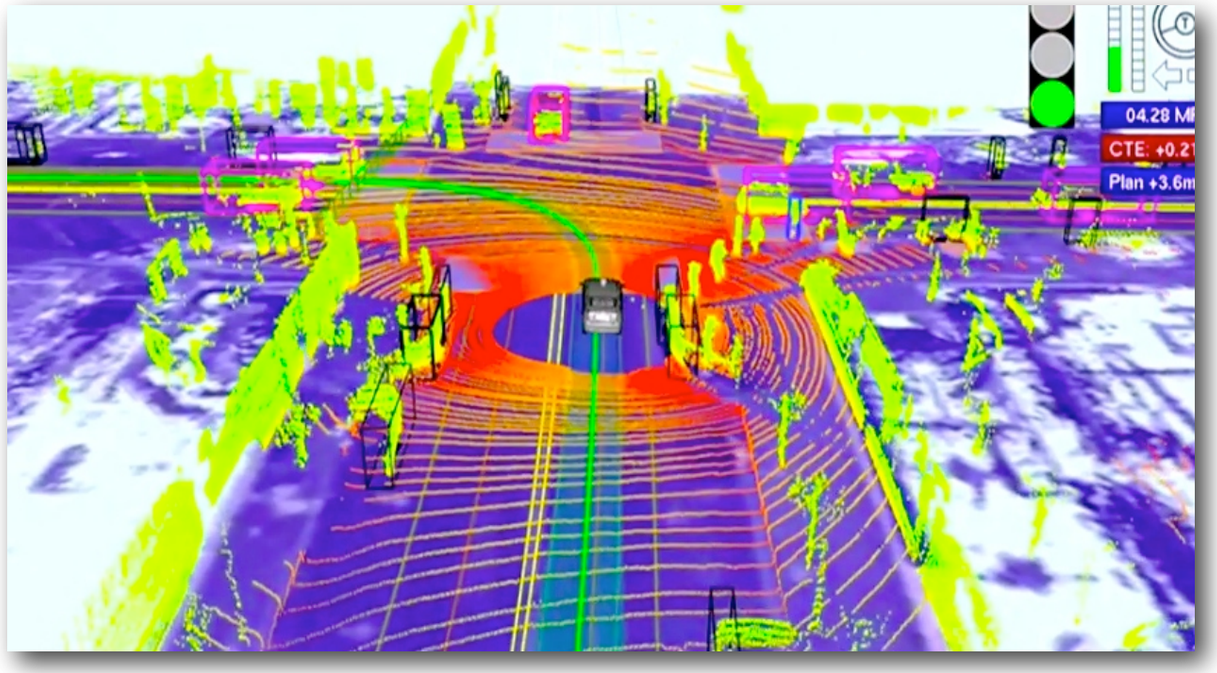
Localization beyond Satellite Systems

Mobile and Ubiquitous Games

ICS 163

Donald J. Patterson

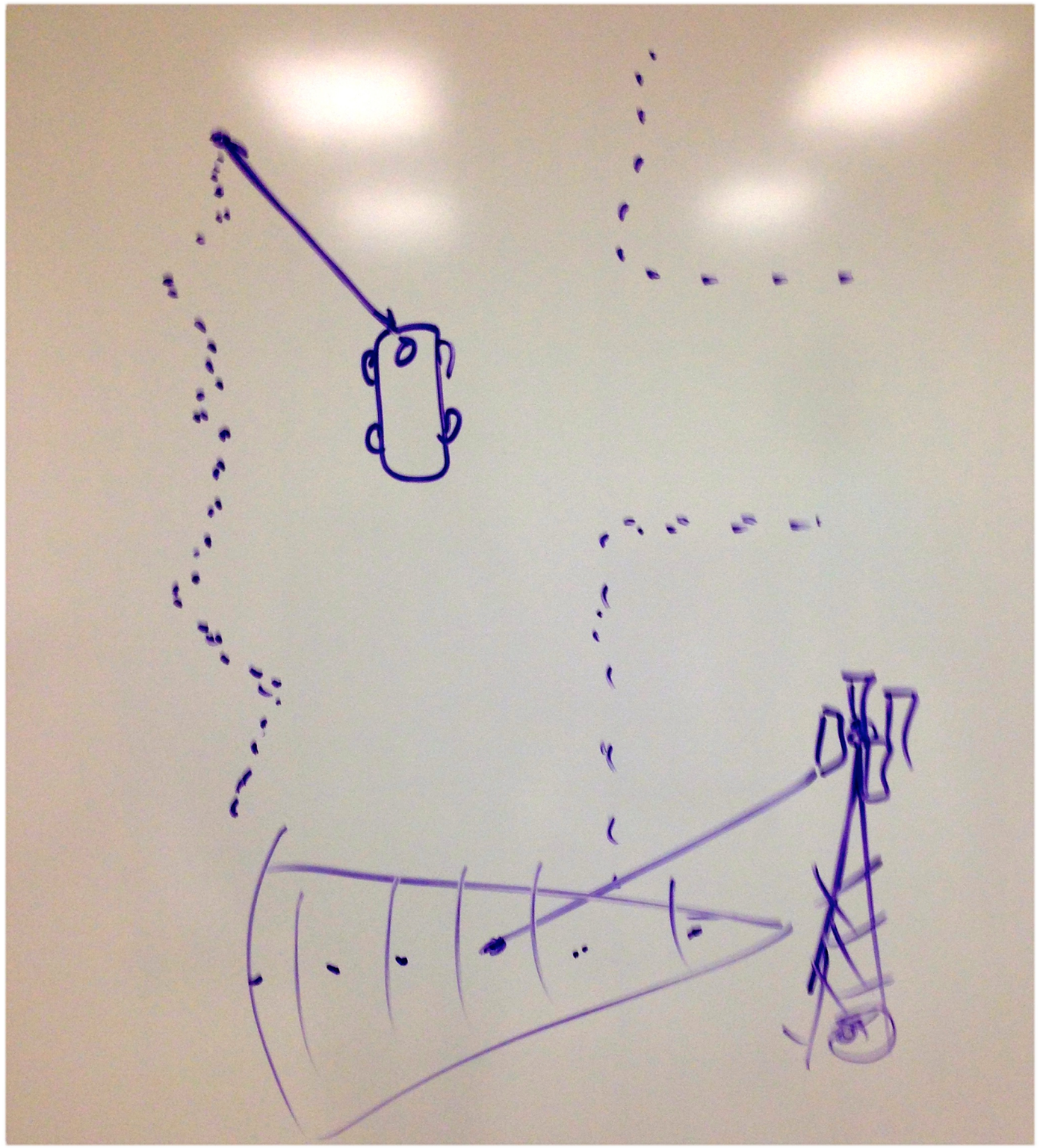
Google's self-driving car



Two things seem particularly interesting about Google's approach. First, it relies on very detailed maps of the roads and terrain, something that Urmson said is essential to determine accurately where the car is. Using GPS-based techniques alone, he said, the location could be off by several meters.

