Location Again

Location API's and Room-Size Location

Feb 28, 2006

Larry Rudolph

GPS & Cell Location

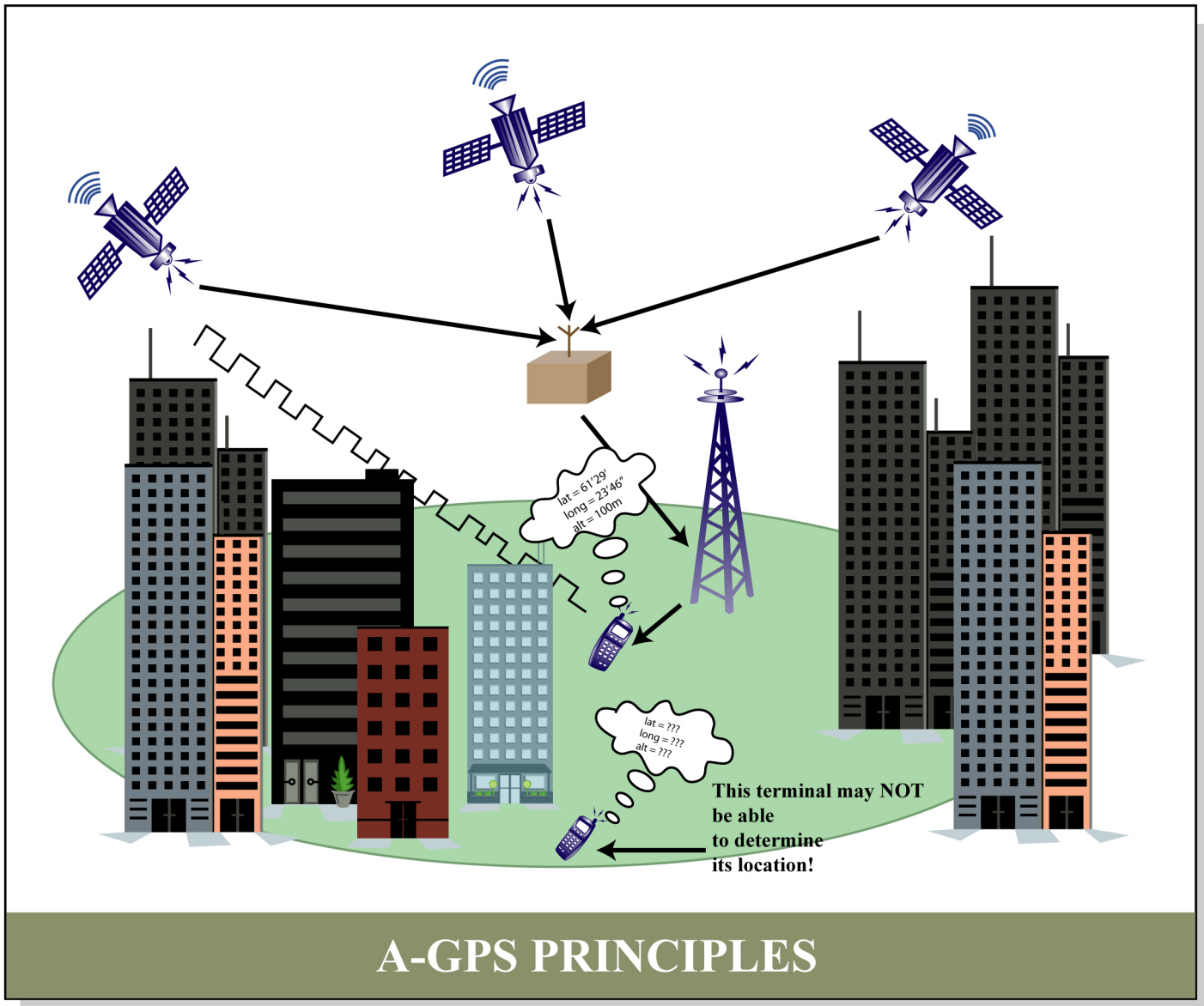


Figure by MIT OCW.

