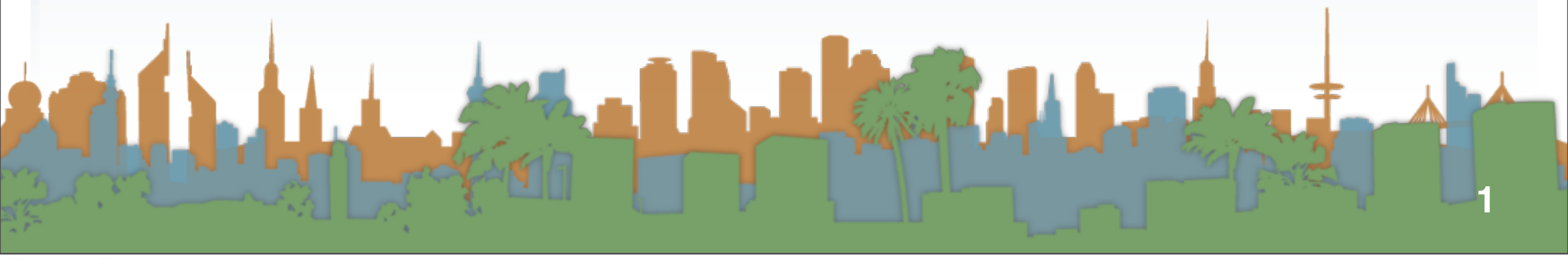
Location in Ubiquitous Computing

Assoc. Professor Donald J. Patterson
INF 241 Winter 2012



Computing with Location

- Navigation
- Global Location
  - All things GPS
- Model-based localization vs. fingerprinting
  - Localization beyond GPS
- Beyond localization
  - Nomatic*IM context

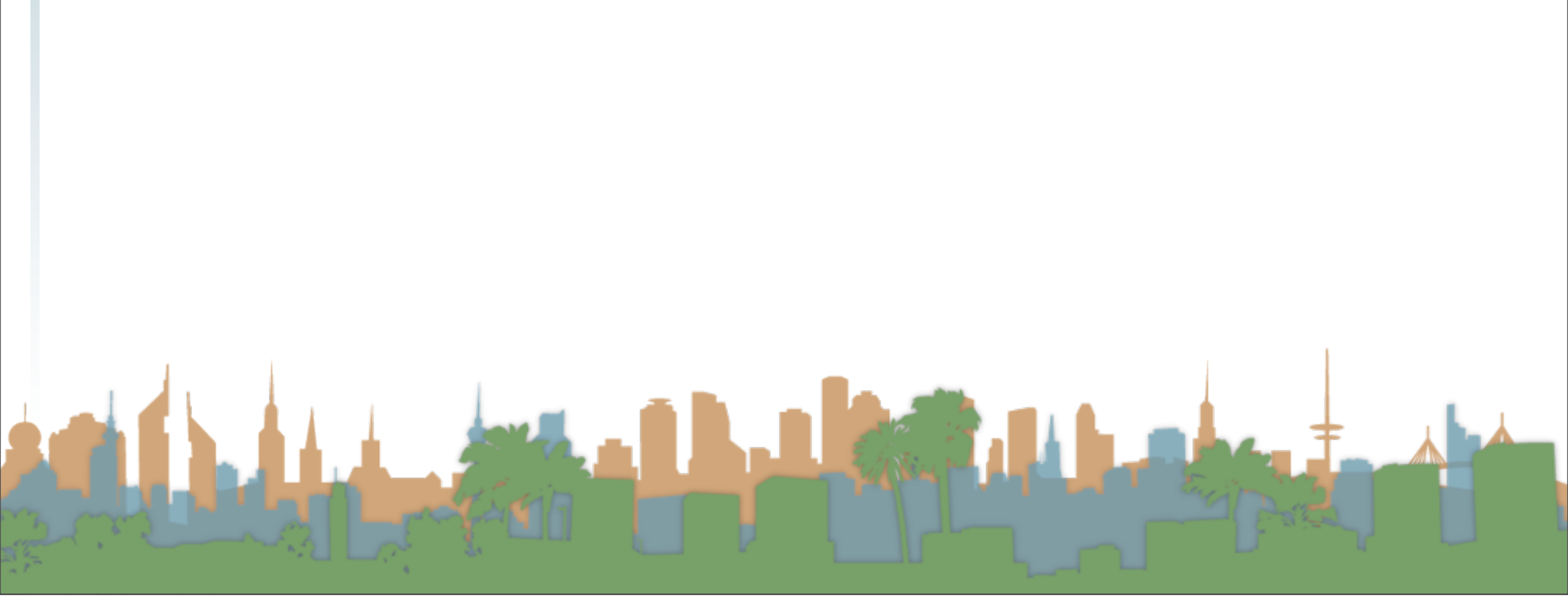
Tools for Navigation

- Navigation Tools
  - Clocks
  - Odometer
  - Electronic Aids
  - Radio navigation aids
    - ground-based
    - space-based

Global Location GPS

Global Location GPS

- Latitude and Longitude
  - What are they?
  - Datum



Global Location GPS

Global Location GPS

- Current GPS
  - Fully operational
  - accurate, continuous, global 3-D position and velocity
  - also distributes universal coordinated time
  - 24 satellites
  - 6 orbital places
  - 4 satellites per plane
  - not geosynchronous

Global Location GPS

Global Location GPS

- Current GPS
  - Based on
    - Time Of Arrival (TOA)
    - knowledge of satellite orbits
  - Satellites have atomic clocks on board
  - 2 frequencies
    - L1 1575.42 MHz
    - L2 1227.6 MHz

Global Location GPS

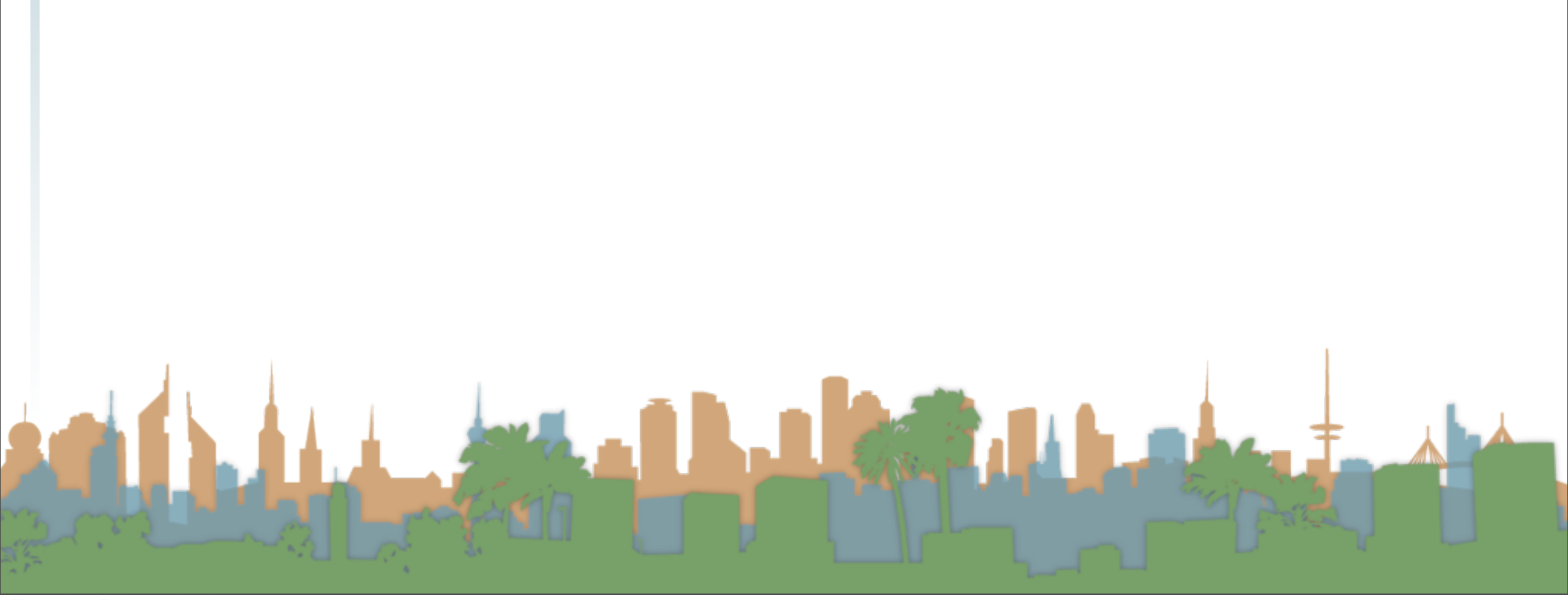
Global Location GPS

- Current GPS
  - Receiver requirements
    - Must have local clock
    - 3-D position requires four satellites
      - time or height reduces this

