A Geometric Stack for Location-Aware Networking

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Location as a First Class Citizen

The objective of this project is to design protocols and network services that embed location information into the future Internet architecture. As the Internet begins to encompass a larger, pervasive, and more mobile set of devices, including our cars, portable phones, and sensing nodes, an awareness of geolocation is of increasing importance for applications but also for network management.

Approach

- Design new cross-layer protocols that exploit location information to improve wired/wireless communications
- Create a scalable Internet location service that has low deployment complexity
- Integrate privacy enhancing technologies to regulate flow of sensitive location information within the network
- Inform standards (e.g., IETF Geopriv) development

Addressing the goals of the FIND program

Information about the position of people and devices will be critical for future Internet application and services.

Localization – A solved problem?

- Don't we already know how to do this? Many localization systems already exist
- Yes, they can localize, but...
  - Missing the big picture
  - Not general

Analogy: Electronic communication

1960's Leased lines (problem solved!)
1970's Packet switching
1980's Internetworking
1990's The Internet
Universal, general purpose communication:
Communication between any 2 devices on the planet

- Universal, general purpose localization still open

Localization Vision

- Real time physical location of everything

Universal

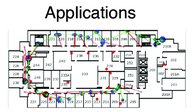
- Works with any wireless device with little/no modification
- Supports vast range of performance
  > city, campus, building, room, shelf
- Localize in any environment the device could be in
  > outside, inside, under the bed

General Purpose

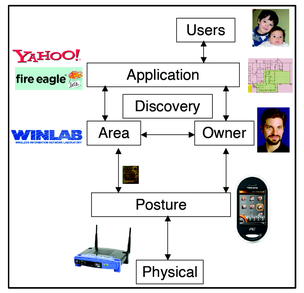
- Resulting position information can be used for a wide variety of apps
- Returns positions to the entity of concern

Future Challenges

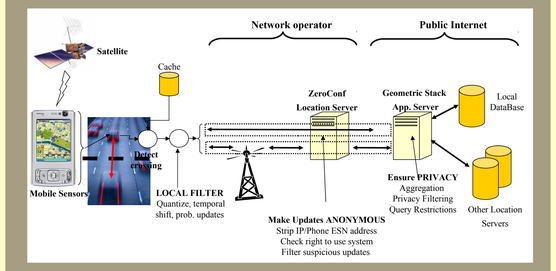
- What are the broader roles?
  - *Who needs to be involved to realize universal localization?*
- Location stacks
  - *What are the standards for communication between the roles?*



- Increasing accuracy to 1 meter
  - *Add to the communication stack's physical layer?*
    - *Finer clocks, reflectors, angular measurements*
  - *Additional infrastructure to communication layers?*
- Defining contracts between the roles
  - *Who owns the information, how do they control it?*
  - *Can we build systems to match?*

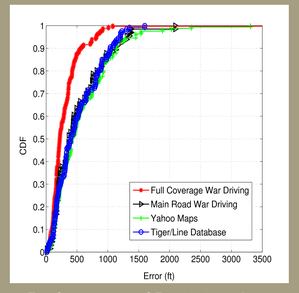


Privacy-Aware, Zero-Conf Location Service



Example application using ZeroConf Location Service

- Location service provides tracking of moving objects and position of network infrastructure elements to support both location-aware protocols and applications
- Location service contains data cleansing modules to render data anonymous when applications (e.g., automotive traffic congestion monitoring) access aggregate traces

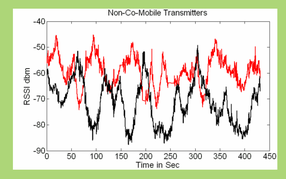


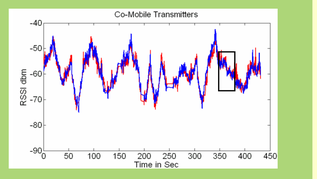
Performance of Bootstrapping ZeroConf LS with Postal Addresses

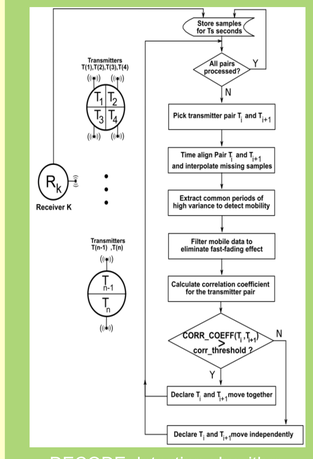
- Location service database can be bootstrapped through geocoded postal addresses (provides similar accuracy as wardriving) of some infrastructure elements and will be continually updated and refined at run-time

Detecting Co-Moving Wireless Devices

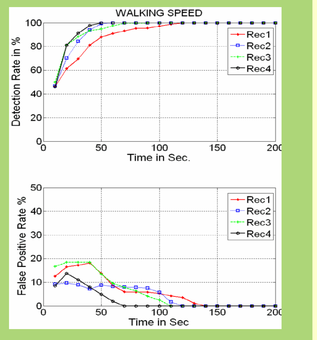
- Detection of multiple transmitters held by the same person and multiple radios attached to the same device
- Localize and estimate method does not work well as position estimates are not stable.
- Processing of raw RSSI traces reveal correlated fades
- Simple Correlation Coefficient Metric used







DECODE detection algorithm



Selected Publications

- G. Chandrasekaran, M. A. Ergin, R. P. Martin, M. Gruteser, J. Yang, and Y. Chen. DECODE: Detecting Co-Moving Wireless Devices. Proc. of IEEE MASS 2008, (Accepted for Publication), Sept. 2008.
- G. Chandrasekaran, M. A. Ergin, M. Gruteser, and R. P. Martin. Bootstrapping a Location Service Through Geocoded Postal Addresses. Proc. of LoCA 2007, vol. 4718, pp 1-16, Sept. 2007.

National Science Foundation
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NSF NeTS FIND Initiative

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WIRELESS INFORMATION NETWORK LABORATORY