http://spectrum.ieee.org/automaton/robotics/artificial-intelligence/how-google-self-driving-car-works

Google's self-driving car



http://spectrum.ieee.org/automaton/robotics/artificial-intelligence/how-google-self-driving-car-works

Global Location GPS

A Survey and Taxonomy of Location Systems for Ubiquitous Computing

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Abstract

Emerging mobile computing applications often need to know where things are physically located. To meet this need, many different location systems and technologies have been developed. In this paper we present a the basic techniques used for location-sensing, describe a taxonomy of location system properties, present a survey of research and commercial location systems that define the field, show how the taxonomy can be used to evaluate location-sensing systems, and offer suggestions for future research. It is our hope that this paper is a useful reference for researchers and location-aware application builders alike for understanding and evaluating the many options in this domain.

1 Introduction

To serve us well, emerging mobile computing applications will need to know the physical location of things so that they can record them and report them to us: Are we almost to the campsite? What lab bench was I standing by when I prepared these tissue samples? How should our search-and-rescue team move to quickly locate all the avalanche victims? Can I automatically display this stock devaluation chart on the large screen I am standing next to? Where is the nearest cardiac defibrillation unit?

Researchers are working to meet these and similar needs by developing systems and technologies that automatically locate people, equipment, and other

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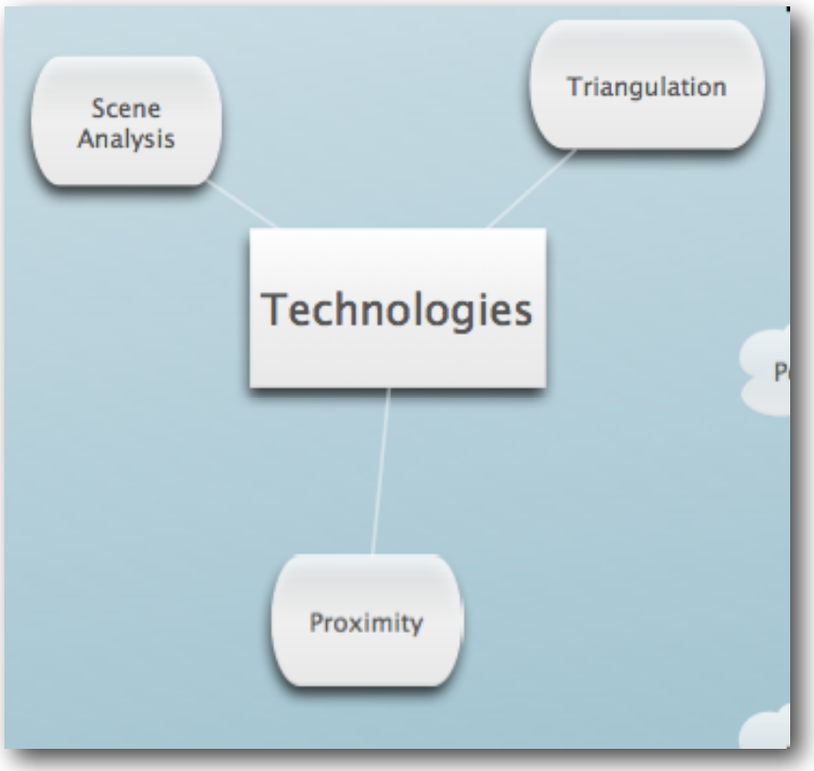
Properties of Location Systems

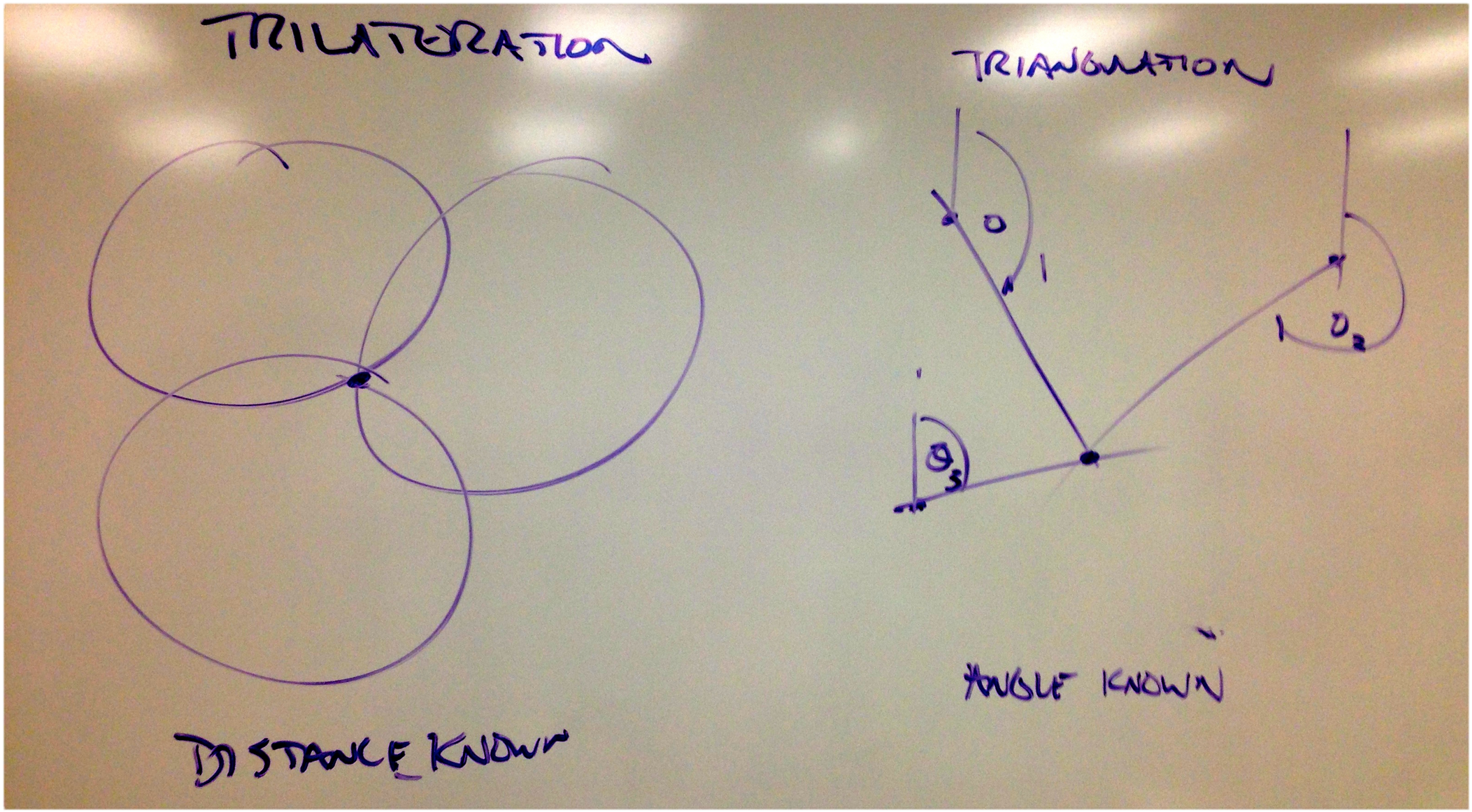
- Technologies
  - Scene Analysis
  - Triangulation
  - Proximity
- Physical Position
  - Position
  - Representation
    - Place
  - Relativity
    - Relative
    - Absolute
- Limitations
  - Indoor/ Outdoor
  - Equipment needs
  - Battery Power
- Cost
  - Infrastructure
  - Incremental Users/ Improvements
  - Deployment
  - Maintenance
- Accuracy
- Scale
  - Regional
  - Global
  - Local
- Recognition
  - GUID
- Computation
  - Assisted
    - Cell-phone
  - Infrastructure
    - Broadcast ID
  - Local
    - GPS

