Mobile and Ubiquitous Computing
Privacy, Security and Trust

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Overview

- Security of RFID
- Privacy and UUIIDs in RFID
- Location data and analytics
- Can we trust mobile and ubiquitous systems?

Unauthorized data access

- Poor access control is common
- Open source software
- Easy availability of portable readers
- Metro Future Store price modifications
- More details at http://www.rfdump.org

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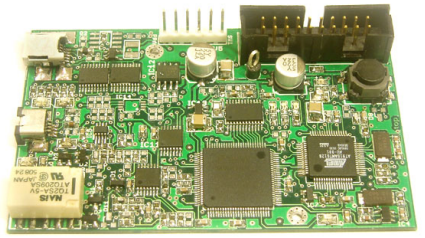
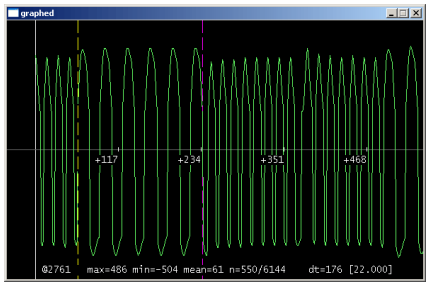
Cloning

- Implantable Verichip
- Custom hardware proxmark3
- Capture of transmission
- Analysis of signal (not simple replay) and ID extraction
- Transmission of recorded ID
- Similar device for HF tags is the HF Demotag





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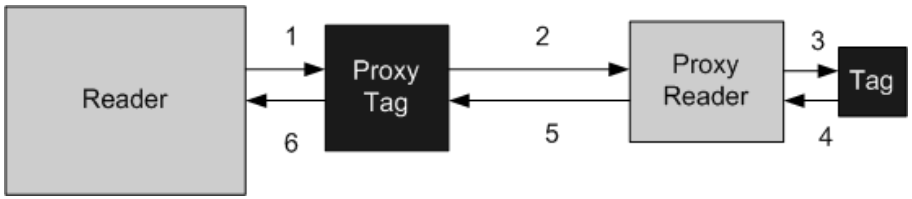
Relay attacks

- Classic “man in the middle” attack
- Works because the actual range is far greater in practice
- Theorized in 2005, implemented in 2006
- Simple modifications to COTS equipment
- Distance 2 can be unlimited e.g. mobile communication
- Distance 3 can be up to 4 meters



Data injection

- a.k.a. RFID virus http://rfidvirus.org
- Classic buffer overflow attack using EPC data
- Captured public imagination
  - your cat carries a computer virus…
- Limited scope in practice

