

# Sentient Computing

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# Location-Aware Computing

A real-world environment where people are wearing location tags



A 3D rendering of a world model constructed and updated in real time using the location system

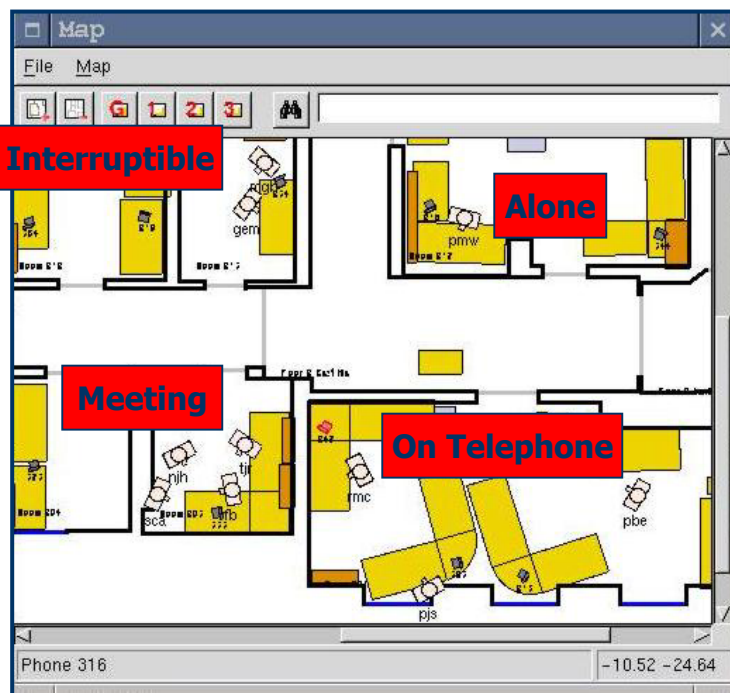


Location tags are **worn by people** and **attached to objects**

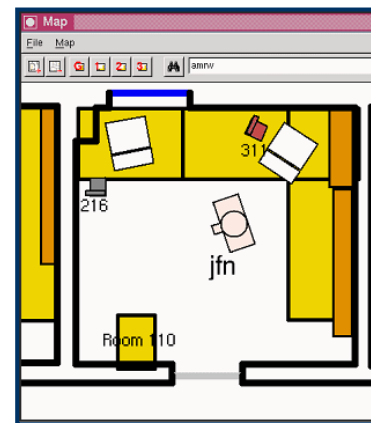
So accurate tag location allows us to **sense where people and objects are**

This lets us build an up-to-date **model of the world** to be shared by applications, making them **context-aware**