Properties of Location Systems

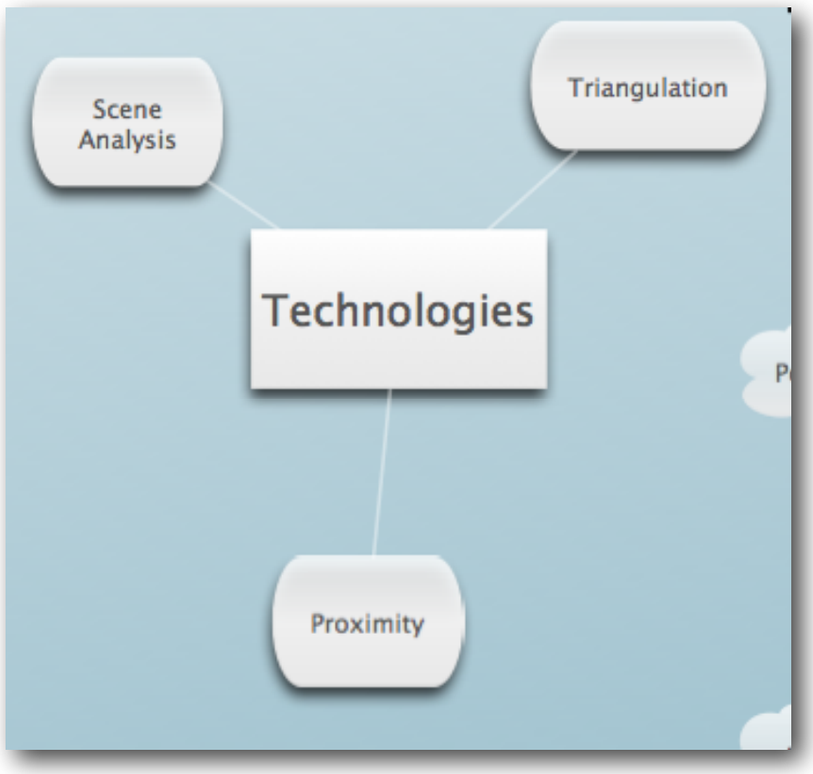


- Technologies
  - Triangulation
    - Multiple references to fixed locations which resolve position using angles
  - Trilateration
    - GPS is an example
    - multiple references to fixed locations which resolve position using circles

