizing network topology is important in such a situation where proximity networks are implemented.

Topology Control with Message Lifetime Actuation

• The Generalized Gossip Algorithm for Proximity Networks:
  \[ v_q | \tau + 1 = (1 - \theta) \eta | \tau + \theta \chi | \tau \]
  Belief of Next Time Instant \( \eta \) + Current Neighborhood Belief \( \chi \)

• Introducing a proportional constant \( P \) results in an additional degree of freedom and increase flexibility of information network topology:
  \[ L_{\text{in}} = L_{mb} + P(L_{mb}v) \]

• Message lifetimes among nodes are now heterogeneous due to the asynchronous belief update scheme.
• Expected degree (connected nodes) increases linearly with increasing message life.
• Proportional constant \( P \) affects how much the expected degree of the network varies with belief.

Results

Expected degree demonstrates a linear relationship with ensemble expectation of message lifetime controlled via belief feedback:

\[ E_e[k] \approx E[L_m] \left( \alpha \sum g_i \right) \quad \text{for} \quad \alpha E_e[L_m] \ll 1 \]

• Degree distribution exhibits a Poisson distribution according to the following equation:
  \[ P(k|E_e[L_m]) = \left( \frac{N}{k} \right) p^k (1 - p)^{N-k} \approx \frac{(E_e[k])^k}{k!} e^{E_e[k]} ; N \gg 1 \]

• Variation of expected degree with \( P \) and its behavior in response to the presence or removal of the hotspot.

Future Work

• Analyze relationship between proportional constant \( P \) and the rate degree/belief convergence under current framework;
• Analyze evaluation of expected characteristic of interaction matrix \( \Pi \);
• Determine the impact of proportional feedback control policy on the centrality measure of the network.

References