# Presence and personalisation



*Presence*



*Auto call routing  
Mobile desktops*



*Device  
personalisation*

More information available at: <http://www.uk.research.att.com/spirit>

# Location: Active Badge

## Infra-Red Network

10 meter range

diffuse

room-scale location

**First deployed 1988**

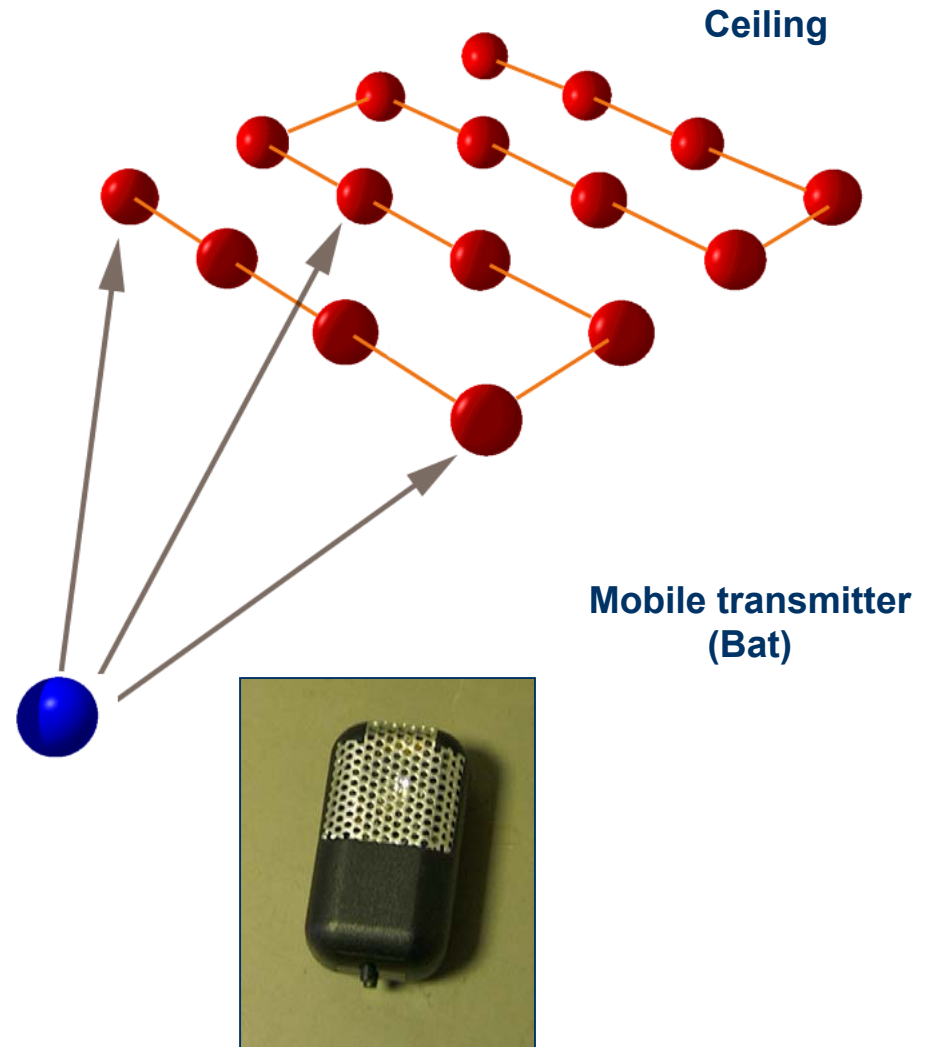


# Location: Active Bat

## Ultrasonic transponder

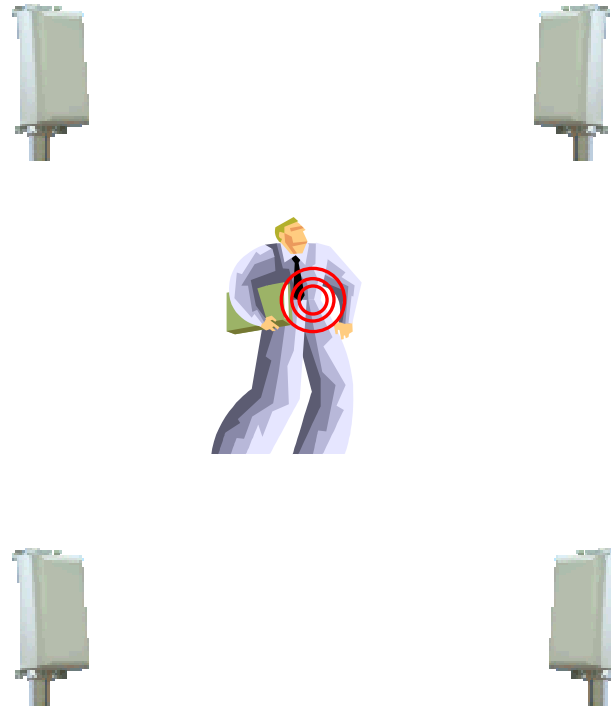
- Measure pulse time of flight
- Radio synchronised
- 3D location