Properties of Location Systems

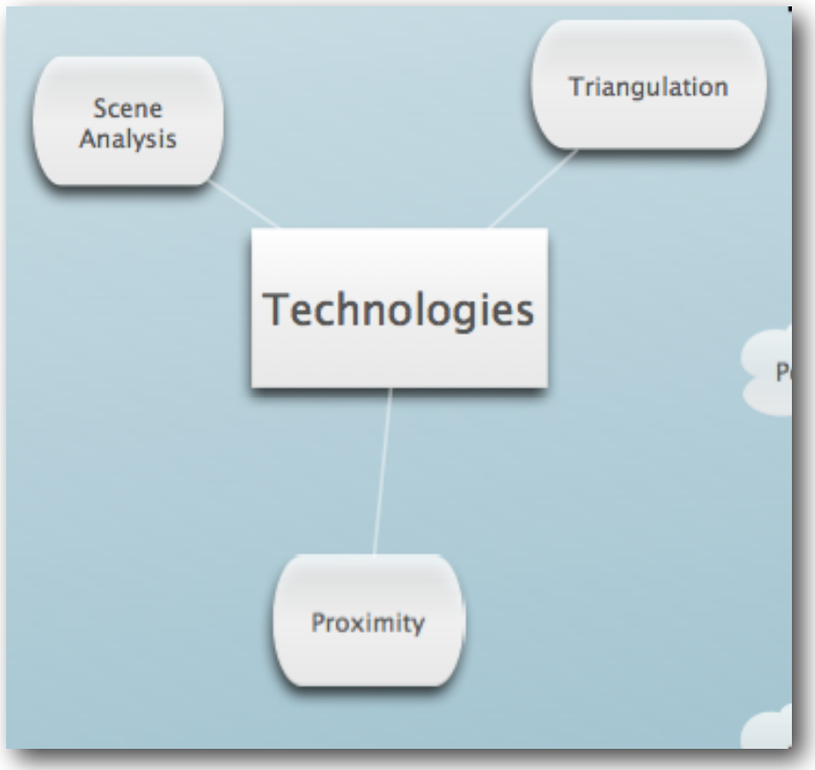


Properties of Location Systems



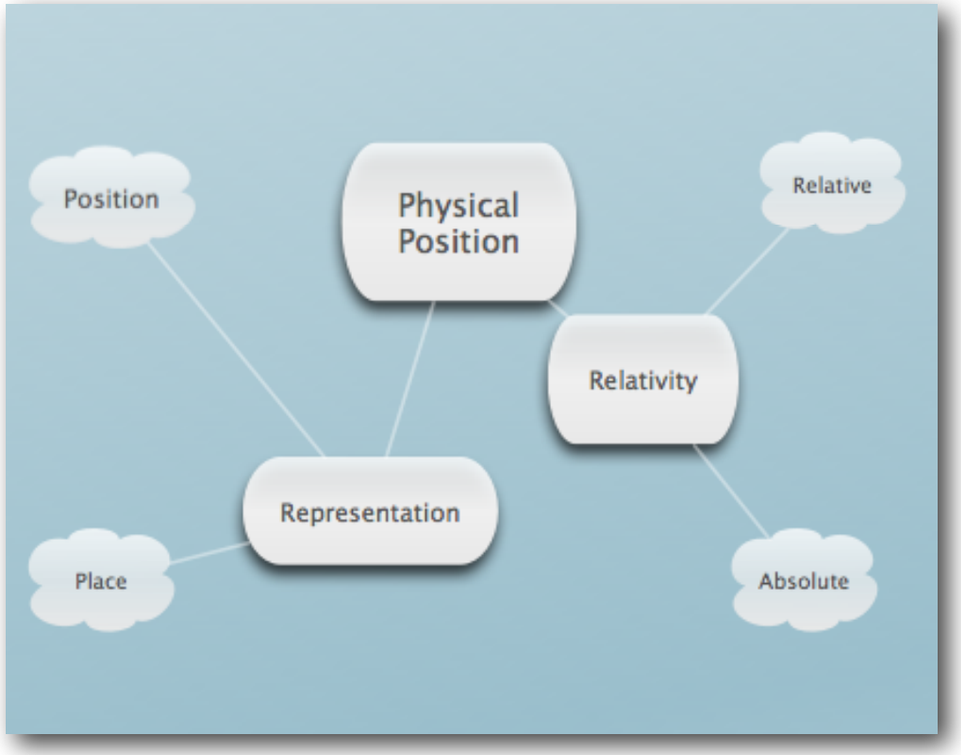
- Technologies
  - Proximity
    - Knowing that you are near a fixed location
  - Typically based on non-localization technology
  - Cell-towers, Credit card usage, login information

Properties of Location Systems



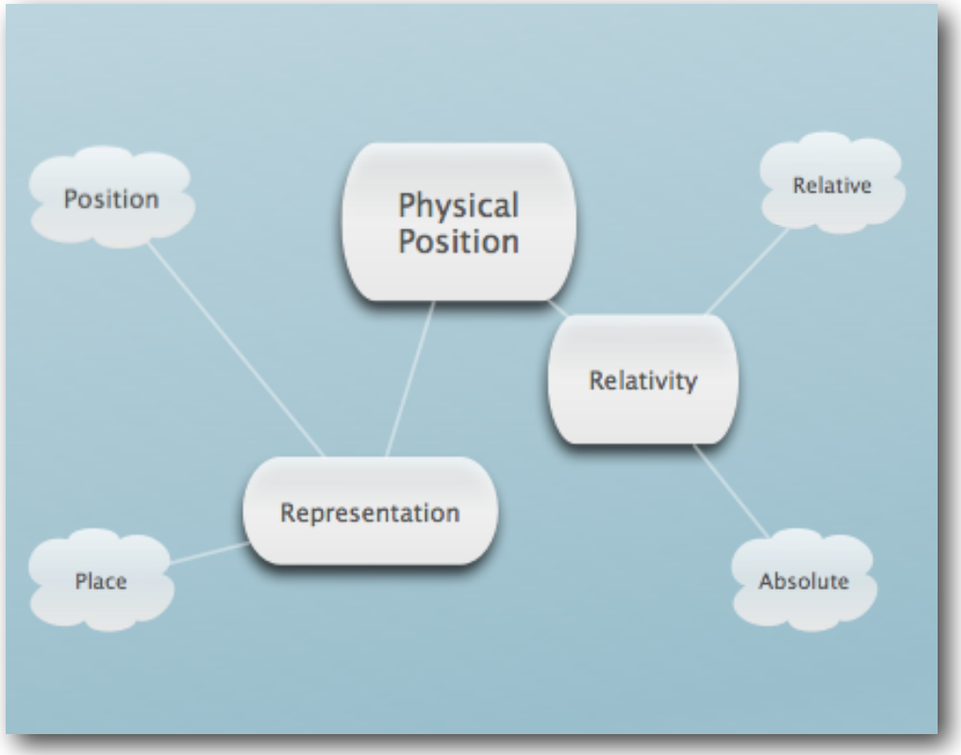
- Technologies
  - Scene Analysis
    - Evaluating content from a fixed camera
      - Color histograms from doorways
    - Evaluating content from a mobile camera
      - tour guide scene matching

