RADAR: An In-Building RF-based User Location and Tracking System

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Outline

- Motivation
- Basic approach: NNSS algorithm
- Generating a radio map
  - empirical method
  - mathematical modeling
- Performance
- Summary and ongoing work

Motivation

- Prerequisite to location-aware services
- Outdoors solution (GPS) fails indoors
- Traditional solution: dedicated technology
  - short-range, line-of-sight infrared
  - ultrasonic pulses
- Our goal: leverage *existing* infrastructure
  - off-the-shelf RF wireless LAN
  - more scalable and cost-effective

RADAR

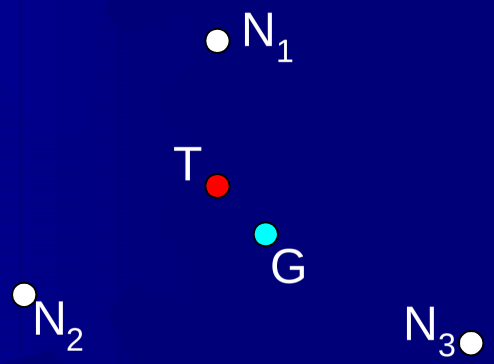
- Key idea: signal strength matching
- Inputs:
  - radio map
  - building layout
- Offline calibration:
  - tabulate <location,SS> information
- Real-time location & tracking:
  - find best match to measured SS in table

Constructing a Radio Map

- Empirical method
  - base stations emit beacons periodically
  - measure SS tuple at various locations
  - record SS along with corresponding coordinates
    - user orientation needs to be included, too!
  - accurate but laborious
- Mathematical method
  - compute SS using a simple propagation model
    - factor in free space loss and wall attenuation
    - Cohen-Sutherland line clipping algorithm
  - more convenient but less accurate