First deployed 1997



# Ultrawideband (UWB) location system overview

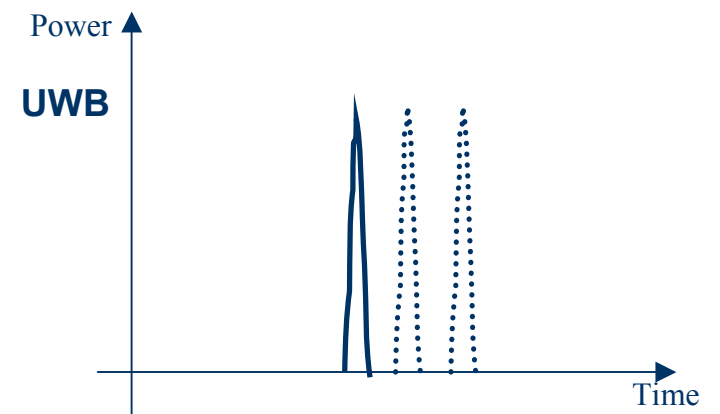
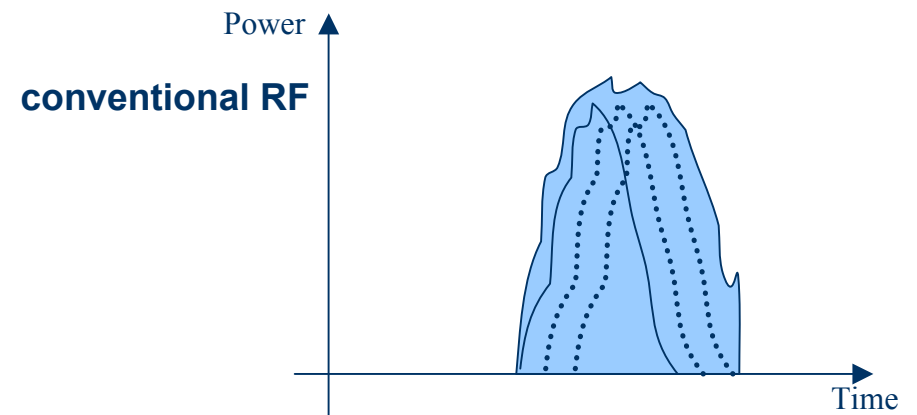
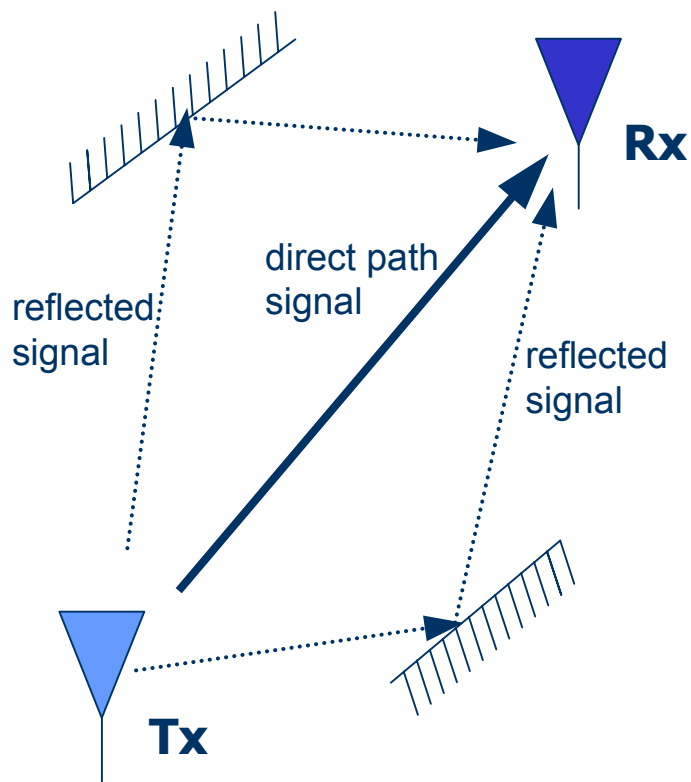
- Wireless tags
  - Carried by personnel
  - Attached to equipment
  - Battery-powered
- Fixed base stations
  - Part of managed infrastructure
  - Can be mounted on walls, ceilings, poles



