Localization Procedure

Orchestrating position estimation protocols in randomly deployed WSNs

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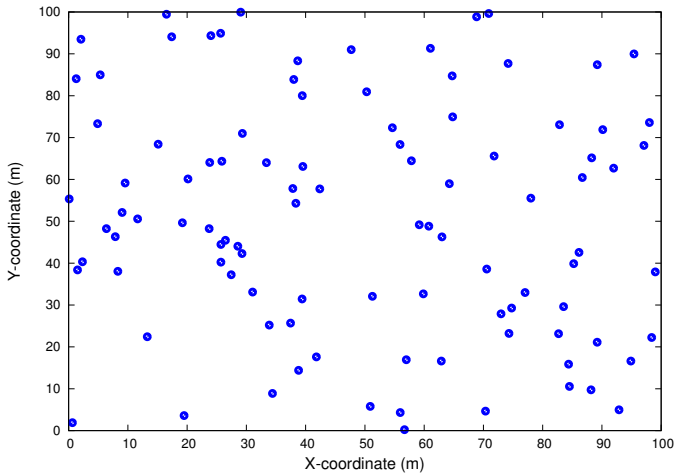
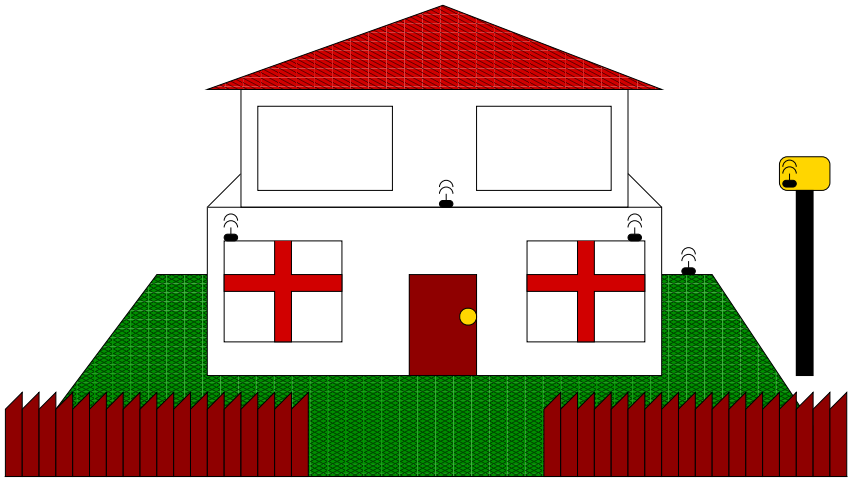
What are Randomly Deployed WSNs?

- Nodes are placed randomly over a field.
- It also encompasses deployments made at convenience (like home surveillance).



(a) Example random deployment of nodes



(b) Example home surveillance deployment

Characteristics

- Nodes determine the best route to the sink.
- Collected metrics are back-traceable to its place of origin.
- In case of a battery run-out, nodes can be easily replaced.

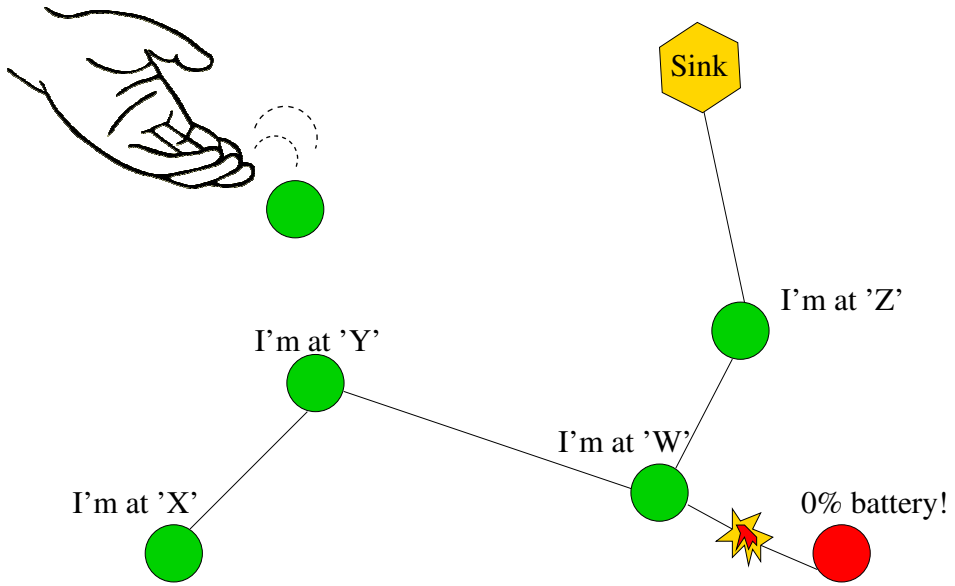


Figure: Replacing nodes

Applications

Because of their ease of deployment, randomly deployed WSNs are often used for:

- Volcano activity monitoring.
  - Very dangerous or difficult places for deployment.
- Forest fire detection.
  - Very big areas.