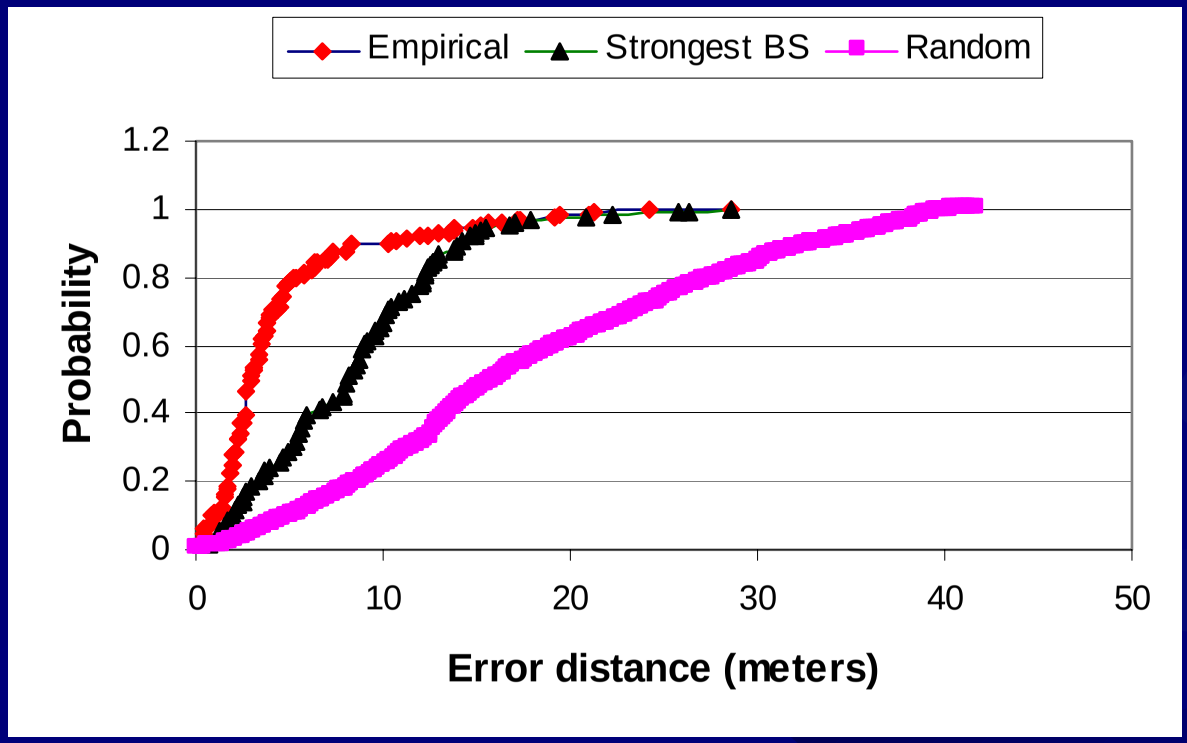
Determining Location

- Find nearest neighbor in signal space(NNSS)
  - default metric is Euclidean distance
- Phys. coordinates of NNSS ⇒ user location
- Refinement: *k*-NNSS
  - average the coordinates of *k* nearest neighbors



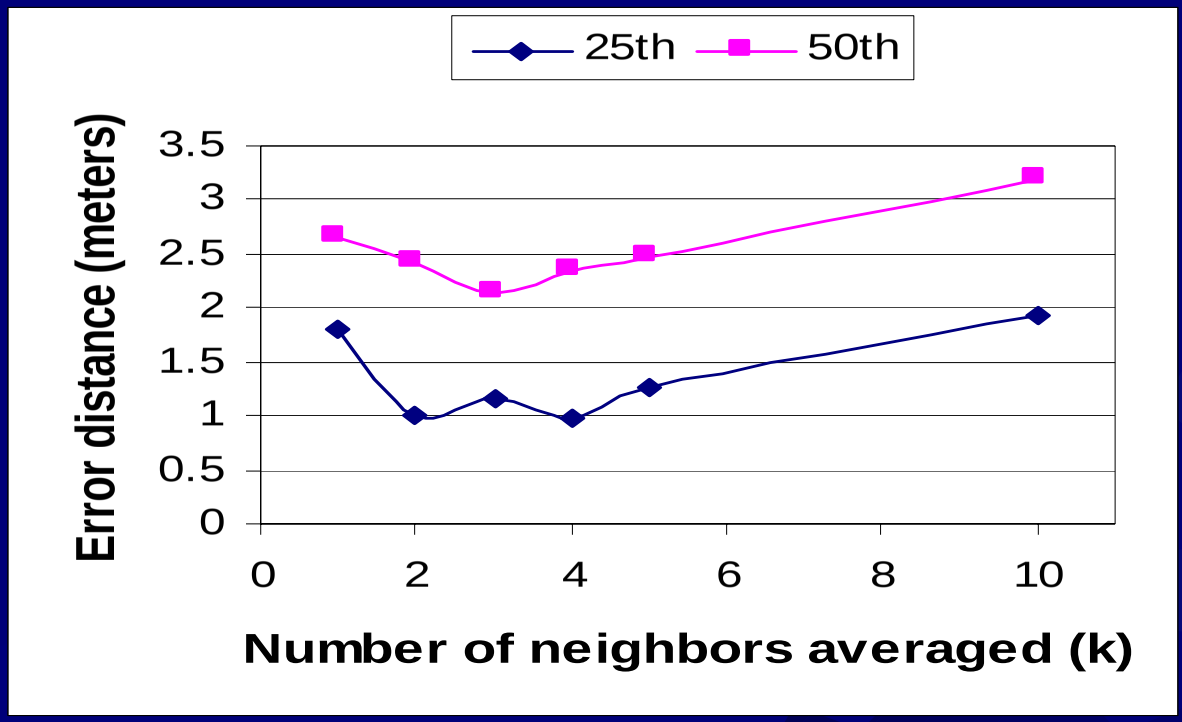
N_1, N_2, N_3: neighbors
T: true location of user
G: guess based on averaging

Baseline Performance



Median error distance is 2.94 meters

Performance with Refinements



Median error distance is 2.13 meters for $k = 3$

Summary

- User location via signal strength matching
- Construction of radio map via empirical measurements or mathematical modeling
- Median error of 2-3 meters
- Leverages existing WLAN infrastructure

Infocom 2000 paper:

http://www.research.microsoft.com/sn/

Ongoing Research

- Probabilistic modeling of user motion
  - constraints imposed by building layout
- Environmental profiling
- Multiple floors

In collaboration with Anand Balachandran (intern from UC San Diego)