Global Location GPS

Global Location GPS

- Basic concept is based on the foghorn paradigm
  - but in 3-D



Global Location GPS

Global Location GPS

- The current and future of GPS
  - WAAS
    - Additional satellites in geosynchronous orbit
  - DGPS assistance from a land based receiver
  - Galileo
    - European competitor
    - GPS compatible
- GLONASS

Global Location GPS

Global Location GPS

- The current and future of GPS
  - BeiDou
    - Chinese competitor
    - centralized system
  - Japanese Quasi-Zenith System

Global Location GPS

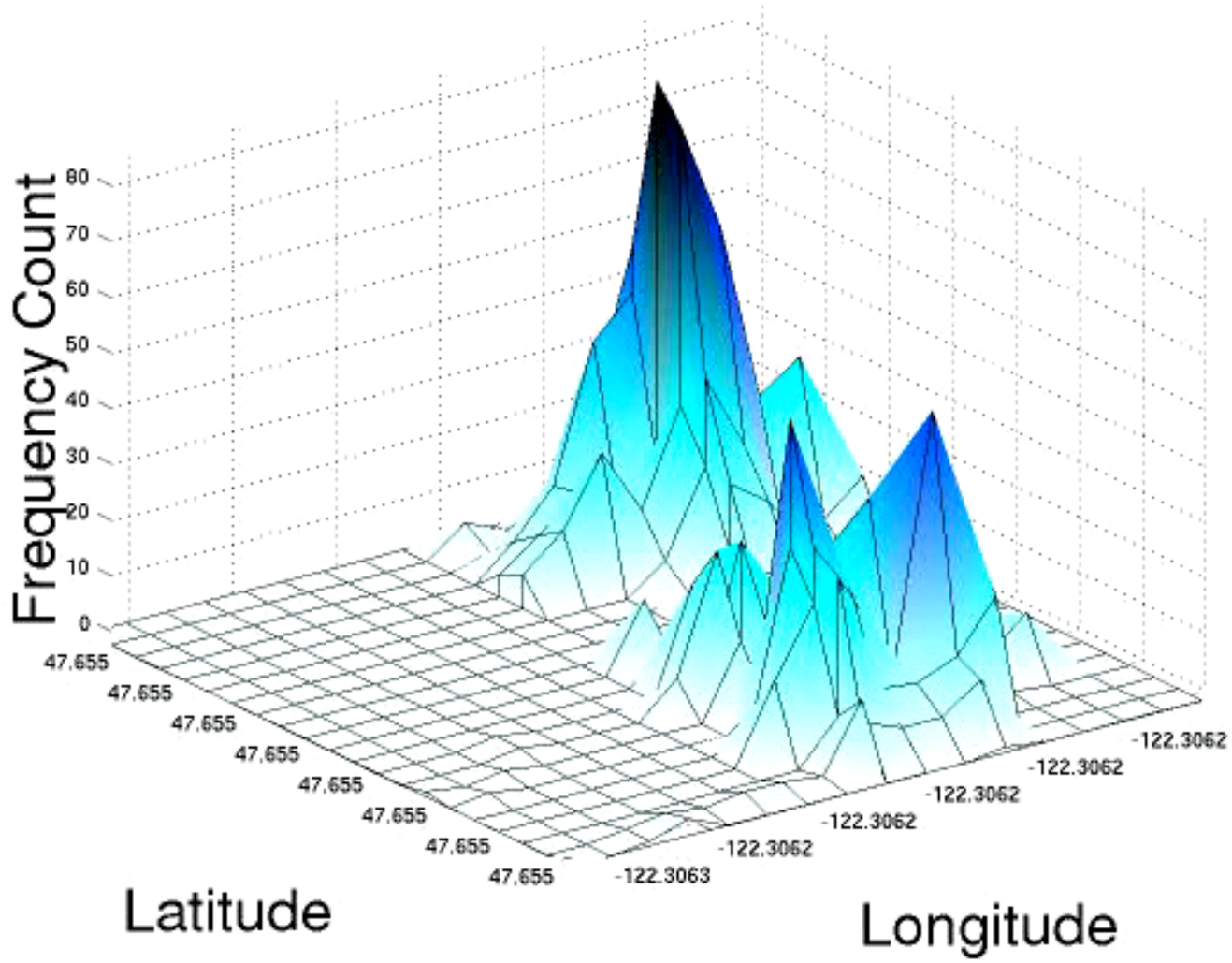
Global Location GPS

- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
  - How do you design for this?

Global Location GPS

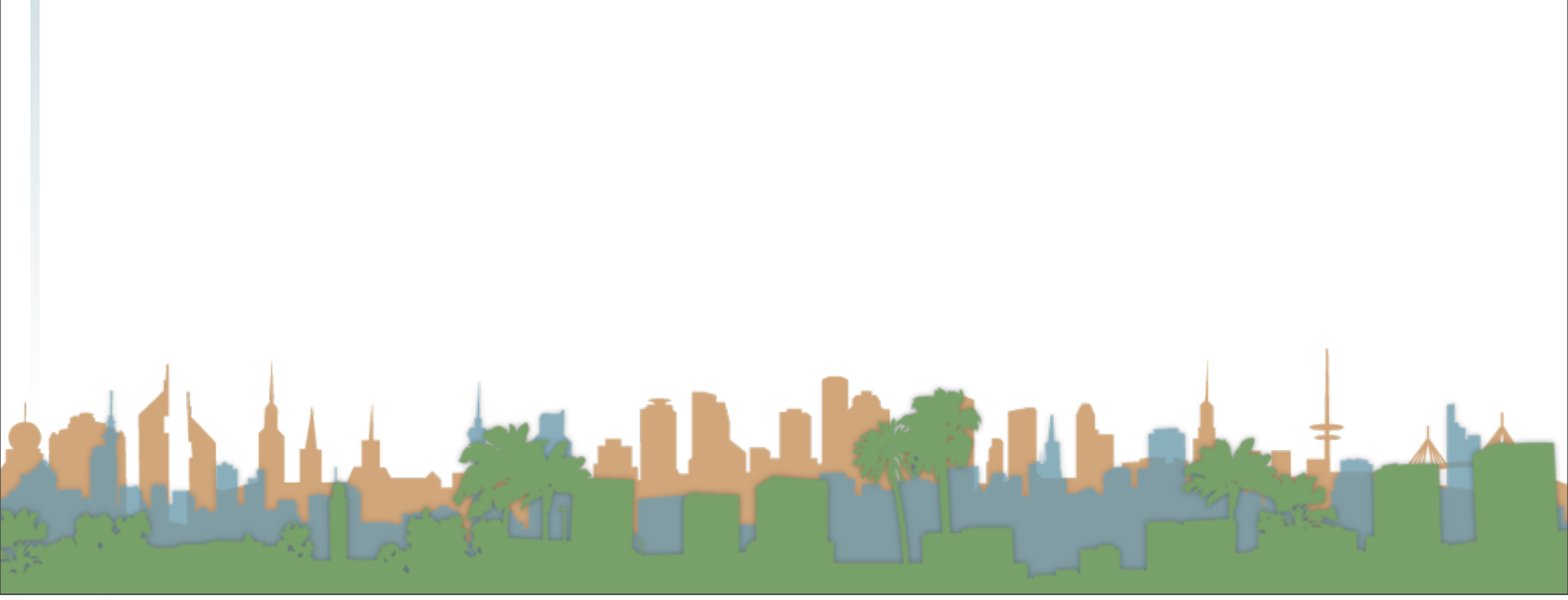
- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
  - How do you design for this?
- Urban canyons
  - What are they?
  - Japanese response, European response