# UWB sensor features / benefits

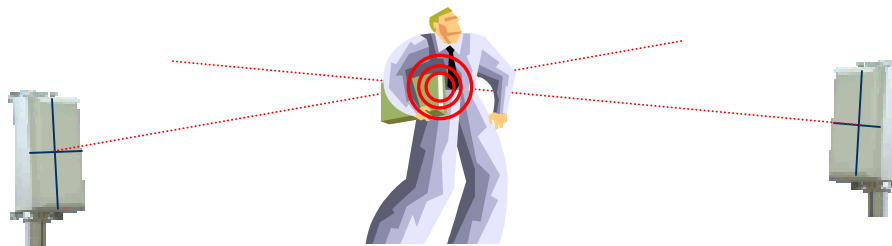
- Robust indoor and outdoor operation
- Non-line-of-sight operation
- Leading edge detection and multipath rejection
- Long measurement range
- Low power consumption

# UWB immunity to multipath



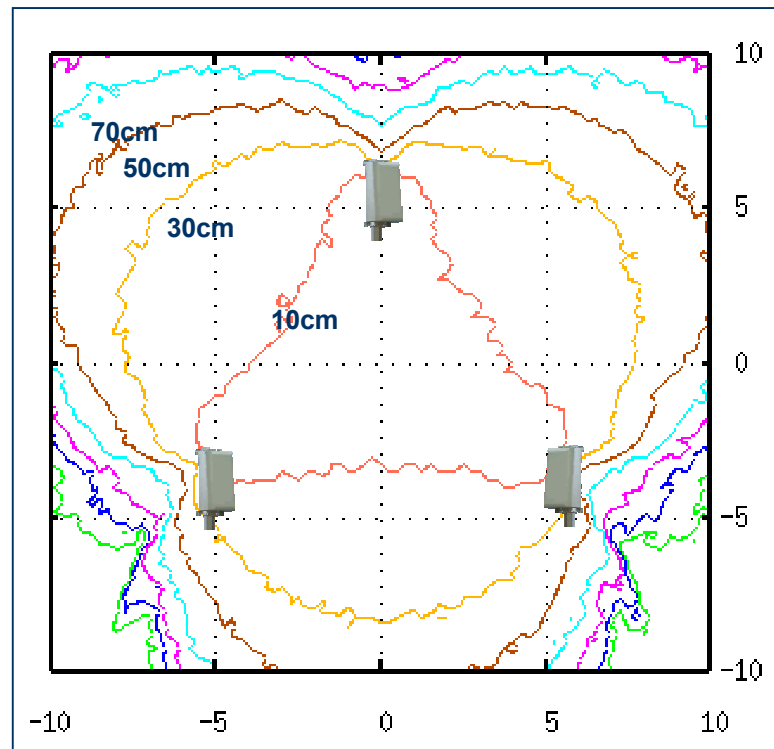
# Calculating a 3D position

- Calculates tag position from multiple sensor readings
- If tag clock offset was zero, would just need readings from three base stations
  - Base station clocks are all synchronised
- But tag clock offset is unlikely to be zero!
  - Use additional base station readings to solve for position **and** unknown clock offset
  - Nonlinear regression calculation