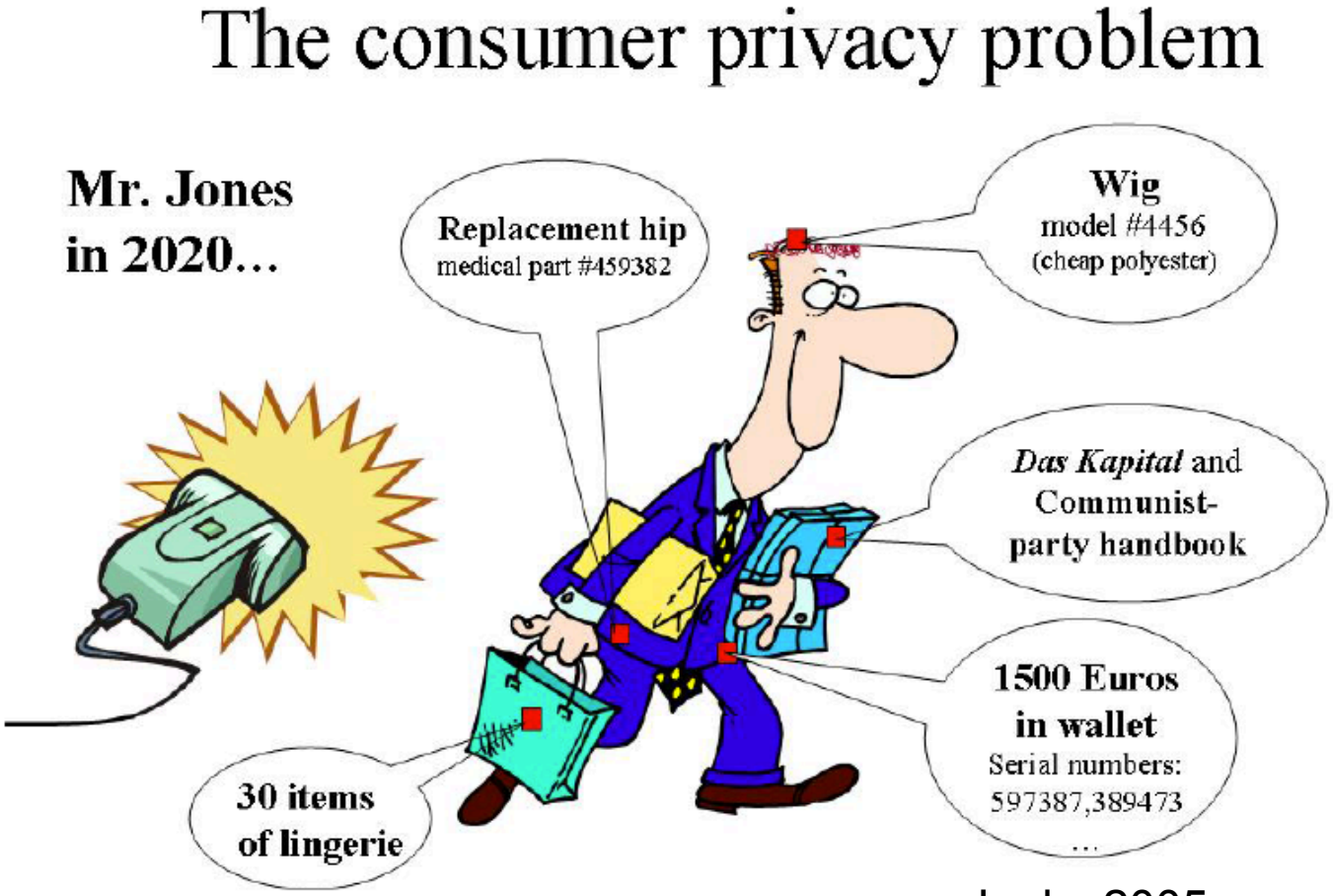
Resolution service attacks

- Object Naming Service (EPCglobal) and OID Resolution Service (ISO)
  - developed on top of DNS
- Inherit well known vulnerabilities (RFC 3833)
  - packet interception, query prediction, cache poisoning, server betrayal, DoS
  - affect integrity and
- Some limitation of directory integrity concerns due to single domain operation under EPC
- Client access issues completely dependent on correctness of query responses
- Access control of ONS non-existent

Tracking

- Mostly an open question due to limited practical experience
  - Lessons to be learnt from location privacy
- EPC Standards describe global repository of track and trace information
- Complex access control and trust federation issues
- Major privacy concerns