Global Location GPS



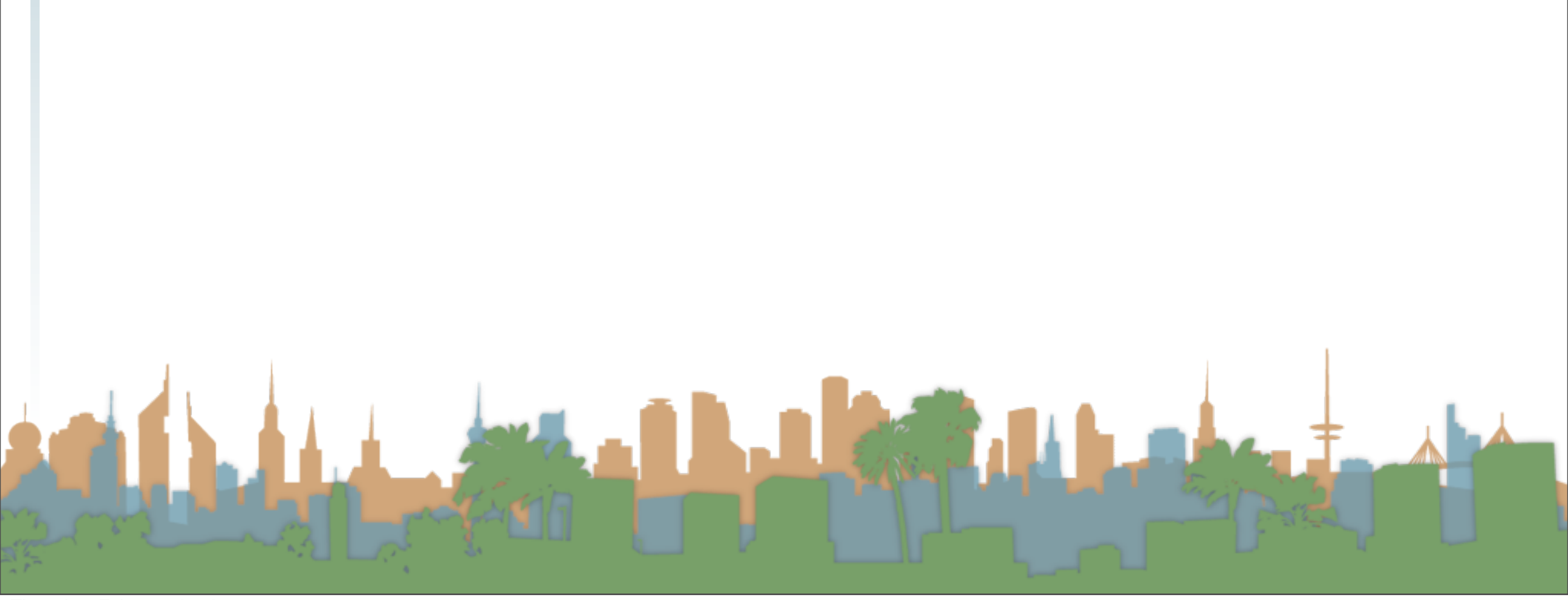
Global Location GPS

Representing Location



Representing Location

- Absolute
  - In reference to an origin (e.g., GPS)
    - Exact, Unambiguous, Machine friendly



Representing Location

- Absolute
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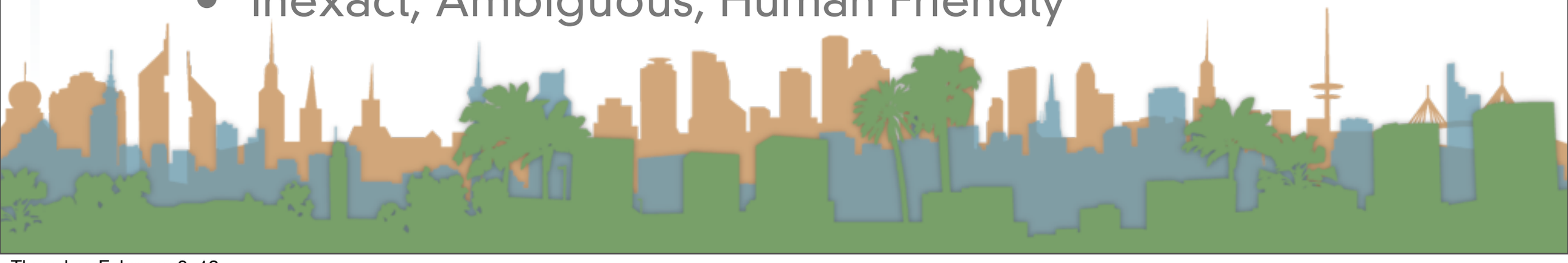
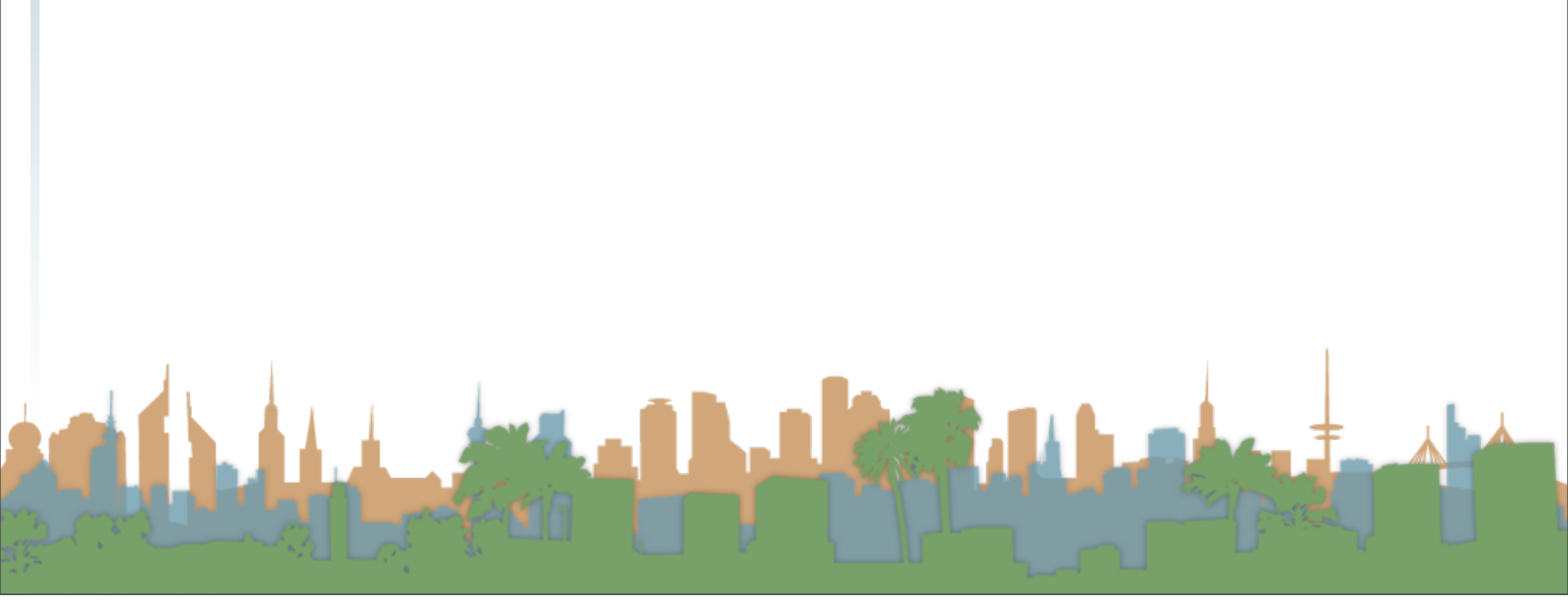
    - Exact, Unambiguous, Machine friendly
- Relative (e.g., laser range finder)
  - In reference to another position

Representing Location

- Absolute
  - In reference to an origin (e.g., GPS)
    - Exact, Unambiguous, Machine friendly
- Relative (e.g., laser range finder)
  - In reference to another position
- Symbolic
  - In reference to common knowledge
    - Inexact, Ambiguous, Human Friendly