# UWB sensor system accuracy

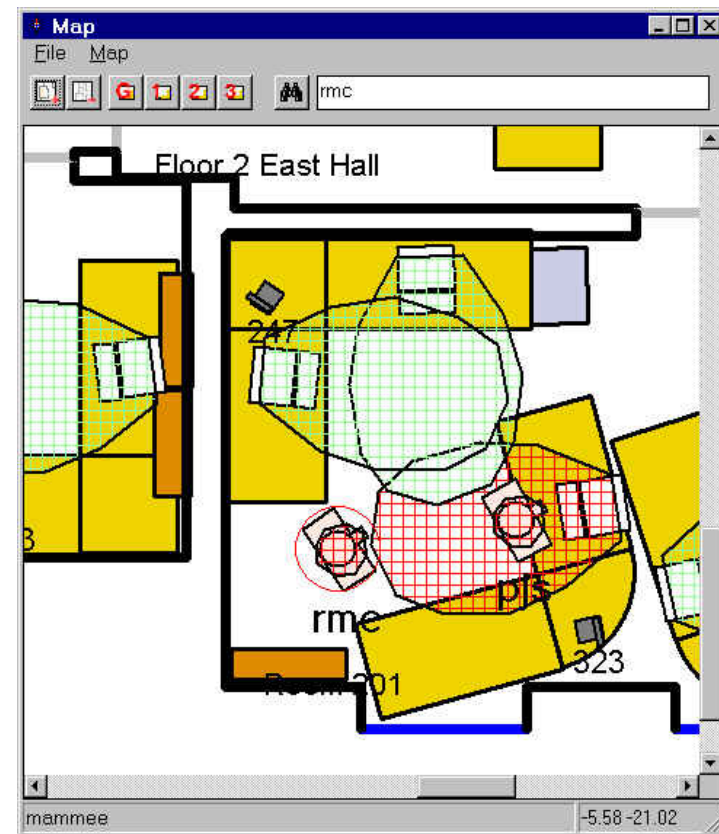
- Three base stations in 20m x 20m space
- 2D accuracy test
- 95% confidence contours



Ubisense

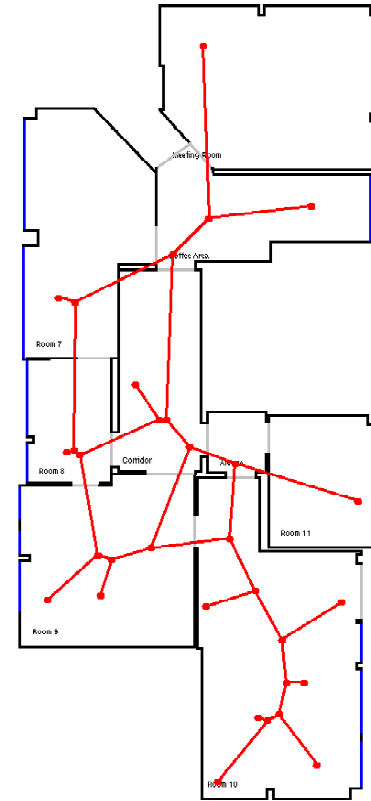
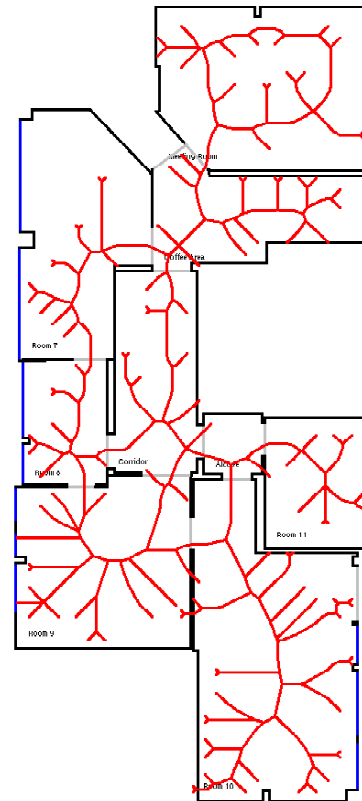
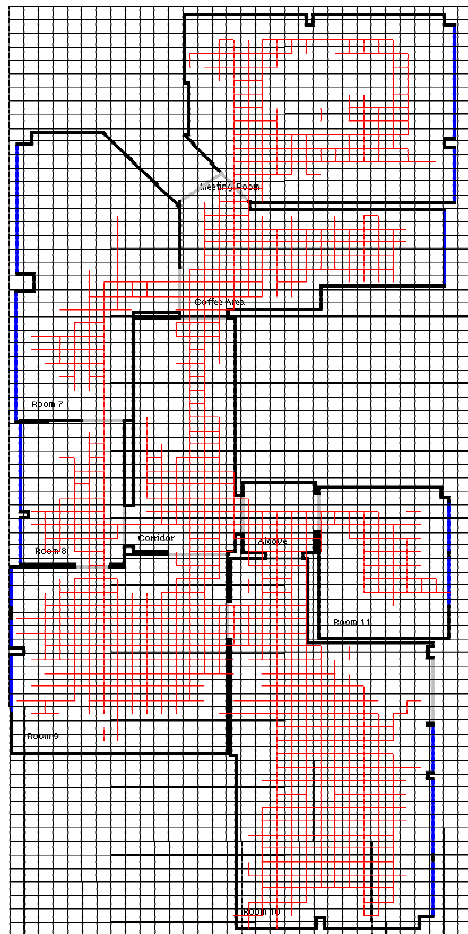
# Programming with space