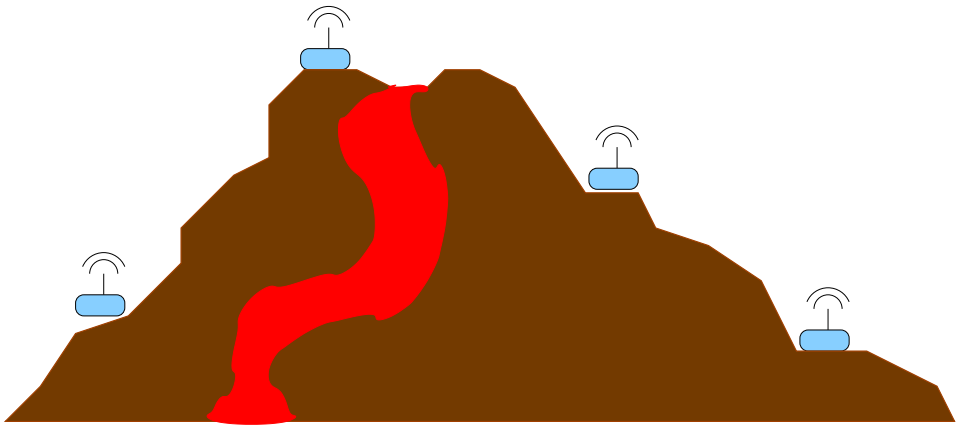


Figure: Volcano monitoring example

Pro's and Con's of random deployments

Pro's:

- Allows rapid deployment.
- Reach very restrictive or dangerous places.
- Allows fast network reinforcement.

Con's:

- Metrics need to be traceable to their origin.
- Relies on location aware nodes (*Anchors*).
- Localization often decreases network lifetime.

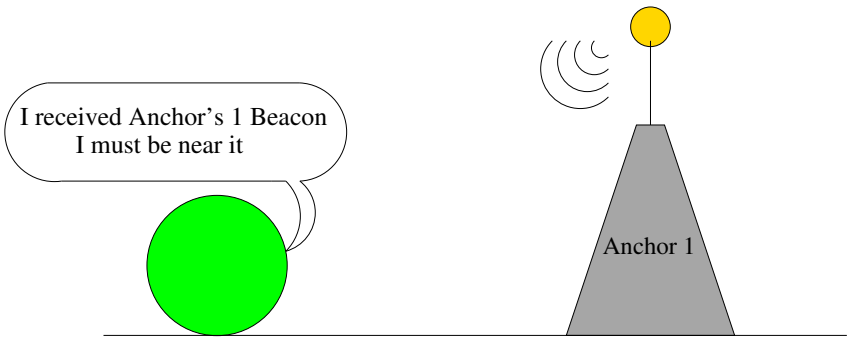
Node Localization

To make metrics traceable:

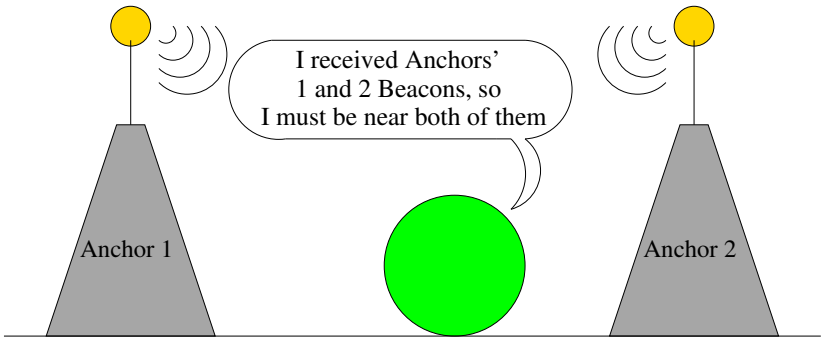
1. All nodes are equipped with GPS modules.
   - 1.1 Decreasing network lifetime due to the modules ↓.
   - 1.2 Increasing the size and weight of the nodes ↓.
   - 1.3 Augmenting the required budget ↓.
   - 1.4 Very low estimation error ↑.
2. Some nodes use GPS modules
   - 2.1 Nodes derive a position estimation from Anchors: increased estimation error ↓.
   - 2.2 Additional workload is added to the nodes (estimation) ↓.
   - 2.3 Added network traffic (*Beacons*) containing location information ↓.
   - 2.4 Cheaper and scalable approach ↑.

Measuring Distances

- Any *Unknown* node (unaware of its position) may derive an estimation from Beacons.
- Beacons are packets containing the position of the sender (usually an Anchor).