Location Server's Location

- Where should the server be located?
  - On handset
    - Respond to inquires about location with option to deny
    - When handset lost or disconnected, cannot find it.
  - In network
    - Privacy concerns

Client's Role

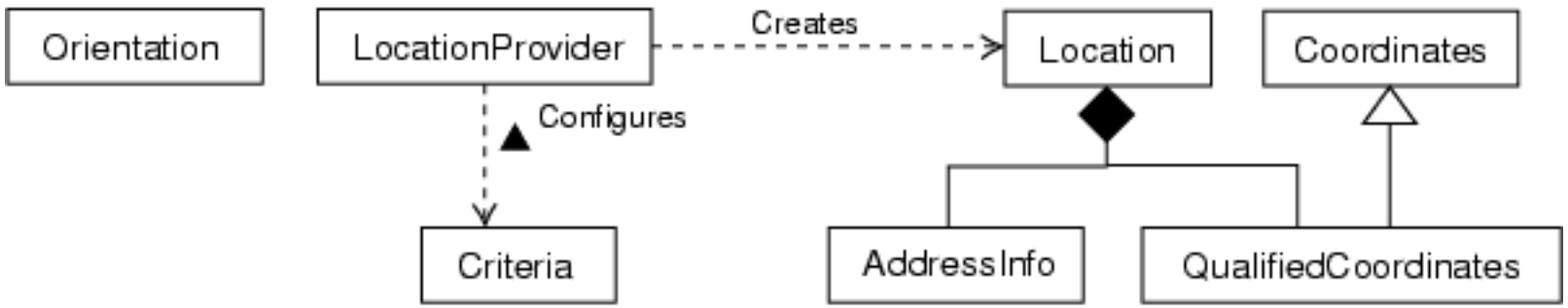
- Ask server for location of handset
  - Must know how to contact handset
  - Long round-trip, so done asynchronously
- How to ensure privacy?
  - emergency call --> always allow
  - ask server's owner
    - when and how often?

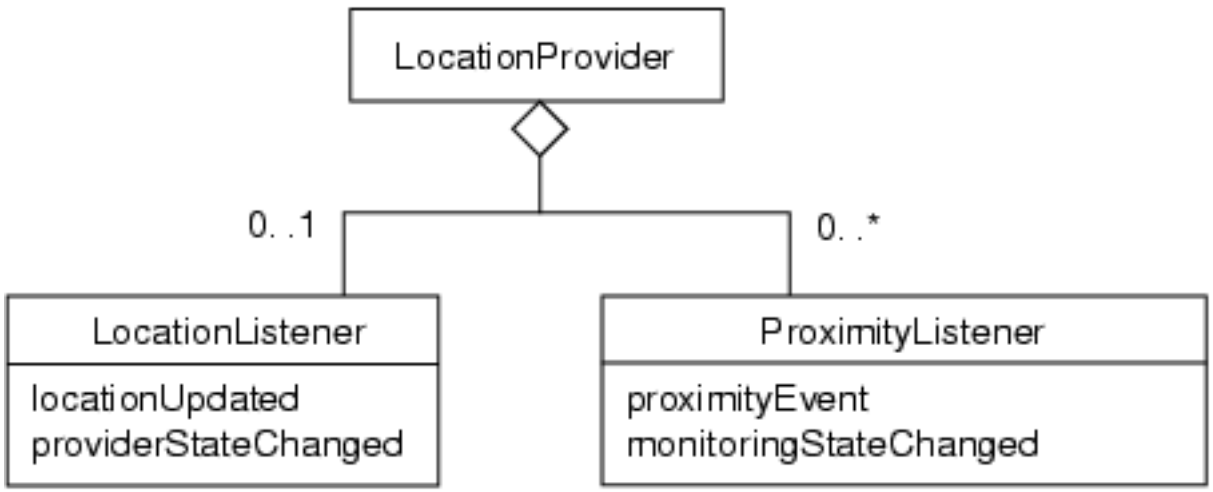
What information?

- Current position (Cell or GPS or Other)
  - How current? How precise?
- Request periodic updates
  - what happens when client disconnects
- Heading and orientation information
- Waypoints (and associated notes)
- Lots of competing systems
  - J2ME, Symbian, and each operator

Lots more details

- Time, angle of arrival, speed, acceleration
- Type of location technology specs
  - number of satellites, cell towers, weather
  - pitch, roll, magnetic compass quality
- My strategy:
  - first list all information you think is important and then check with standard


Orientation
LocationProvider
Creates
Location
Coordinates
Configures
Criteria
AddressInfo
QualifiedCoordinates


LocationProvider
0..1
0..*
LocationListener
locationUpdated
providerStateChanged
ProximityListener
proximityEvent
monitoringStateChanged

- http://www.jcp.org/en/jsr/all (J2ME Packages)

How to spoof

- Borrow friends phone
  - register it with tracking service (TS)
  - TS sends msg to phone for confirmation
  - Answer msg, delete it, return phone
- No need to borrow phone if know phone ID
  - when phone is turned off, put its ID into a different phone, do the above steps, and then turn off.