Properties of Location Systems



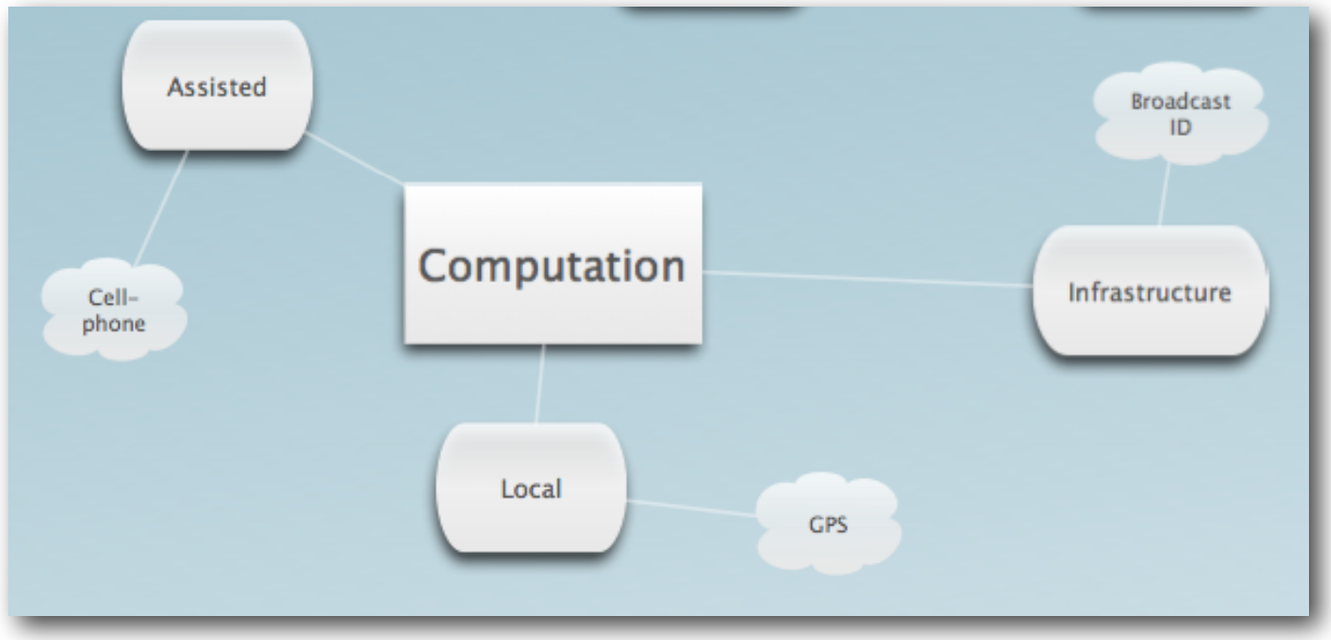
- Properties
  - Physical Position/Symbolic location
    - Position
      - Exact, Unambiguous, Machine friendly
  - Place
    - Inexact, Ambiguous, Human Friendly

Properties of Location Systems



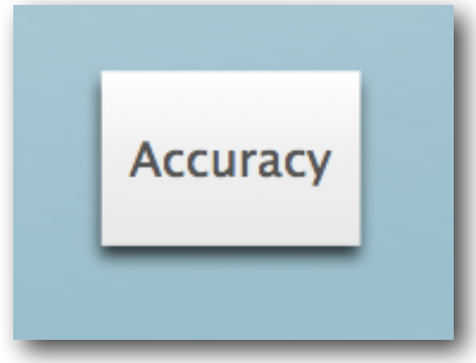
- Properties
  - Absolute/Relative
    - GPS is absolute
    - Laser range finder is relative
  - Transforming between the two is possible with additional information

Properties of Location Systems



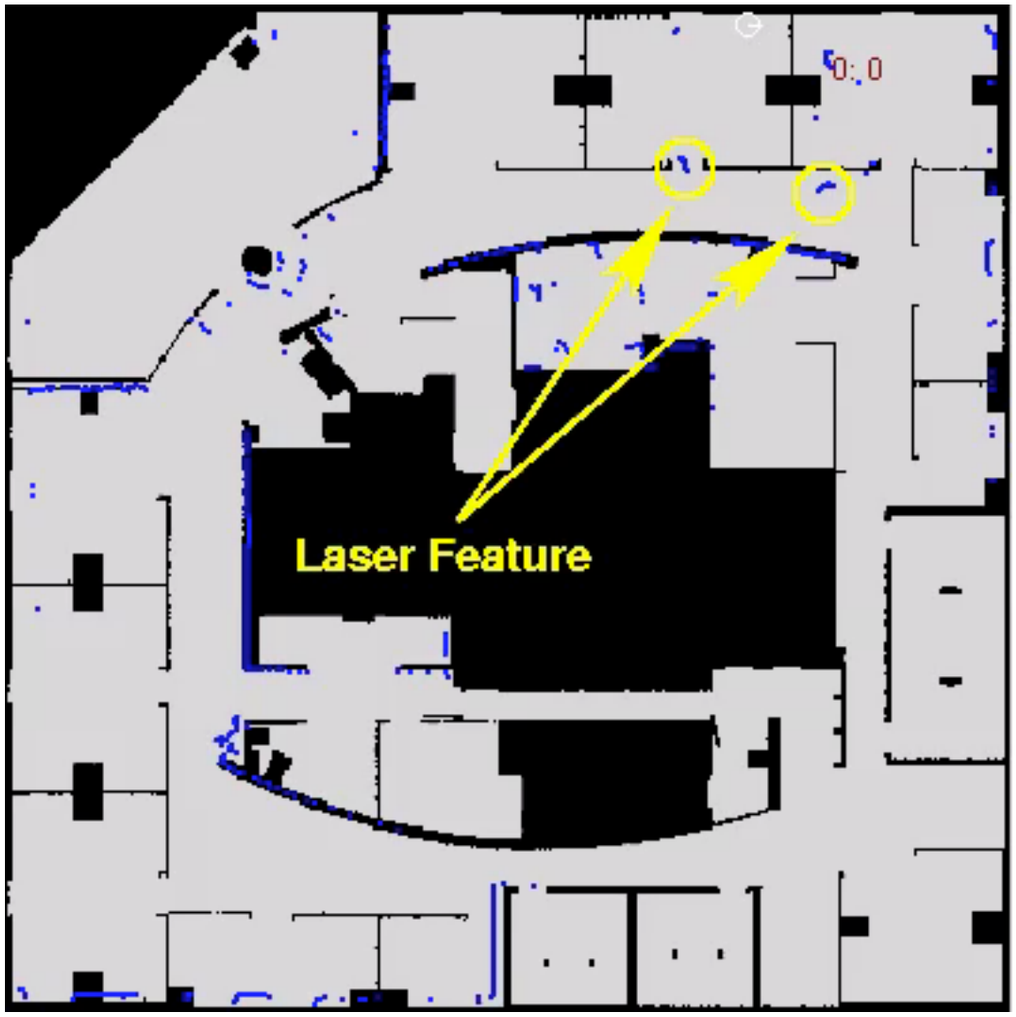
- Properties
  - Where is the computation done?
    - GPS locally - private, scalable
    - Cell-phone positioning - assisted, scalable to a degree, location is revealed
    - Broadcast ID-badge systems - localization is in infrastructure

Properties of Location Systems



- Properties
  - Accuracy and precision
    - GPS 15m - 95% of the time
    - Sensor fusion tries to improve accuracy and/or precision by combining sensors
  - Accuracy and precision may change to conserve battery life.