(a) Estimating a position with 1 Beacon

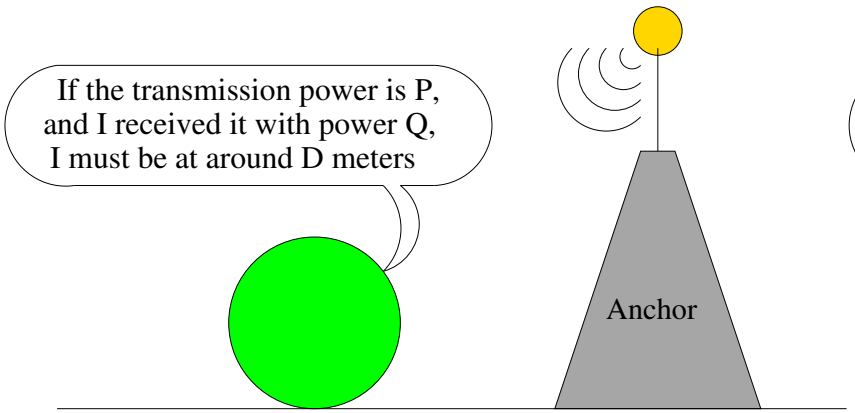


(b) Estimating a position with 2 Beacons

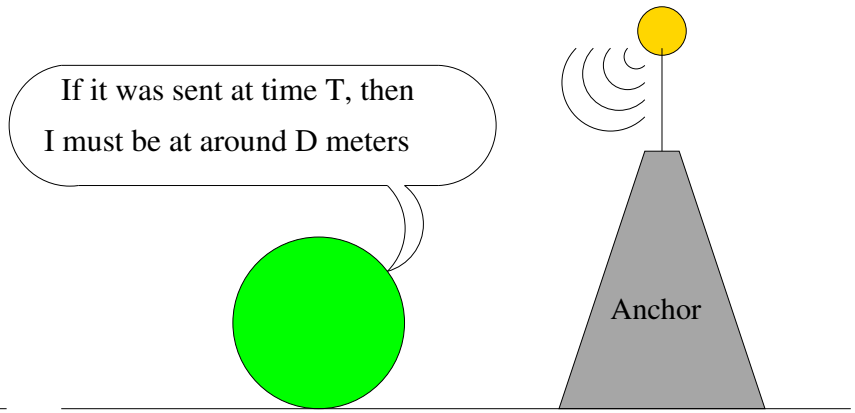
- Applications may tolerate different levels estimation errors.

Making Range Estimations

- Make use of the electromagnetic characteristics of the Beacon transmissions to derive a straight line estimation to the transmitter.



(c) RSSI position estimation



(d) Time of Arrival (ToA)

Localization Protocols

Range-free

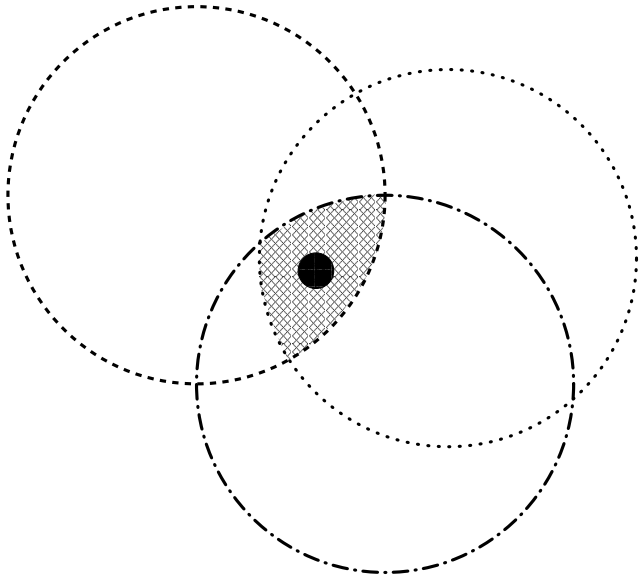


Figure: Bounding-Box example

Range-based

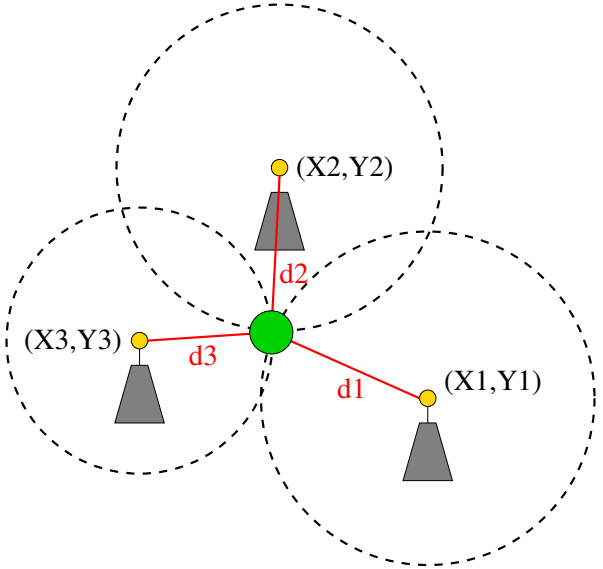


Figure: Lateration example

Range-free and Range-based

Range-free protocols:

- Only consider the effective connection with surrounding Anchors.
- Usually consume less battery.
- Error is subject to the number of connections to different Anchors.

Range-based protocols:

- Use ranging techniques to restrict the underlying optimization problem.
- Increased battery consumption, usually subjected to the ranging technique used.
- The error is usually reduced due to the availability of more data.