RFID Constellations

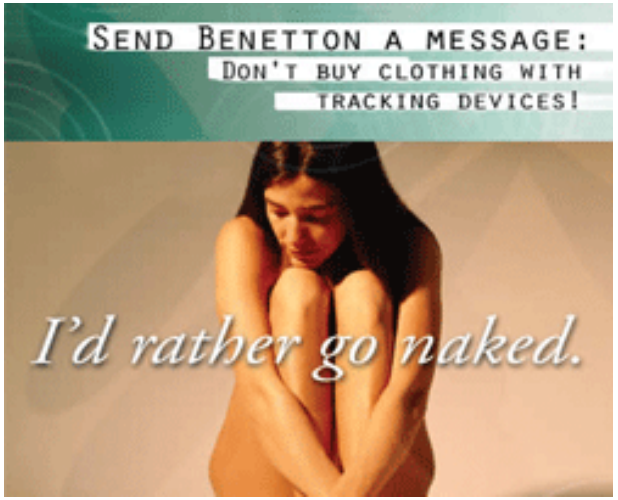


Juels, 2005

Tag Constellations Uniquely Identify an Individual

Privacy debate

- RSA CEO “would be very worried of his privacy” (quoted by InfoWorld, April 2004)
- EPC Europe VP says “there are more myths in RFID than there are in Greek mythology” (quoted by BBC, April 2004)
- Sisley trial (Sisley is a Benetton brand)
  - Announced 11 Mar 2003,
  - CASPIAN calls for boycott 13 Mar 2003,
  - Sisley withdraws plans 15 Mar 2003



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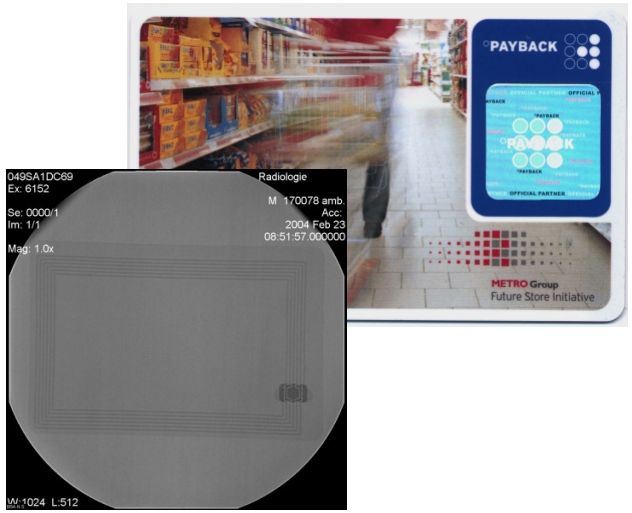
Real-world problems

- Metro Future Store
- http://www.future-store.org
- Violations of own privacy statements



Information is our concern

METRO Group will be pleased to inform you about the background and benefits of new technologies also in future. We will tell you where RFID tags are used, what product information is contained and, above all, how you as a consumer can take advantage of such information.

By the way:

- Wherever RFID is used, this is made visible.
- The chips exclusively store product data but no customer data.
- Outside the Extra Future Store the RFID tags become inoperable.

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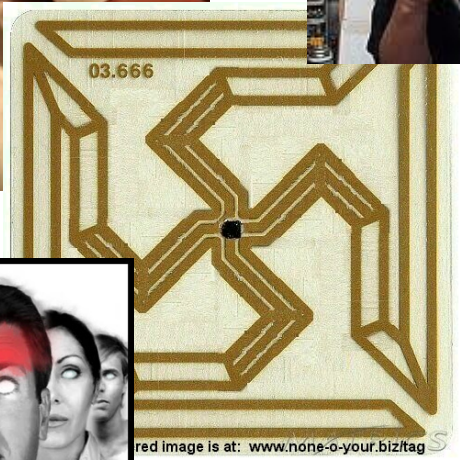
Strong sentiments



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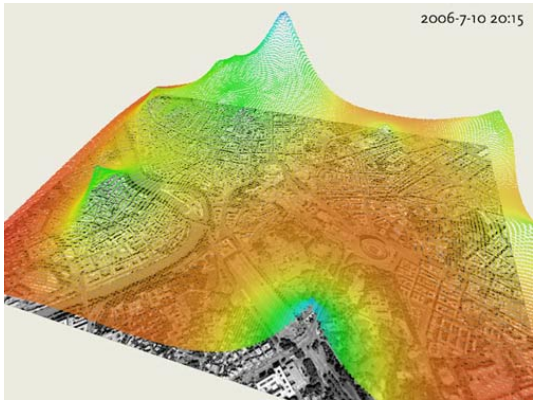
True concerns