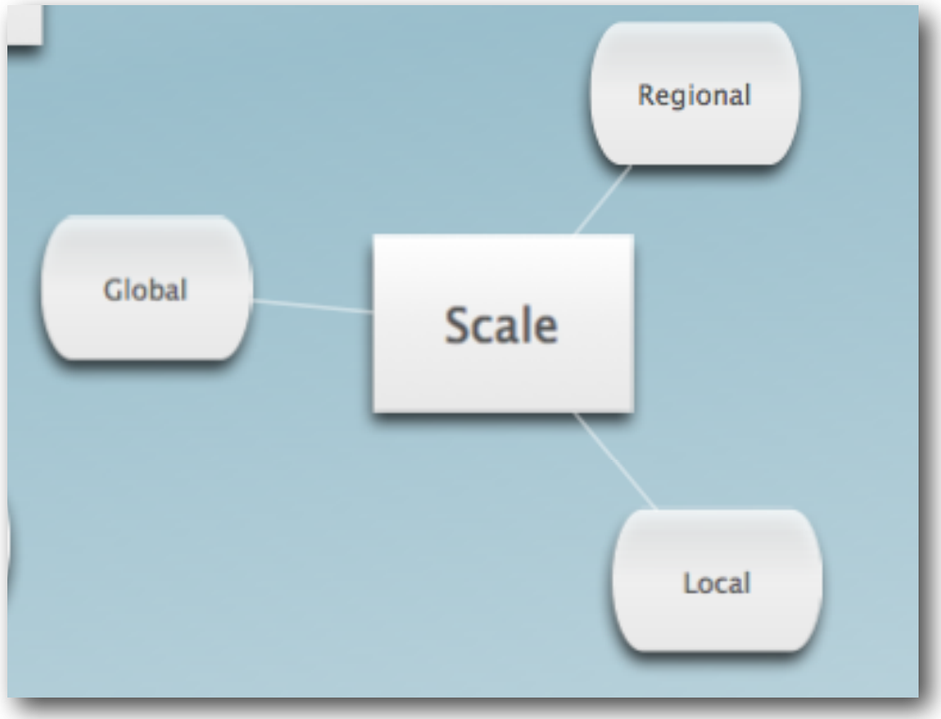
Properties of Location Systems



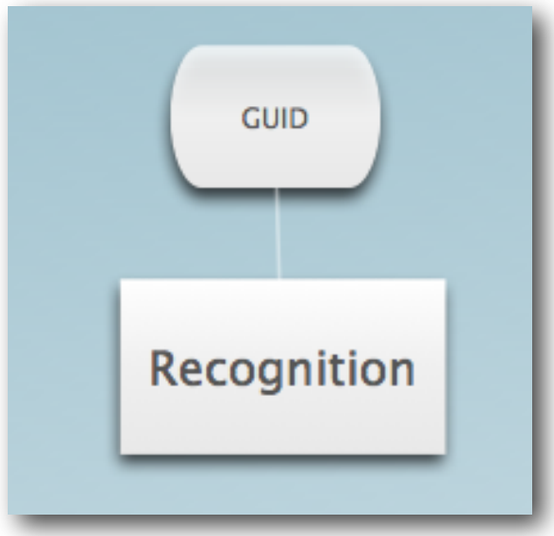
Properties of Location Systems

Properties of Location Systems

- Properties
  - Scale
    - Global, Regional, Local
      - GPS - Global
      - RFID Readers -local
      - Cell-phone localization regional



