Percolation of Localization in Wireless Sensor Networks (WSNs)

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Plan

- Introduction

- Our focus

- Protocol Implementation

- Scope of our study

- Simulation Model / Assumptions

- Simulation Results

- Observations/Open questions
Introduction
WSNs

- Communicate wirelessly
- Numerous
- Spatially distributed
- Autonomous
- Tiny & cheap nodes
- Power constrained
Need for Localization in WSNs

- Application needs
- Better interpretation of sensed data
- Quality of network coverage
- Geographic Routing
- Target movement Monitoring

Coordinate System

- Relative
- Absolute
Our focus: localization with iterative trilateration

-Coarse Grained Localization

-Fine Grained Localization

\[
\begin{align*}
(x - x_1)^2 + (y - y_1)^2 &= r_1^2 \\
(x - x_2)^2 + (y - y_2)^2 &= r_2^2 \\
(x - x_3)^2 + (y - y_3)^2 &= r_3^2
\end{align*}
\]

\[
\begin{align*}
\begin{aligned}
&\quad r_1 = t_1 \times v \\
&\quad r_2 = t_2 \times v \\
&\quad r_3 = t_3 \times v
\end{aligned}
\]
Protocol Implementation
Basic Lateration

- $t_1$ et $t_4$ measured by node UN
- $t_2$ et $t_3$ measured by node AN
- $t_3-t_2$: response time

$$d = \frac{v \cdot ((t_4 - t_1) - (t_3 - t_2))}{2}$$

Ref: L. de Nardis, M. Gabriella Di Benedetto (Univ. Rome), 2005
Tri-lateration and MAC Implementation

Beacon: sent by ANs

Query: sent by UNs (1st step of two-way ranging)

Response: sent by ANs (2nd step of two-way ranging)

LN transmits beacon msg
Propagation of localization wave
Scope of our study
• Behavior of Location Propagation?

• Convergence Condition?

• Nature of Convergence Speed of this Process?

• Convergence Speed vs. Average Node Degree, Packet Interarrival Time?

• Predict Time for Full Network Localization?
Simulation Model/Assumptions
Packet Arrival: Poisson Process

Ideal Propagation/Unit Disk graph model

Pure CSMA
Simulation Results
Protocol Convergence

Convergence Speed (sec)

Distance from the AN Group (m)

Convergence Speed (sec)

Distance from the AN Group (m)

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Network Degree

The diagram shows the relationship between the average node degree and the percentage of localized nodes. The data points are divided into two categories: 1350 nodes and 2400 nodes. The x-axis represents the average node degree, while the y-axis shows the percentage of localized nodes. The graph illustrates how the percentage of localized nodes changes with the average node degree for each category.
Percolation Time vs. Average Node degree

![Graph showing the relationship between percolation time and average node degree. The graph indicates a peak in percolation time at an average node degree of around 30, with a decrease before increasing again.](image-url)
Packet Interarrival Time
Observations/Open questions

- Relevance to the “Percolation Theory”
- Estimate Convergence Speed?
- Determine Critical Network Degree?
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