Localization using DOT3 Wireless Sensors


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A DOT3 mote with its radio chip (CC1000) in the middle

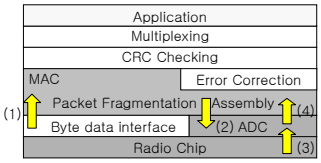
Motivation

- Wireless sensors can be used for locating objects:
  - Previous works used GPS, ultrasound, magnetic field or radio signal strength.
  - Cricket: calculates speed difference of radio and ultrasonic wave.
  - RADAR: compares the vector of signal strength with pre-measured data
- We use DOT3 wireless sensors for localization.
  - DOT3 is the new sensor platform with ChipCon radio with good range (1000 ft outdoors).
  - Besides data communication, ChipCon radio supports the strength of the received signal (RSSI) but its application is not yet explored.
  - Using signal strength have an advantage of not requiring additional hardware.
  - Our goal is to locate objects using DOT3 sensors in coarse granularity (rooms or cubibles).

Design & Implementation

Reading signal strength

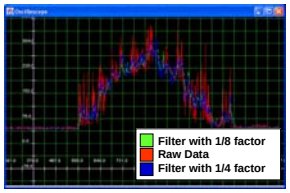
- ChipCon radio generates RSSI and this can be read by ADC.
- We modified the network stack of DOT3 to make the signal strength information available for each packet.



(1) Detects the end of preamble
(2) Posts sampling ADC
(3) Samples radio signal strength
(4) Notifies the arrival of packet with signal strength by filling strength field

Modification to network stack

- Received signal strength values are filtered to give stable output.
  - Estimate = (1- α) * Estimate + α * sampled
  - α = 1/8 works reasonably well and can be efficiently implemented with bit shifting.



Filtering raw signal strength

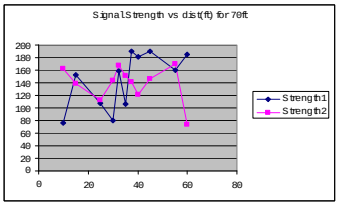
Localization methods

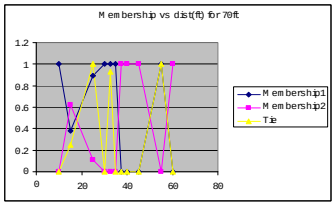
Network nodes advertise their existence by beaconing messages. Then, application nodes hear the signal strength from them.

- Strongest Beacon
  - The application node maintains the table of (net node, strength)
  - Reports the one with strongest signal as closest node
- Using neighboring nodes.
  - The application node A1 overhears the membership report of other application nodes and keeps the table of strength of these application nodes and their membership.
  - In case of tie, A1 follows the membership of the closest application node.

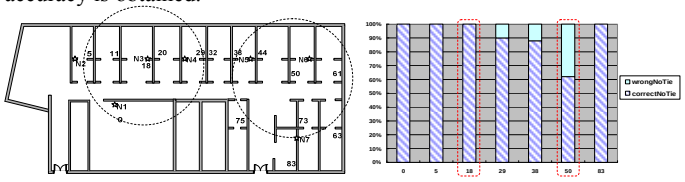
Evaluation

- In open space test, we observed severe interference, and signal strength is not strongly correlated to distance.

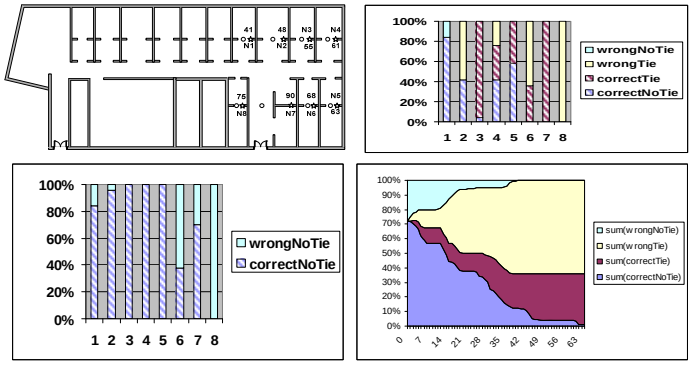




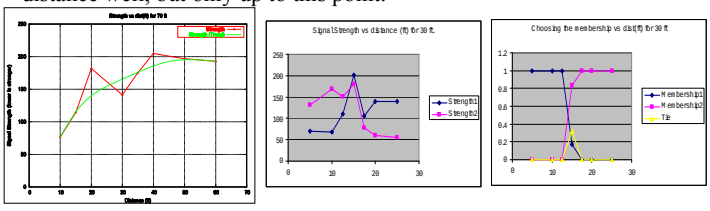
- In real office room, screens help. Especially in sparse case, good accuracy is obtained.



- In dense case, accuracy gets worse. Tie breaker decreases accuracy. If one node can't determine membership, nearby nodes are also likely to suffer, giving no help in tie break



- Signal strength shows knee. Steep slope up to this point differentiates distance well, but only up to this point.



- In office environment, geographical shape has more influence than physical distance, and sometimes it is different from physical floor plan.

Conclusion

- Signal strength of ChipCon radio doesn't indicate location accurately.
- However, it can be effective when network nodes are separated more than the knee of signal strength/distance graph and application nodes are within the knee from any of network nodes.