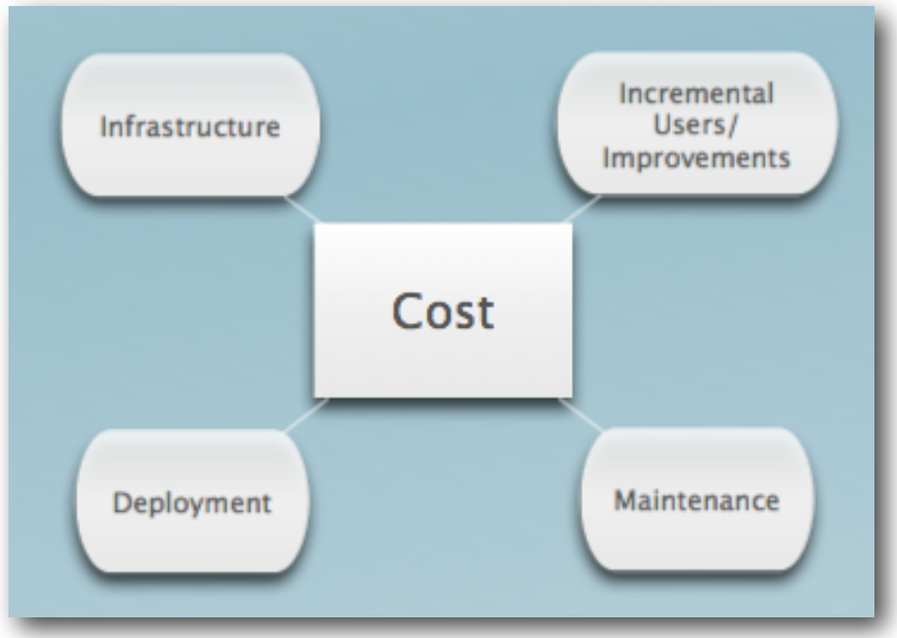
Properties of Location Systems



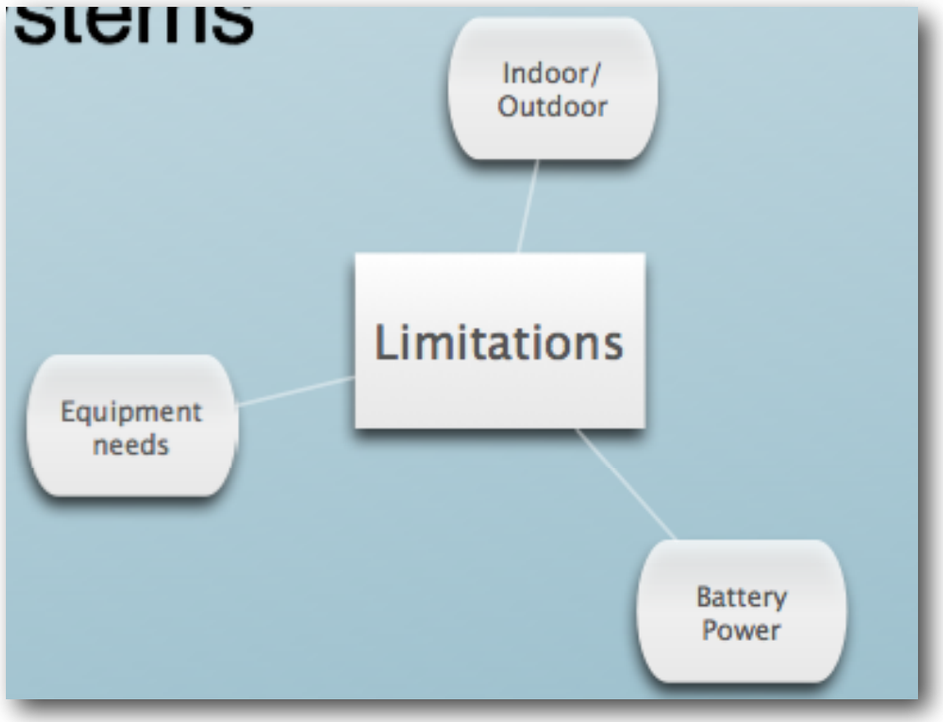
- Properties
  - Recognition
    - GUID - globally unique identifier
      - Do we know who or what you are?
      - GPS - no
      - Sensor fusion - maybe

Properties of Location Systems

- Properties
  - Cost
    - Deployment
    - Infrastructure
    - Maintenance
    - Incremental Users or Improvements



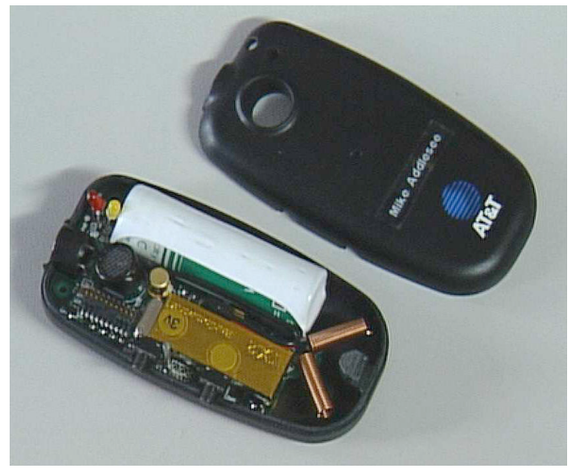
Properties of Location Systems



- Properties
  - Limitations
    - Indoor/ Outdoor
    - Battery Power
    - New Equipment

Examples

- Active Badge
  - GUID broadcast by infrared
  - symbolic proximity
  - absolute positioning
  - sunlight/fluorescent lighting



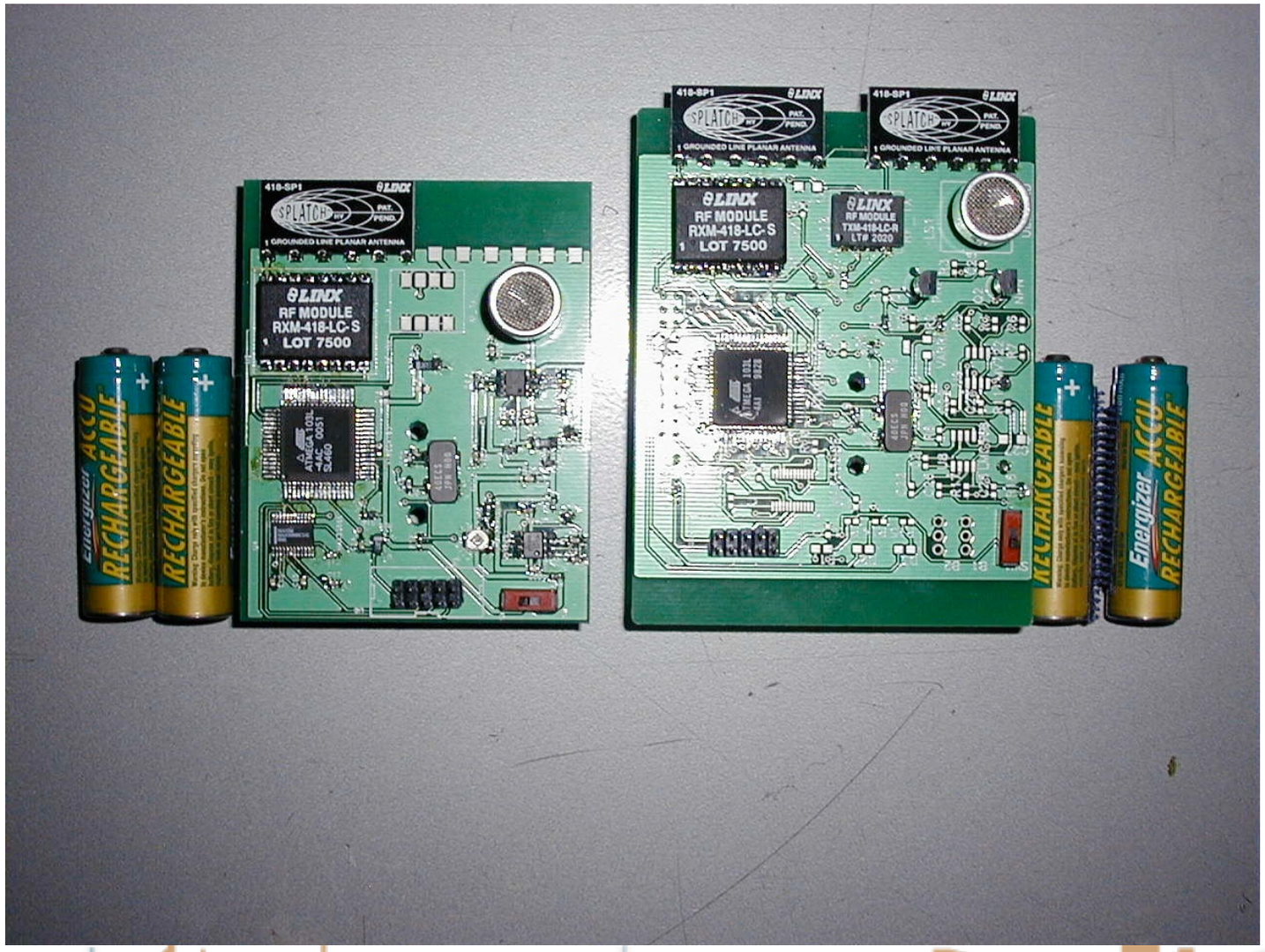
Examples

- Active Bat
  - GUID ultrasonic broadcast by radio request
  - infrastructure computes absolute proximity
  - 9cm 95% of the time
  - bad scalability, hard to deploy, maybe costly

