Localization with Context-Awareness in Dynamic Wireless Sensor Networks

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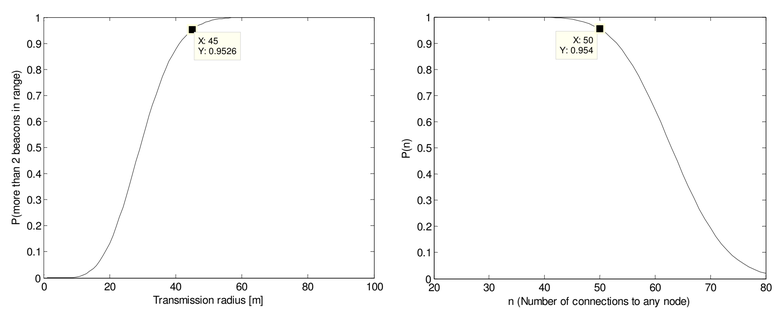
Start

A Wireless Sensor Network (WSN) is typically composed of a number of sensor nodes, which are capable of sensing, signal processing and wireless communication.

Beacons: Nodes with known or estimated location.
Unknowns: Nodes to be localized

Beacon Selection

In later states of a WSN, unknowns with estimated position become new beacons, which provide extra beacons to choose from.

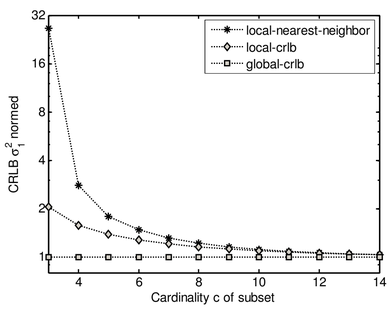


The connectivity of a WSN in a later state of its lifetime. The left figure shows the probability that one node has at least 3 beacons within its transmission range. The right figure shows in the refinement phase, the connectivity between unknowns and both original and new beacons.

Example: Possibility of extra beacons

Localization in 2 phases:

- The massive localization phase:
  - Choose a transmission range that 95% of unknowns have at least 3 beacons in range.
  - Localize most of unknowns with selected subsets of beacons.
- The refinement phase:
  - Nodes with estimated position become new beacons.
  - Localize the residual 5% of unknowns with selected subsets of beacons.



Our distributed beacon selection algorithm (local-crlb) which aims at selecting the best beacons in terms of localization accuracy.

Example: Beacon selection algorithm (local-crlb) with consideration to geometrical context

The Localization Process

Start

A WSN with beacons and unknowns

Context Evaluation

Evaluate context information of network and sensor nodes

Beacon Selection

Select subsets of beacons based on context information

Location Estimation

Estimate the location of unknowns using selected subsets of beacons

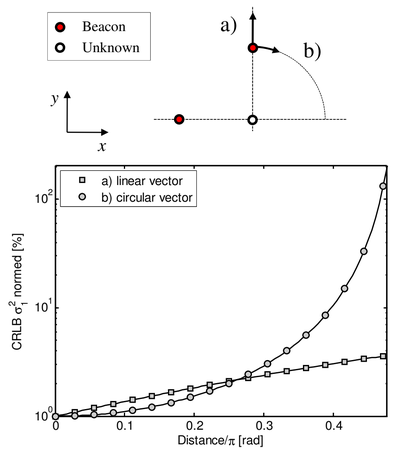
Context Evaluation

Context information in WSNs

- Sensor nodes: power profile, storage and processing capability, mobility, activity rate, etc.
- Network: topology, bandwidth, communication traffic, etc.

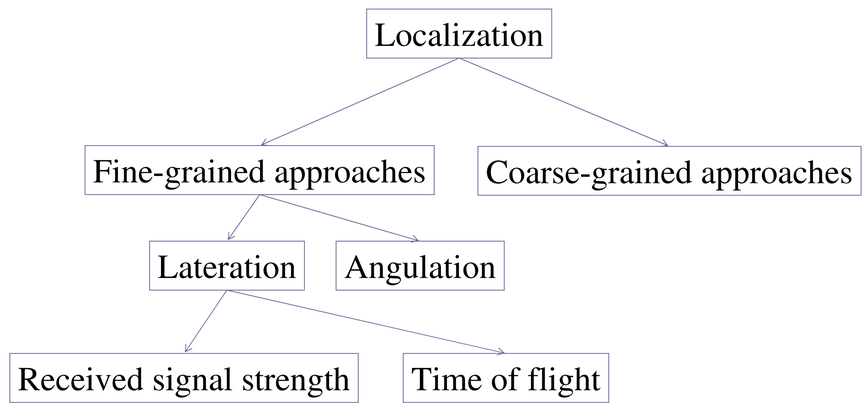
Impact of context Information	Objective
Distance/Angle between beacons and unknowns	Accuracy of localization
Residual energy of beacons	Load balancing / Max. lifetime
Mobility of beacons/unknowns	Optimal interval of refreshing
Etc.	Etc.

The lower accuracy bound on localization with Cramer-Rao-Lower-Bound (CRLB). The figure shows an example of the behavior of CRLB assuming beacon movement along a) a linear vector and b) a circular vector.

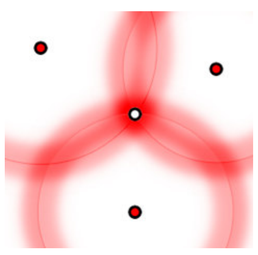


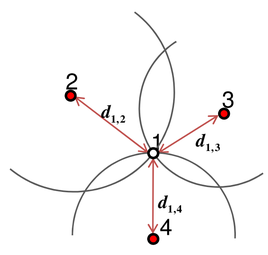
Example: Distance/Angle between beacons and unknowns vs. Accuracy of localization

Location Estimation



Example: Classification of localization techniques





$$(x_1 - x_2)^2 + (y_1 - y_2)^2 = d_{1,2}^2$$
$$(x_1 - x_3)^2 + (y_1 - y_3)^2 = d_{1,3}^2$$
$$\vdots$$
$$(x_1 - x_4)^2 + (y_1 - y_4)^2 = d_{1,4}^2$$

Example: Lateration localization with 3 beacons

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