Larry's Location Larceny

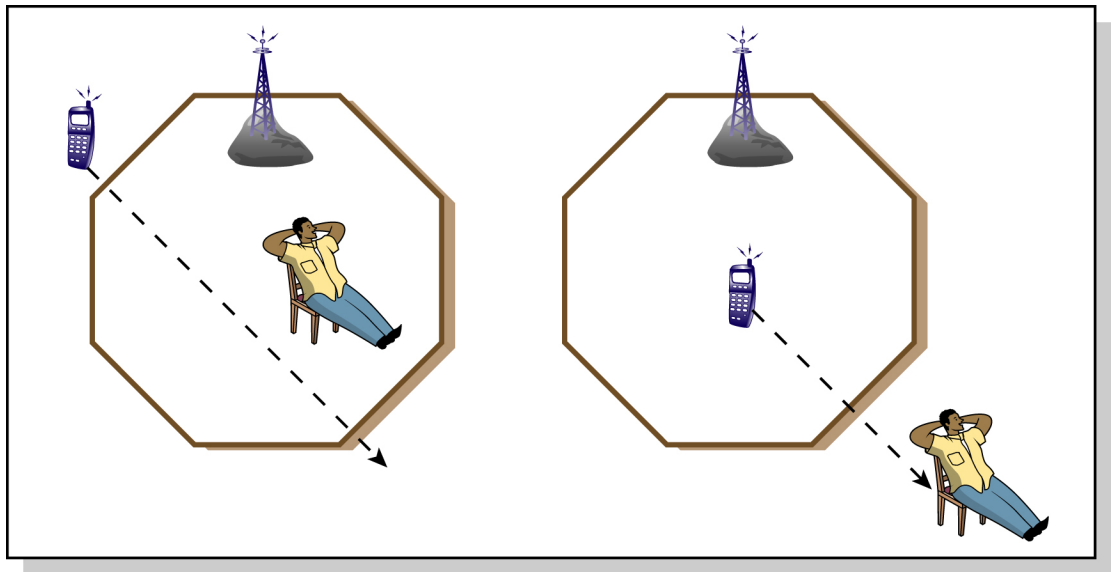


Figure by MIT OCW.

- How to foil tracking -- even when cell towers know your phone's location
- Switch ID's when near each other when
  - Alice and Bob realize they're in same cell

Assumptions

- Phone can forward calls to another phone
- Phones can change their ID (also #, IP)
- Can detect ID & # of incoming call
- Can detect cell tower connection
- Can connect to any of a set of servers

LLL (cont)

- Alice & Bob switch
  - When looking for Bob, you find Alice, and she forwards call to Bob.
  - Bob accepts calls forwarded from Alice (the calls look like they came from Bob)
  - Bob forwards all other call to Alice
- Bob and Charlie switch
  - Look for Bob, find Alice who forwards to Charlie who forwards to Bob

Graph View of LLL

- Nodes always in some cycle
- Forward thru whole cycle

Image removed due to copyright restrictions.

Bookkeeping View

- When switching, just exchange current id info
- How to know when to stop forwarding?

Image removed due to copyright restrictions.

Inverse links

- If a node is shut off rest will be unreachable
- Use servers to deal with reverse links
- Node chooses server at random, if two nodes contact same server and are both in same cell, then
  - switch info, and tell server about switch. nodes periodically make sure partner alive
  - with unsynchronized clocks and freq switching, cannot easily reconstruct cycle

Landmark Databases

- Convert from location to known object
  - how close is “nearby”
- Which databases of landmarks should be used
- Local override to database?