- Roll the GUI out onto the carpet...
  - People are now cursors!
  - Active regions on “floor”
- Spatial index:
  - Define spaces
  - Monitor interactions
  - Generate events
    - *Containment*
    - *Overlapping*
  - +ve and –ve events
- API is sensor agnostic



# Environment Discovery

R.Harle



**Create linkage diagram, prune and refine topological map**

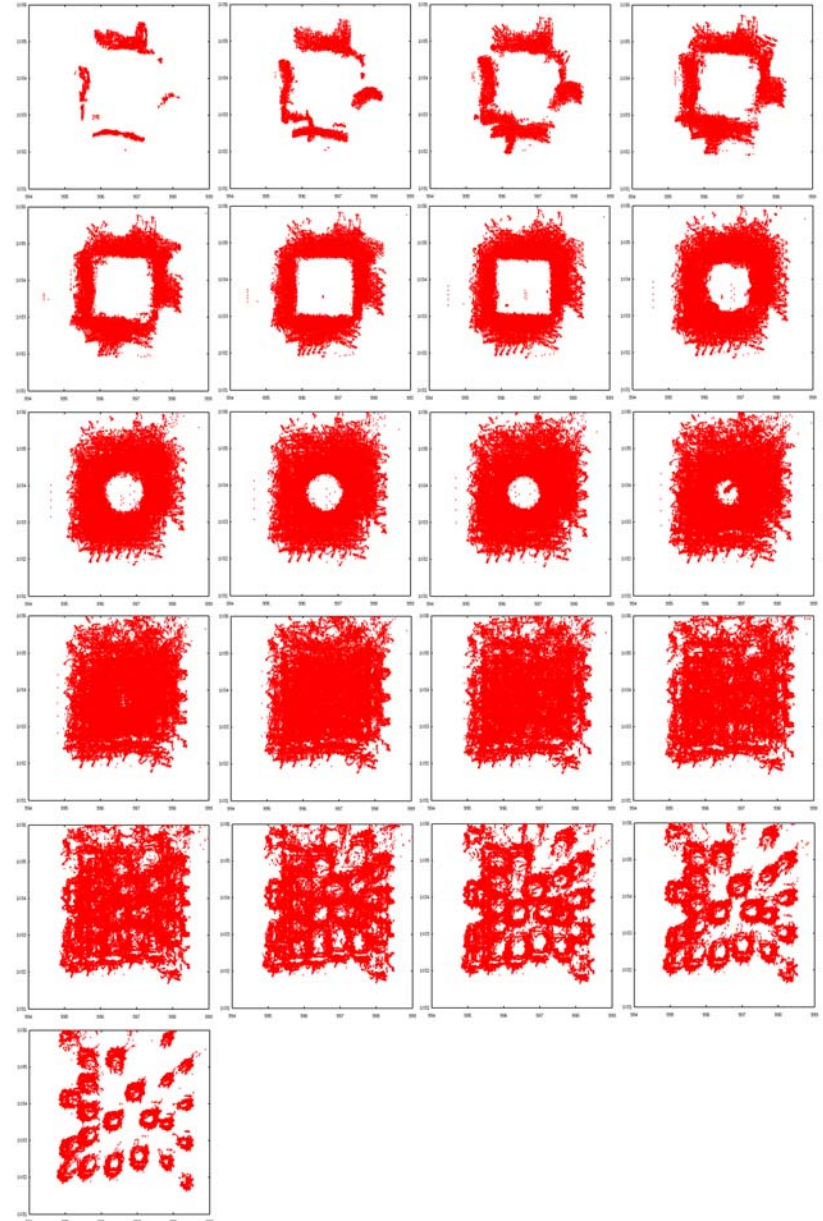


# Environment Discovery

R.Harle

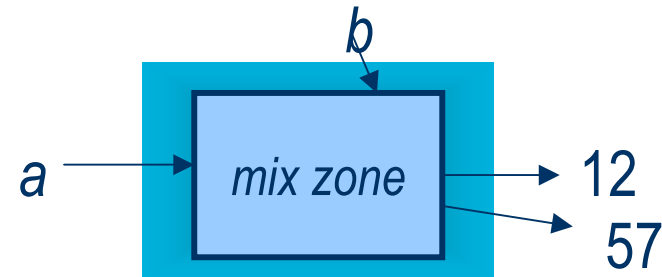
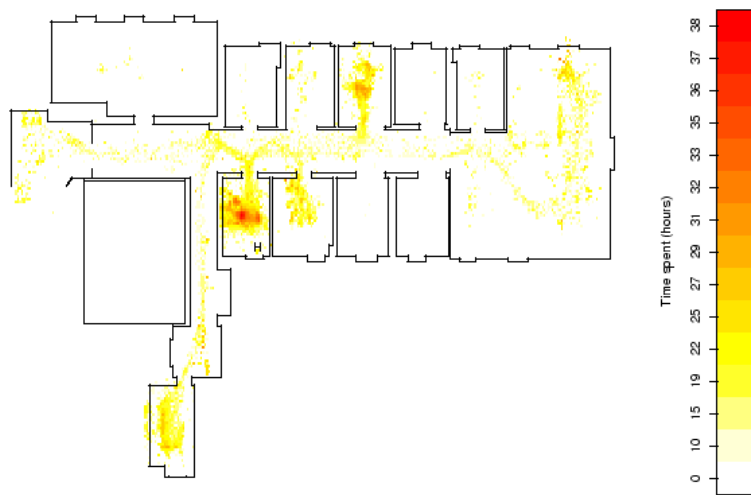