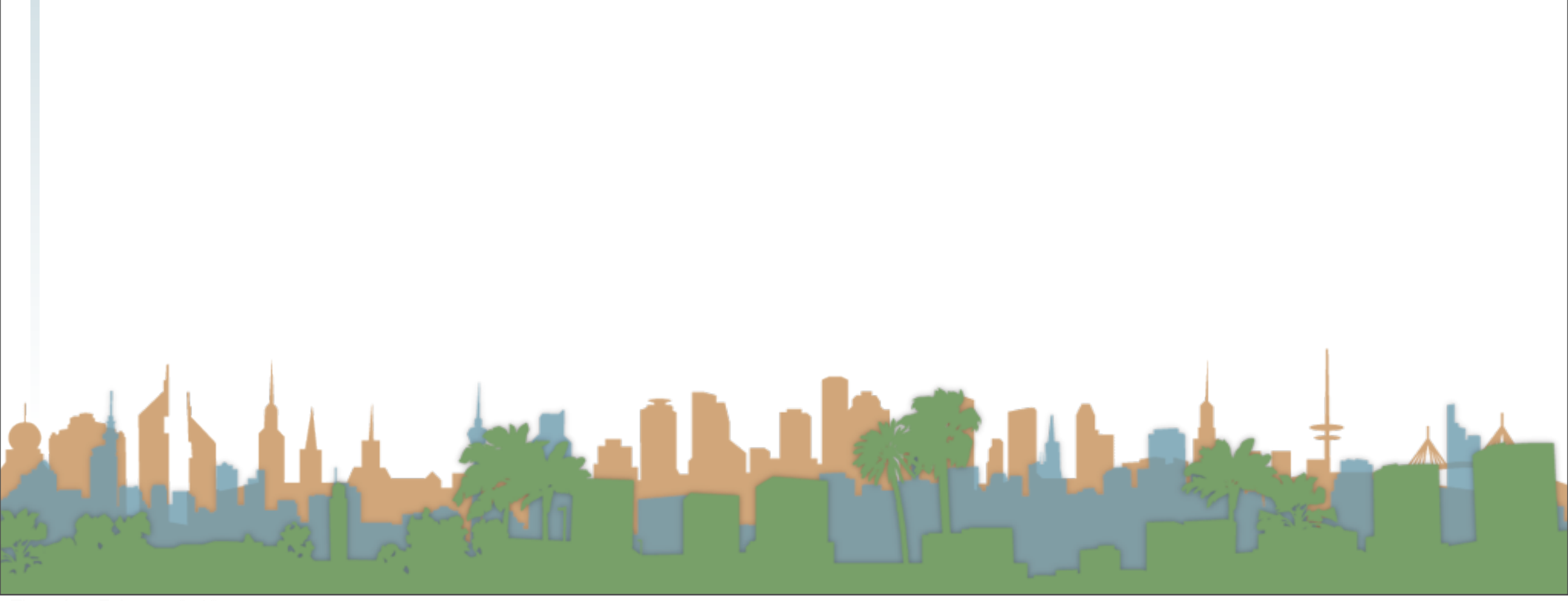


Representing Location

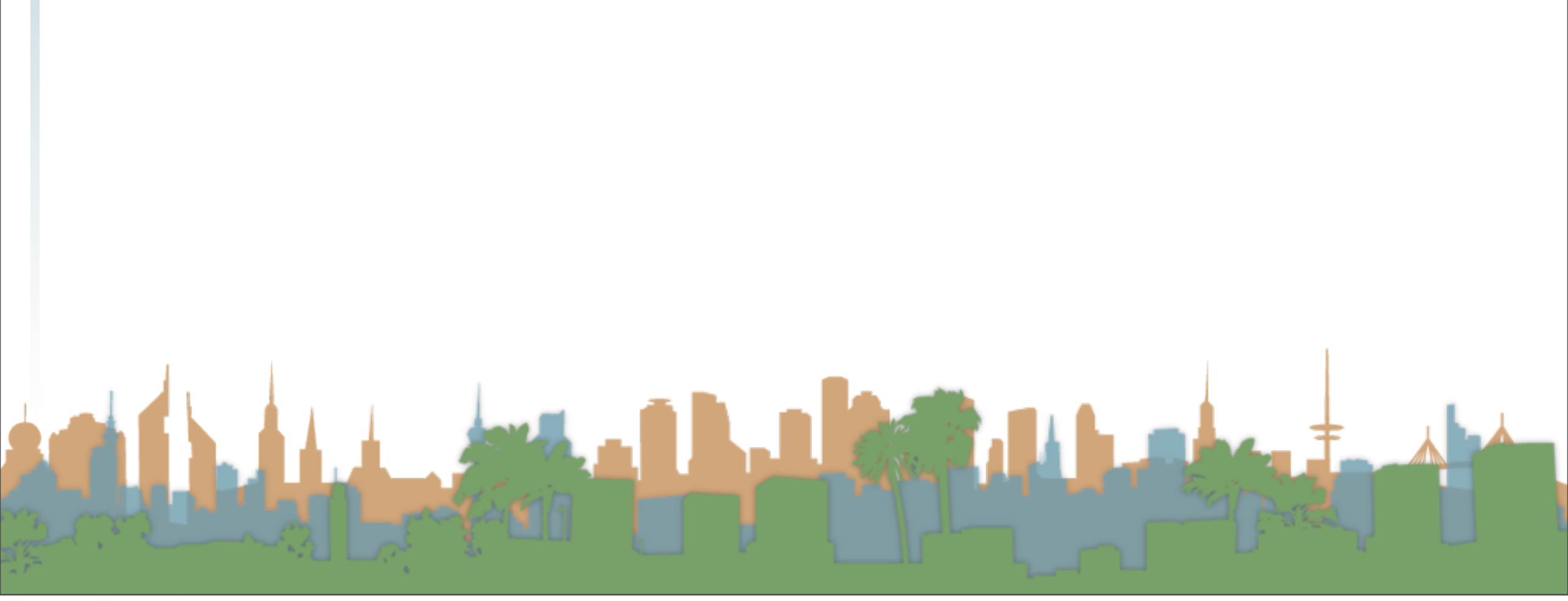


Representing Location

- How can you transform between
  - Relative and Absolute?
  - Absolute and Symbolic?



Tools for Navigation



Tools for Navigation

- Who calculates position?
  - Client based
  - Network based
  - Network assisted

Tools for Navigation

- Who calculates position?
  - Client based
  - Network based
  - Network assisted
- What's the impact?

Categorizing Localization

- 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

Localization beyond GPS

Approaches to Localization

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

Approaches to Localization

- Trilateration
  - GPS is an example
- Multiple references to fixed locations which resolve position
  - Time of flight
  - Signal strength

Approaches to Localization

- Hyperbolic Lateration
- Leverages the difference in signal arrival time

Approaches to Localization

- Triangulation
  - Finds the intersection of multiple lines of sight

Approaches to Localization

- Fingerprinting
  - Surveys the world before hand to find what signals look like when you are there
  - When you are at a place you find the closest match

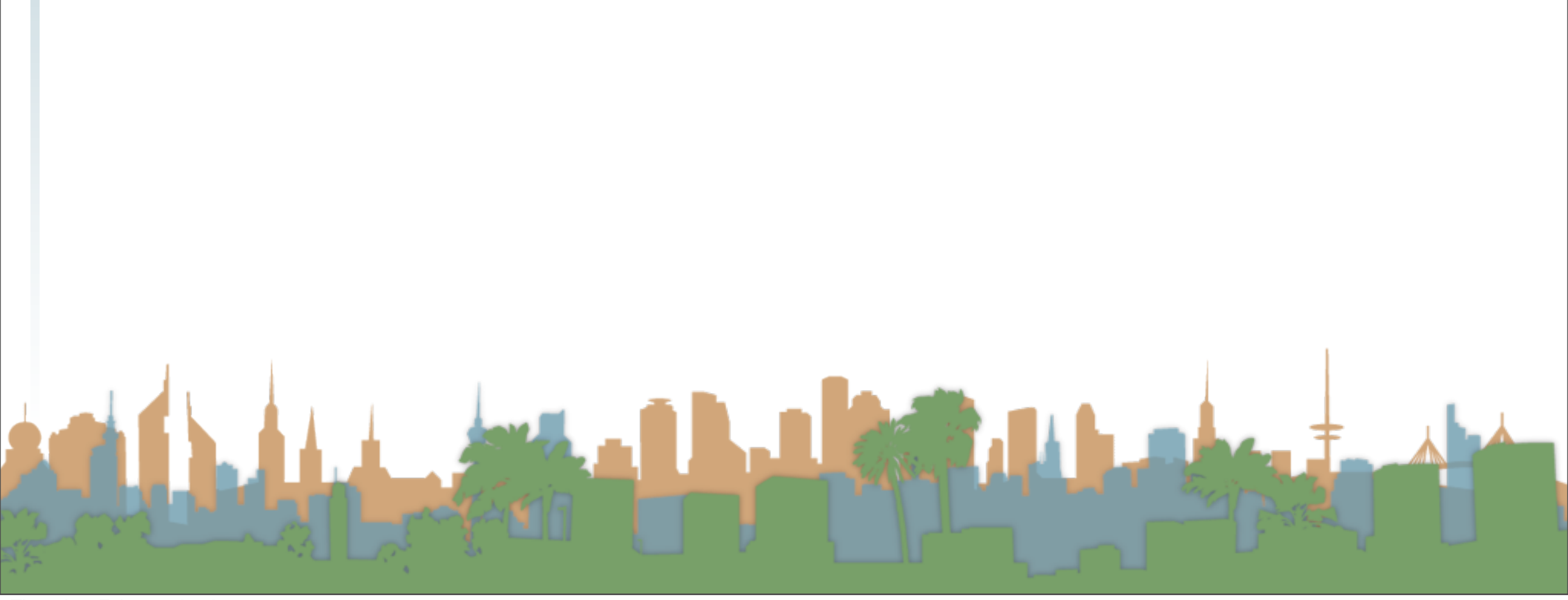
Approaches to Localization

- Dead Reckoning
  - Start at one place you know
  - Keep track of time and odometry