Examples

- Cricket
  - Object based ultrasonic localization
  - radio frequency control signal
  - trilateration base on time-of-flight
  - private, decentralized scalability
  - local computation -> power drain

Examples


LINX
RF MODULE
RXM-418-LC-S
LOT 7500
SPLATCH
1 GROUNDED LINE PLANAR ANTENNA
Energizer
RECHARGEABLE

Examples

- RADAR
  - building-wide tracking system
  - 2-D Wifi based localization
  - “scene analysis” through fingerprinting
  - local computation -> power drain

Properties of Location Systems

Examples

- Smart Floor
  - local tracking
  - anonymous
  - no additional equipment for a person
  - poor scalability
  - costly

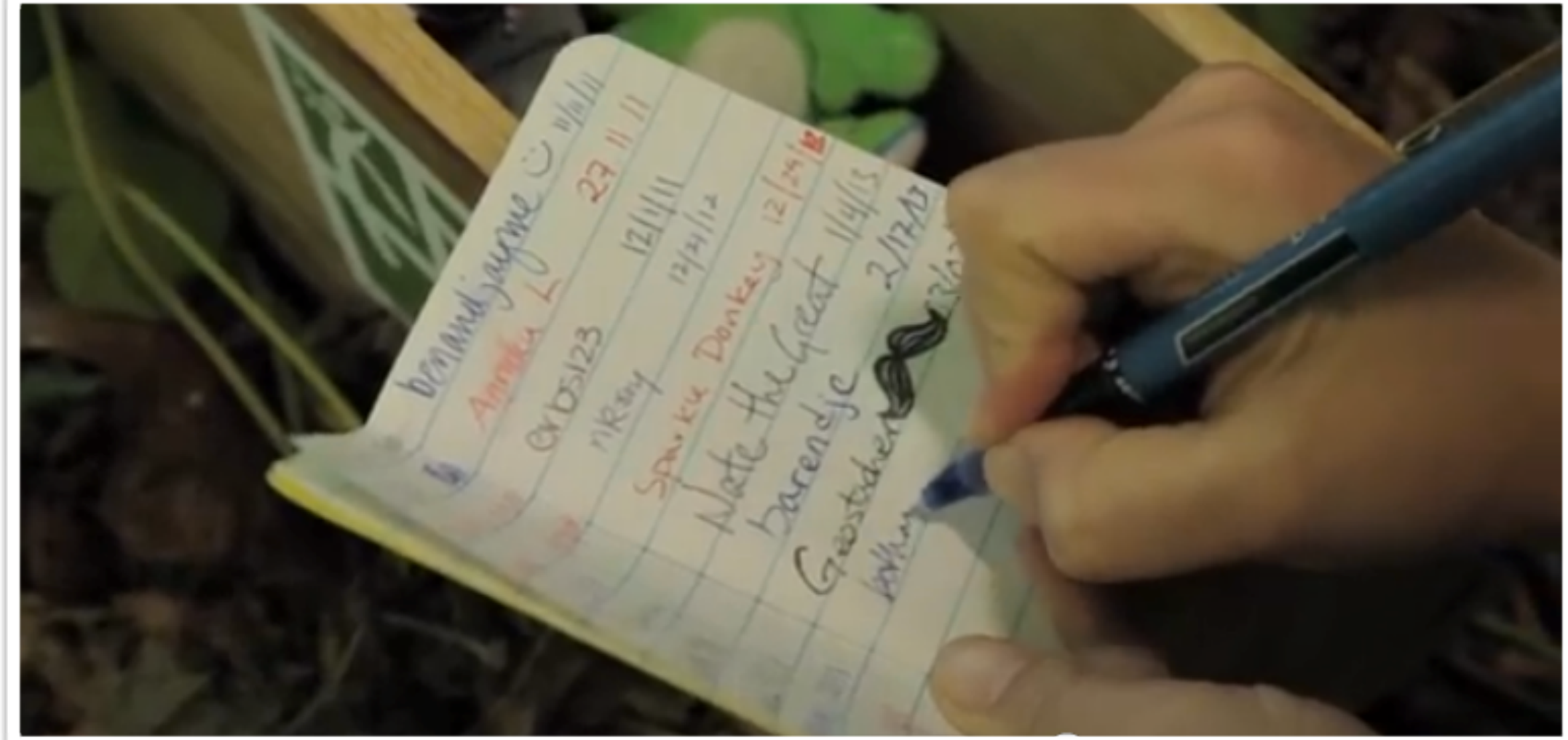
Properties of Location Systems

How does a phone find your location?

- "Real" GPS
- "Assisted" GPS
  - Help with "Real" GPS
  - Send your position
  - Cell-tower based localization
- WiFi based localization
- IP based localization

- What are the properties of each?
- What are other crazy ideas of how to figure out your location?

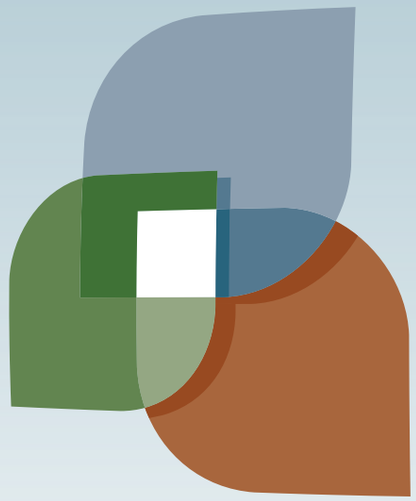
Geo-Cache Assignment



Geo-Cache Assignment

http://www.ics.uci.edu/~djp3/classes/2014_03_ICS163/tasks/geocache

Geo-Cache Assignment



LUCI