Use ray-tracing to update world model



# Location Privacy

A.Beresford, F.Stajano

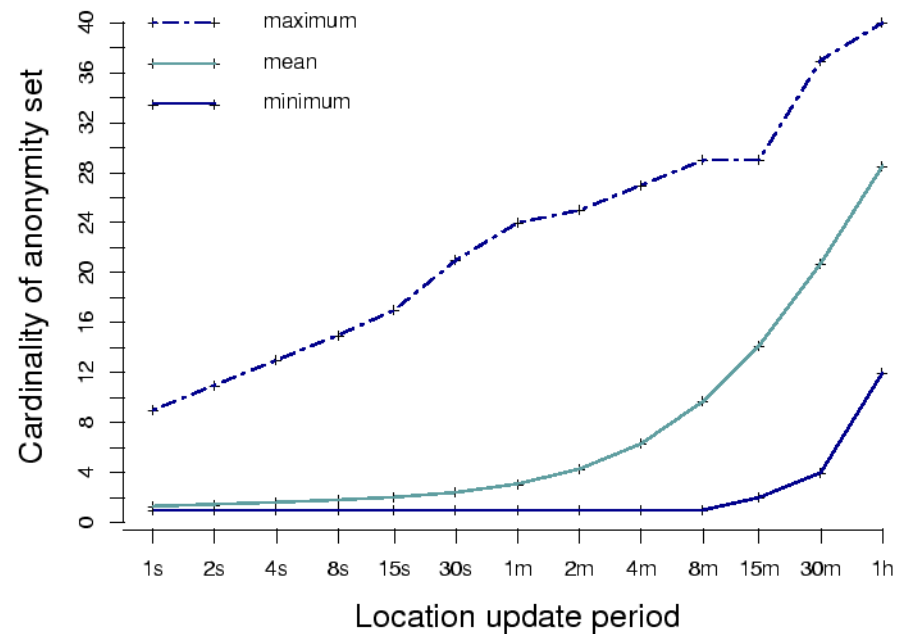


**Frequently changing pseudonyms**

**Mix zones**

**Level of anonymity**

**Do we really mix?**



# What has been achieved since 1988?

ORL

## Location Display Program

ORL/STL Active Badge Project					
Name	Location	Prob.	Name	Location	Prob.
P Alnsworth	X343 Accs	100%	J Martin	X310 Mc Rm	100%
A Mohammed	X222 DVI Rm.	80%	O Mason	X307 LAB	77%
M Chopping	X410 R302	TUE	D Milway	X307 Drill	AWAY
D Clarke	X316 R321	10:30	B Miners	X202 DVI Rm	10:40
D Garnett	X218 R435	11:20	P Mital	X213 PM	11:20
T Glauert	X232 R310	100%	J Porter	X398 LIB	100%
S Gotts	X0 Rec.	100%	B Robertson	X307 LAB	100%
D Greaves	X304 F3	MON	C Turner	X307 LAB	MON
A Hopper	X434 AH	100%	R Want	X309 Meet Rm	77%
A Jackson	X308 AJ	AWAY	M Wilkes	X300 MW	100%
A Jones	X210 Coffee	100%	I Wilson	X307 LAB	100%
T King	X309 Meet Rm	11:20	S Wray	X204 SW	11:20
D Lloupls	X304 R311	100%	K Zielinski	X402 Coffee	100%

12.00 1st January 1990

- Display of names and the nearest extension
- Location probability / Time or Day last seen
- Command Line Interface
  - FIND
  - LAST
  - WITH
  - LOOK
  - NOTIFY
  - HISTORY (1/2Hr)

Active Badges

ORL

## Active Badge Applications

### Location System

- Intelligent telephone call routing
- Secretarial aid for the office
- Tagging laboratory equipment
- Logging use of time and facilities
- Security (when combined with motion sensors)

### Authenticated Badges

- Building Access Control
- Access to computer facilities
- Drug dispensing in hospitals

### Future Implementations

- Badge : Small ASIC design combining beacon with authentication device
- Network: Integrated Buildings (Fire, Smoke, Lighting, Heating, Security, Location)

Active Badges

# Observations

- Raw sensor data and simple logic works
  - Publish user's context
  - Follow-me VNC desktop
  - 0-D control device
- Domain specific agents work
- Feedback to user is very helpful
- Nothing else works (as yet...)
- Inference and prediction rapidly hit a brick wall

# Ubiquitous? Pervasive? Ambient? Calm? Sentient?

- Postulate “Perfect Sensor System”
- How to define context, semantics of queries, user intent
- Will statistical inference work?
- Can functional tests provide foundations?
- How will user interact?
- Is this research area in danger of being discredited?