Approaches to Localization

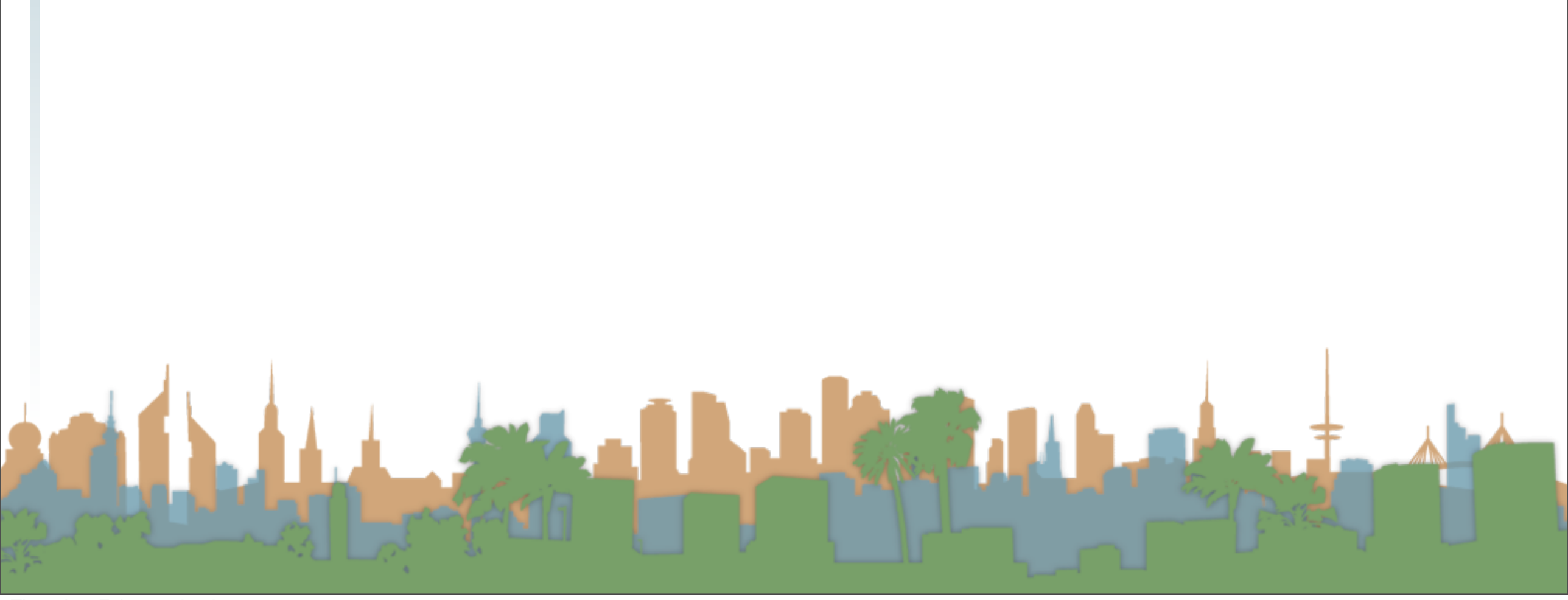
- Scene Analysis
  - Evaluating content from a fixed camera
    - Color histograms from doorways
  - Evaluating content from a mobile camera
    - tour guide scene matching

Sources of Error



Sources of Error

- Incorrect Reference Points



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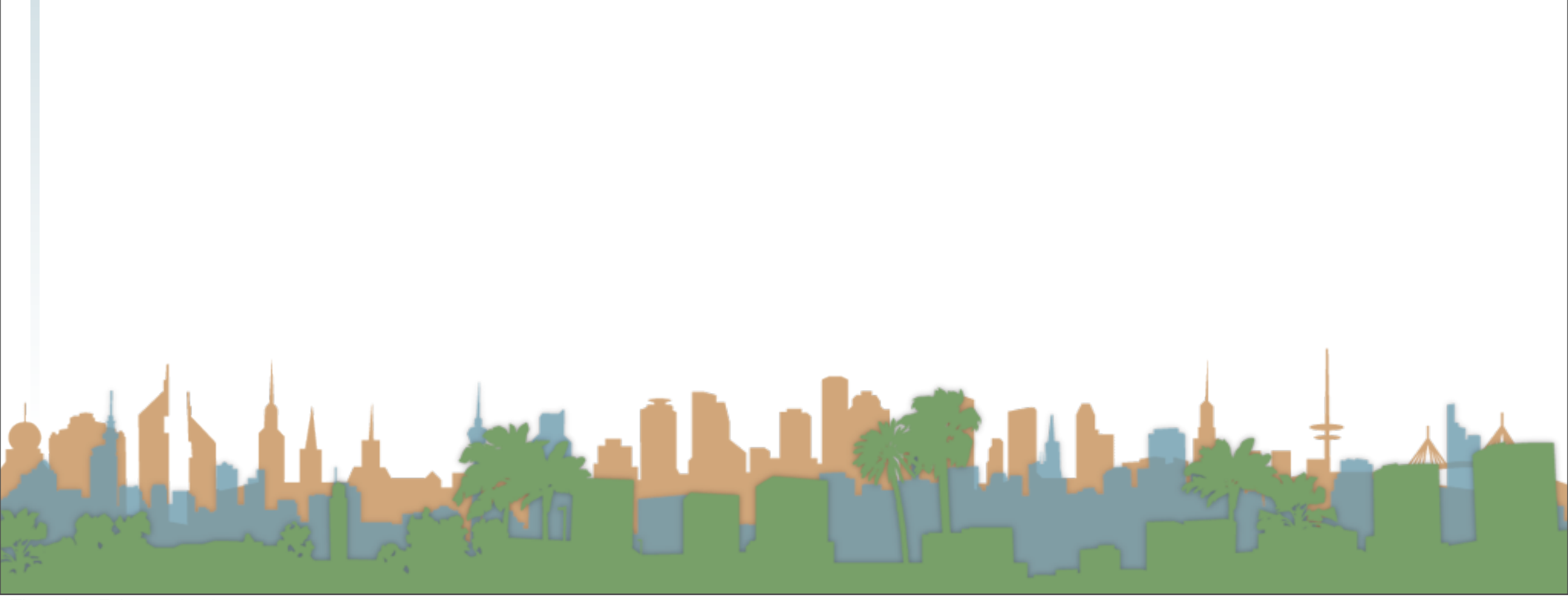
- Incorrect Reference Points
- Atmospheric delay



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- Incorrect Reference Points
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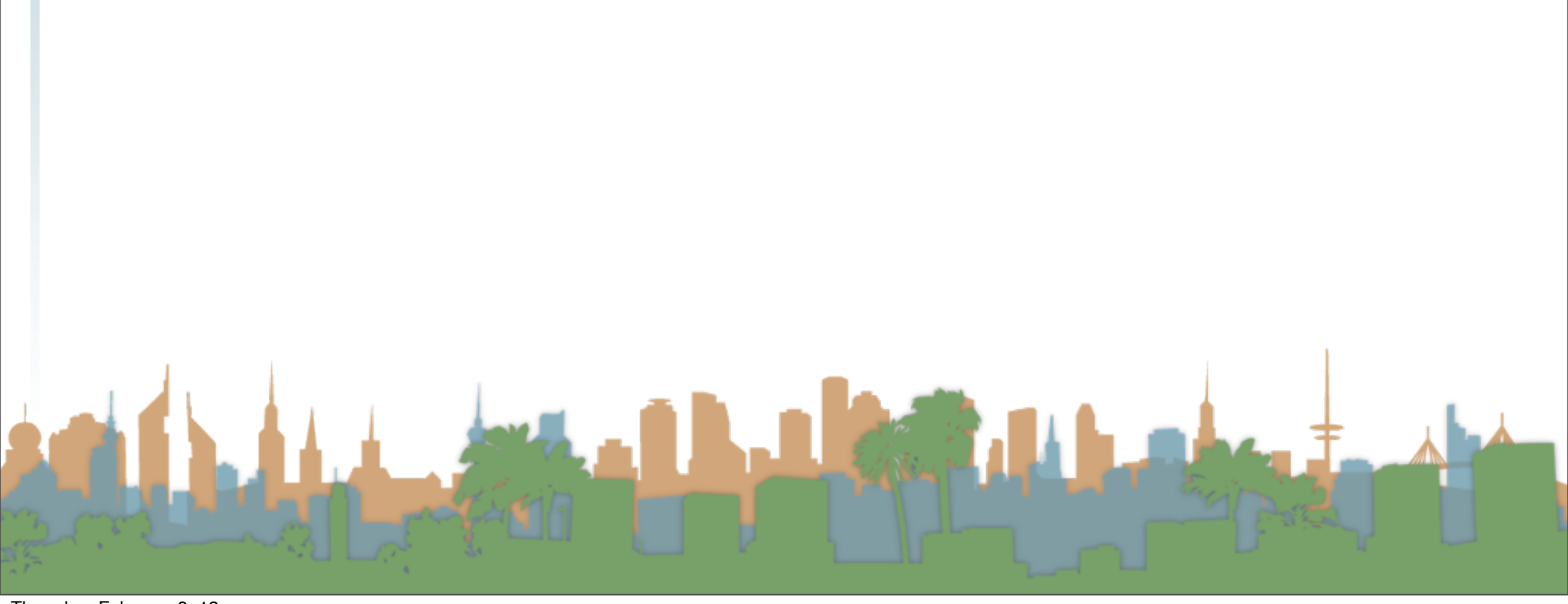