Indoor Tracking
Proximity Events

Room Level Tracking

Beacons & Listeners

- Room-level tracking requires beacons & listeners
- Two choices:
  - Scatter listeners throughout environment that detect your position & update server
    - Server provides location info & alerts
  - Scatter beacons throughout environment and your handheld is listener

Tradeoffs

- Handheld is beacon
  - better power usage
  - better precision (precise listener location)
  - less interference
- Handheld is listener
  - Control over privacy
  - (Can you suggest others)

Bluetooth Beacons

- Bluetooth devices respond to inquires
  - with BT-ID and Name
  - range: 10 meters (room level)
  - leakage through walls & floors
    - hear floor 7, 8, and 9 --> you are on 8
- Inexpensive ($20 / beacon)
  - Handhelds have BT

Bluetooth Beacons

- First decision -- Where to put beacons
  - Put them in PC's -- they are everywhere
  - Unfortunately, they disappear :(
- Put them in powered usb hub, near AC outlet
  - Initialize via laptop, then remove laptop
  - BT Dongle will continue to respond to inquiry

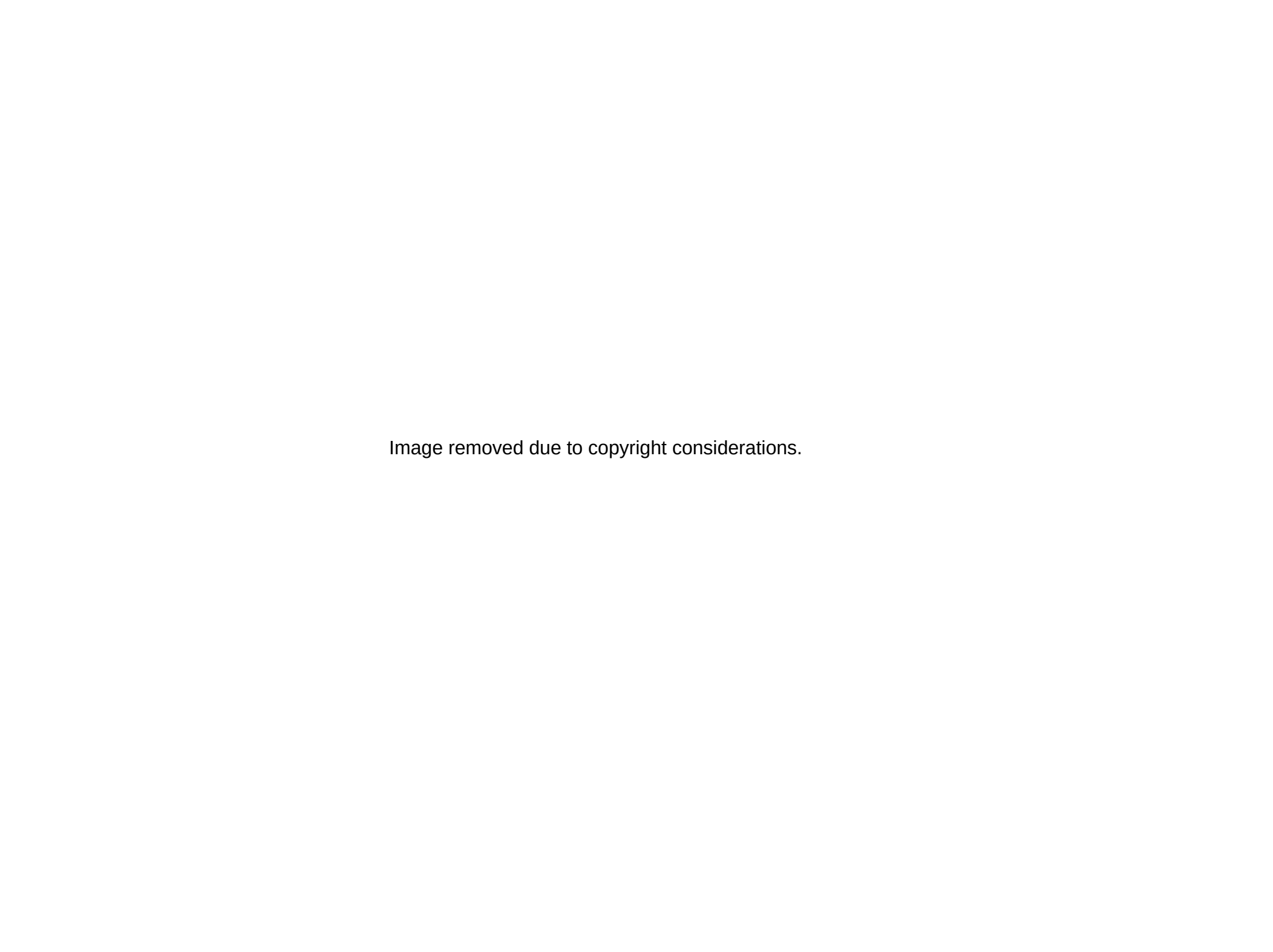
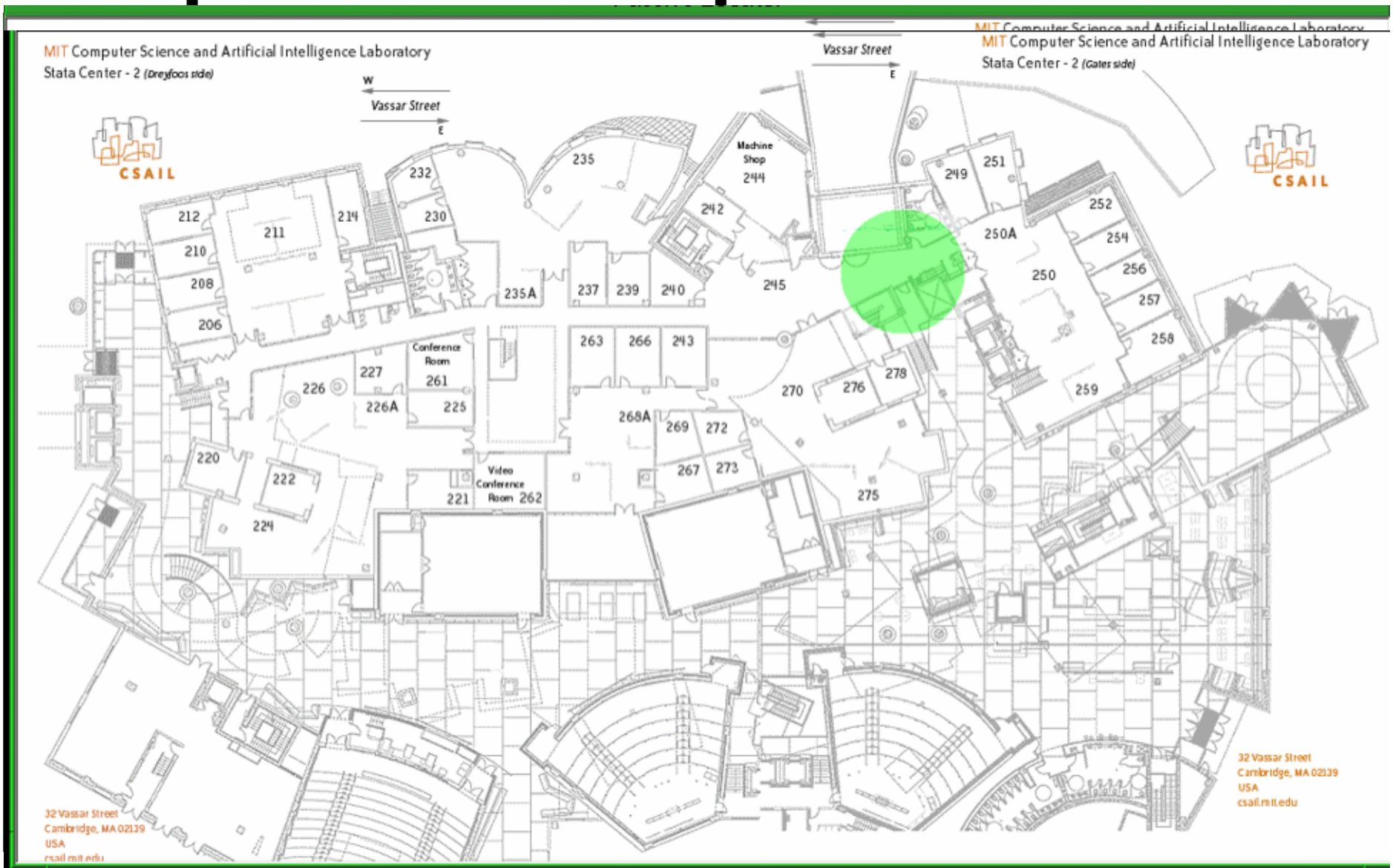


Image removed due to copyright considerations.

When detect BT dongle update map location



What doesn't work

- Signal strength does not work well
  - need radio map
- Track while walking
  - 10 sec to detect, walking rate ~ 1 m/s, easy to miss dongle altogether
- Embed location info in dongle name
  - takes even longer to detect
- Cached BT names, must not use

Several Hacks needed

- Takes too long to recognize dongles
  - Faster if use two dongles
- Signal come and goes
  - Incorporate model of human motion
  - Probabilistic filtering

Image removed due to copyright considerations.

More hacks

- If you know where you are,
  - then know where you might go next
  - can do inquiry of specific dongles