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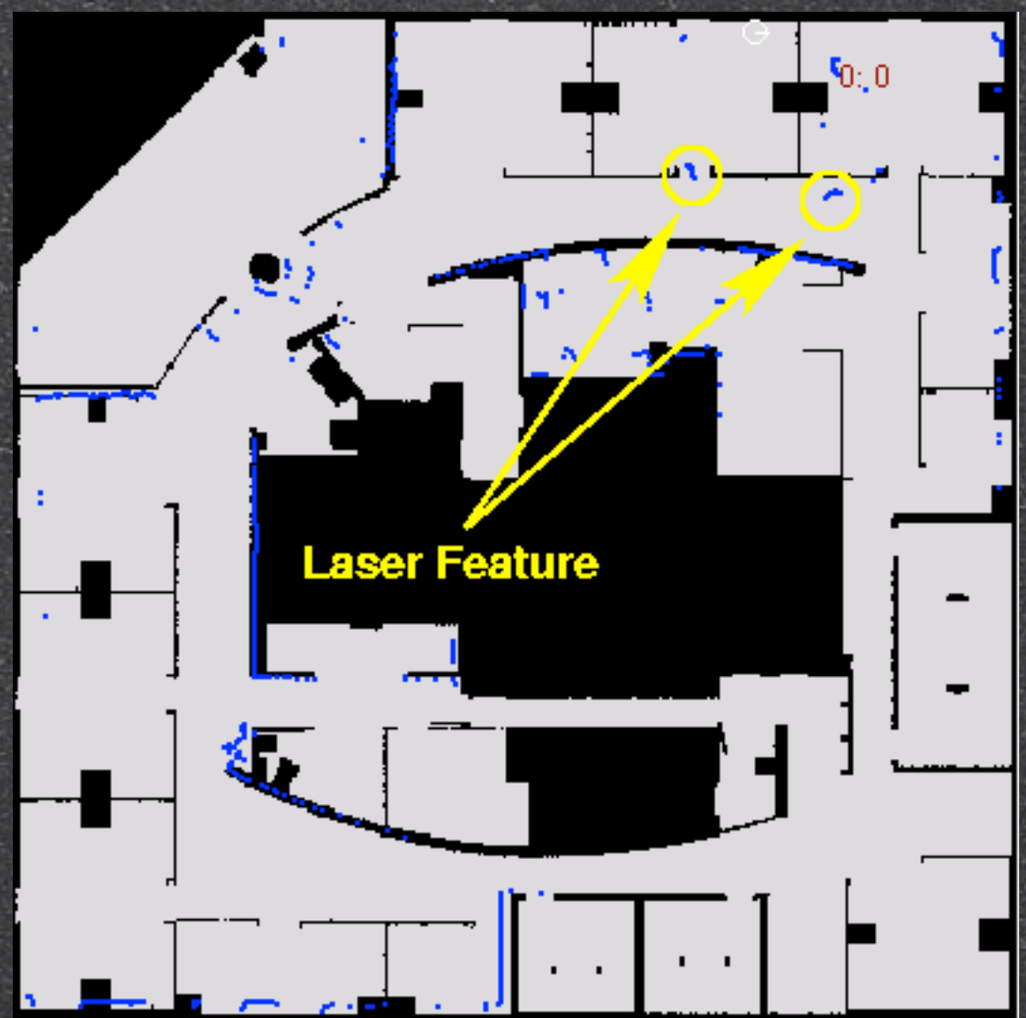
Sources of Error

- Incorrect Reference Points
- Atmospheric delay
- Clock synchronization
- Multi-path propagation
- Geometry

Categorizing Localization

- 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.

Categorizing Localization



Categorizing Localization

Categorizing Localization

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

Categorizing Localization

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

Categorizing Localization

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

Categorizing Localization

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

Examples

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

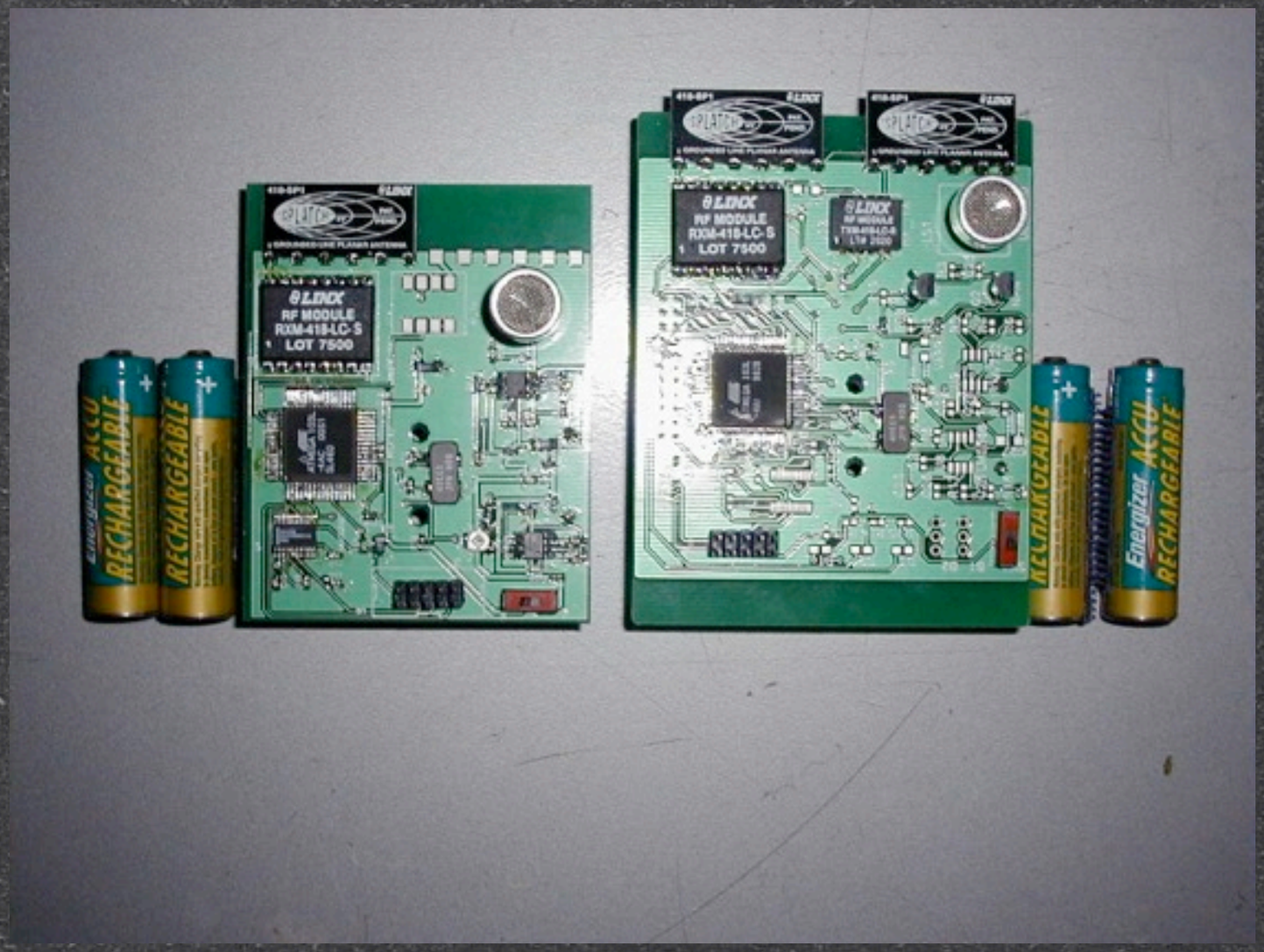
Examples

- 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
    - triangulation base on time-of-flight
    - private, decentralized scalability
    - local computation -> power drain

Examples



Examples

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

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Thursday, February 9, 12

Examples

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

Examples

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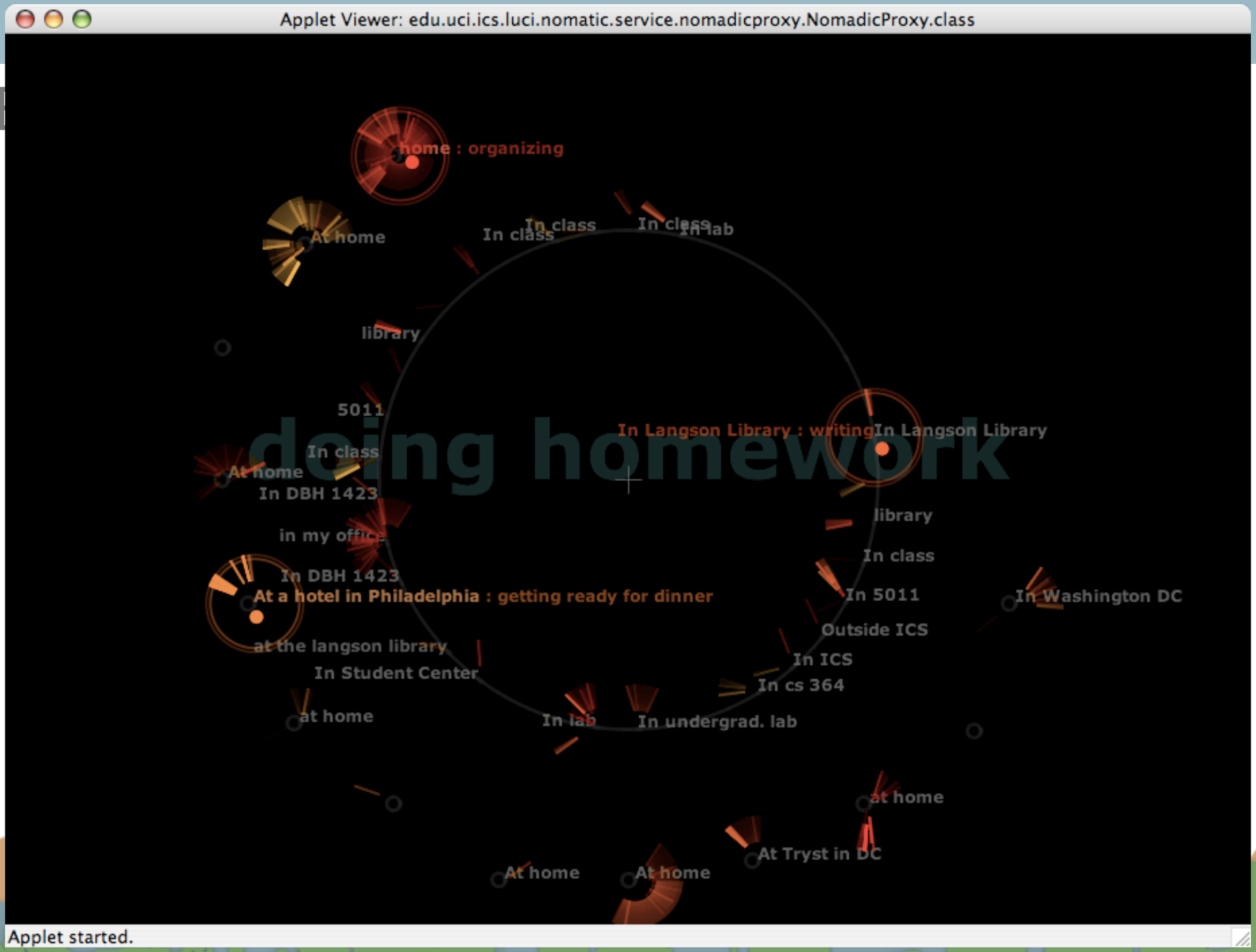
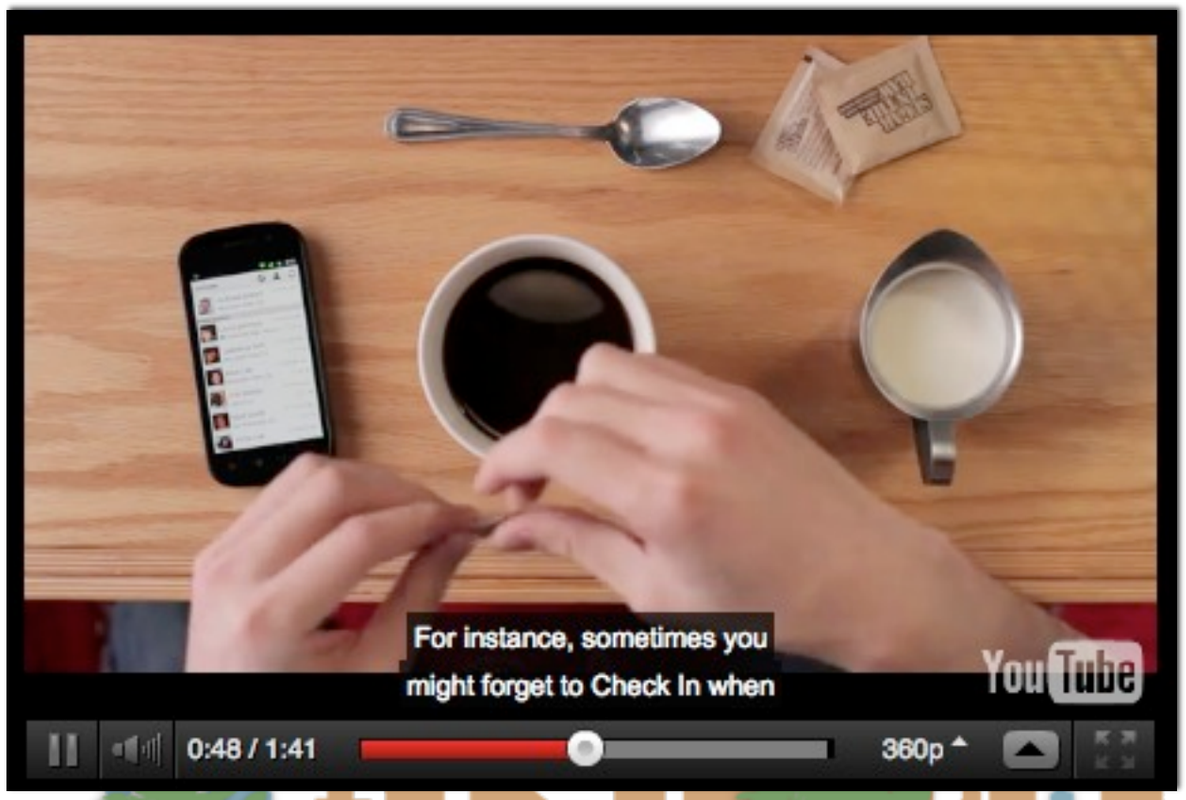
Beyond Localization

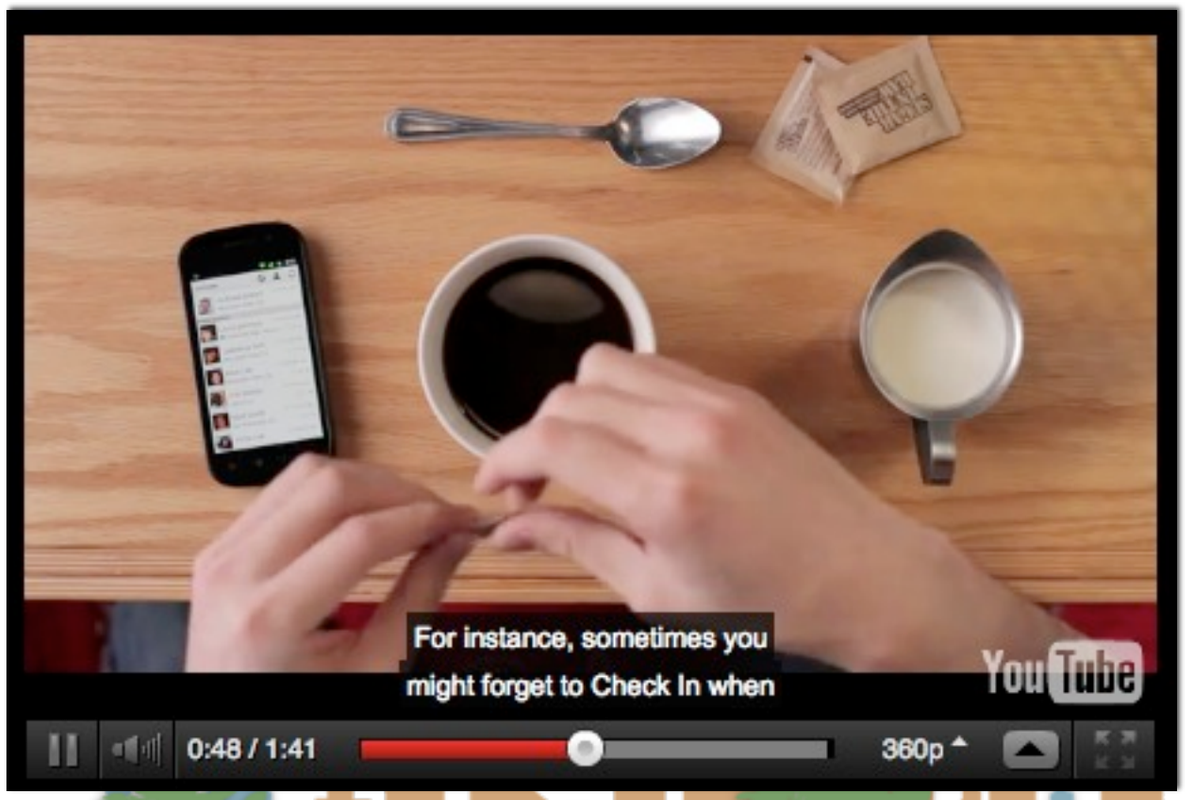

Applet Viewer: edu.uci.ics.luci.nomatic.service.nomadicproxy.NomadicProxy.class
home : organizing
At home
In class
In class
In class
In lab
library
5011
In class
At home
In DBH 1423
doing homework
In Langson Library : writing
In Langson Library
library
In class
In 5011
In Washington DC
Outside ICS
In ICS
In cs 364
In DBH 1423
in my office
In DBH 1423
At a hotel in Philadelphia : getting ready for dinner
at the langson library
In Student Center
at home
In lab
In undergrad. lab
at home
At Tryst in DC
At home
At home
Applet started.

Summary


For instance, sometimes you
might forget to Check In when
0:48 / 1:41
360p
YouTube

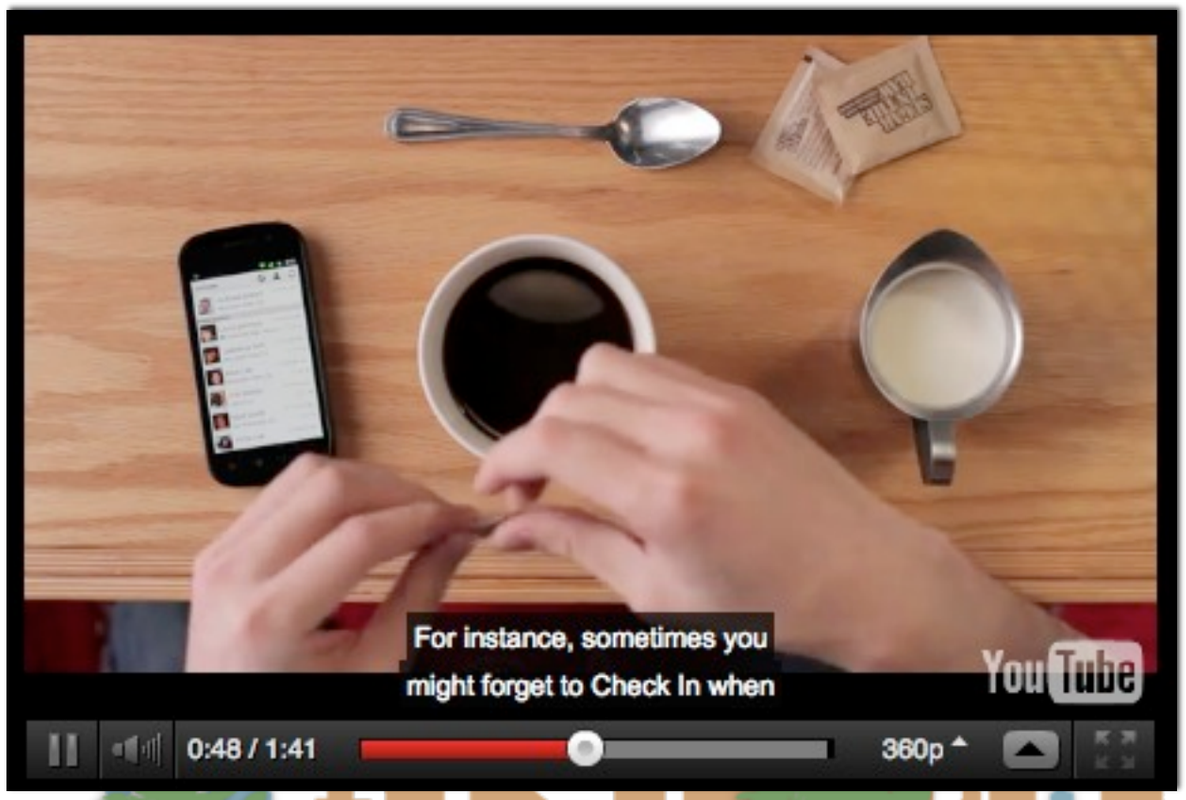
Summary

- No single location system is good everywhere



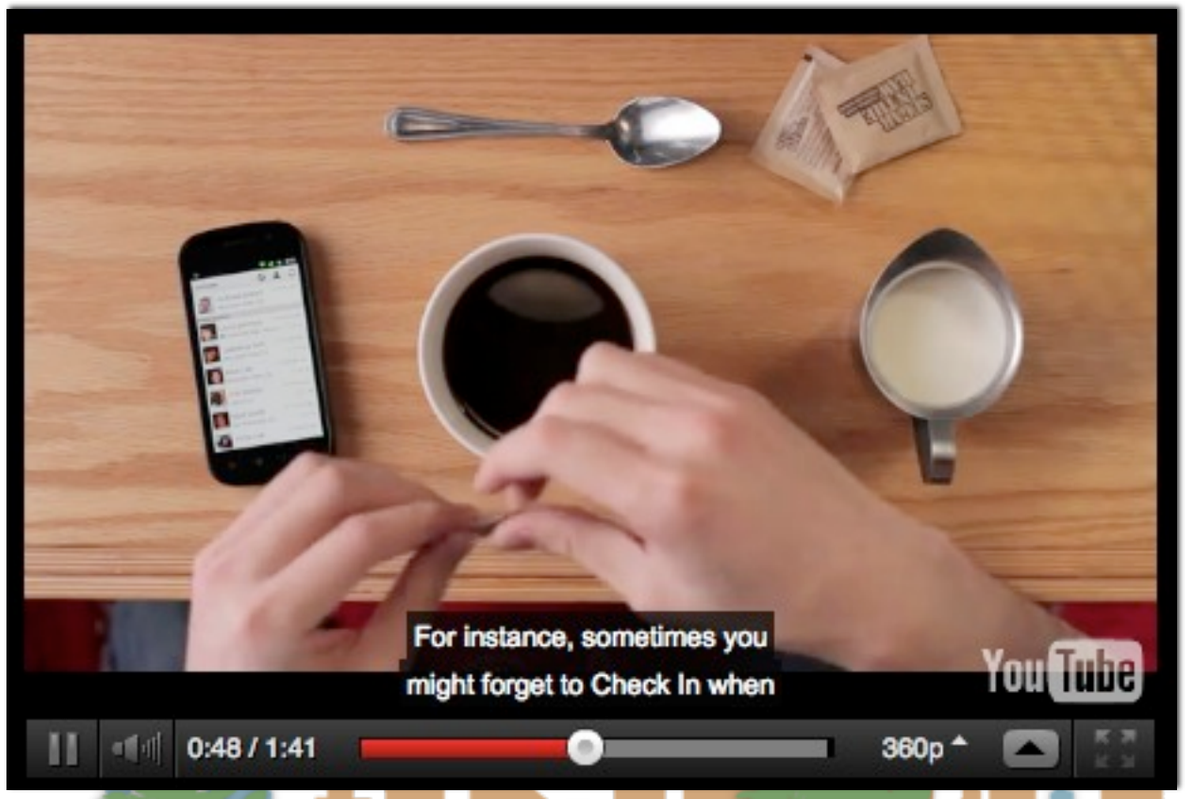
Summary

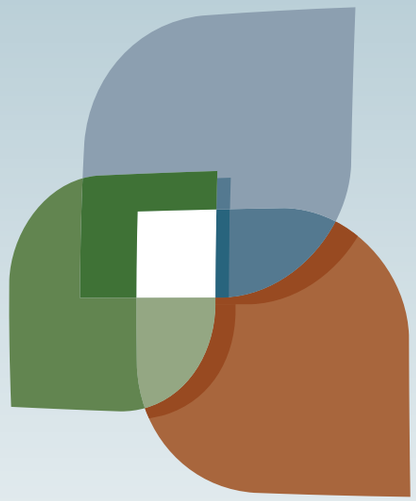
- No single location system is good everywhere
- Sensor fusion or combination systems are a solution



Summary

- No single location system is good everywhere
- Sensor fusion or combination systems are a solution
- Privacy vs Usability





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