Participatory Applications

Participatory Air Quality Sensing



Sense Networks

www.sensenetworks.co

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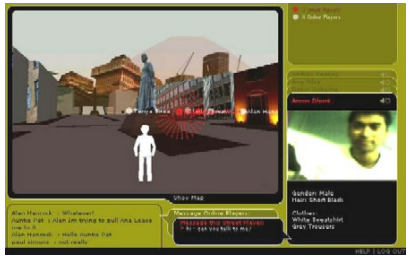
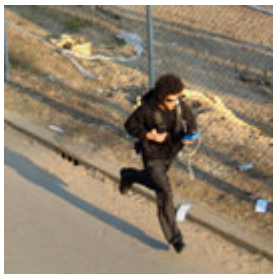
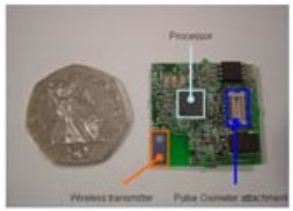
Gaming and healthcare

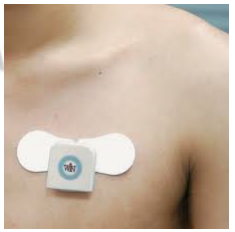
Uncle Roy All Around You
Equator





Medical Body Wireless Sensor Networks





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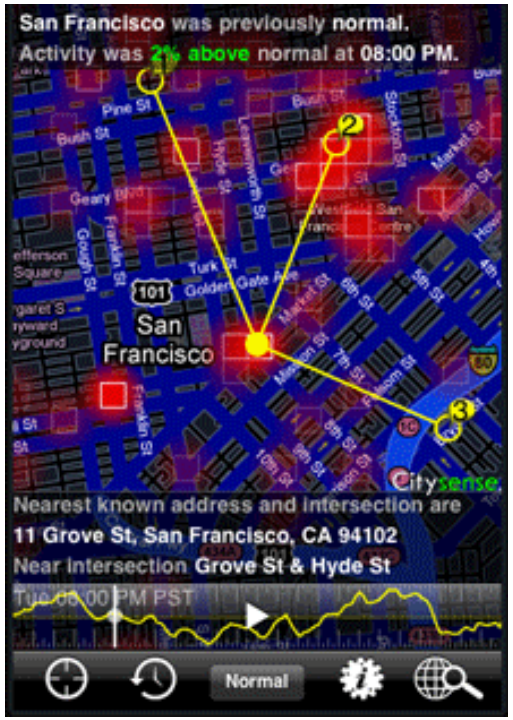
Significant locations

- Identify significant places
- Use mobile phone location records
- Identify hot-spots of activity
- Time specific
- Commercially available through Sense Networks
- Track real-world consumer behaviour



sensenetworks.com

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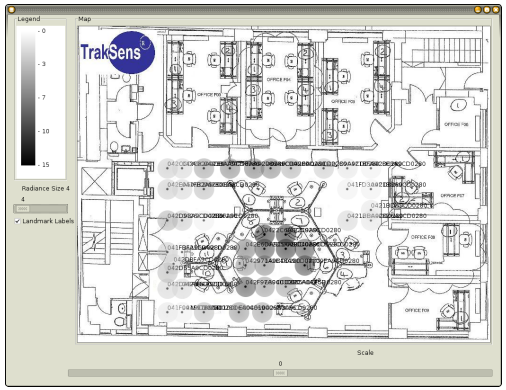
RFID Analytics

- RFID-tagged products and locations
- Scan traffic at specific chock points
- Analyse traffic and identify hot-spots or problem areas
- Visual tools
- Different spatial resolution

Illic *et al*, Auto-ID Lab Zurich



TrakSens

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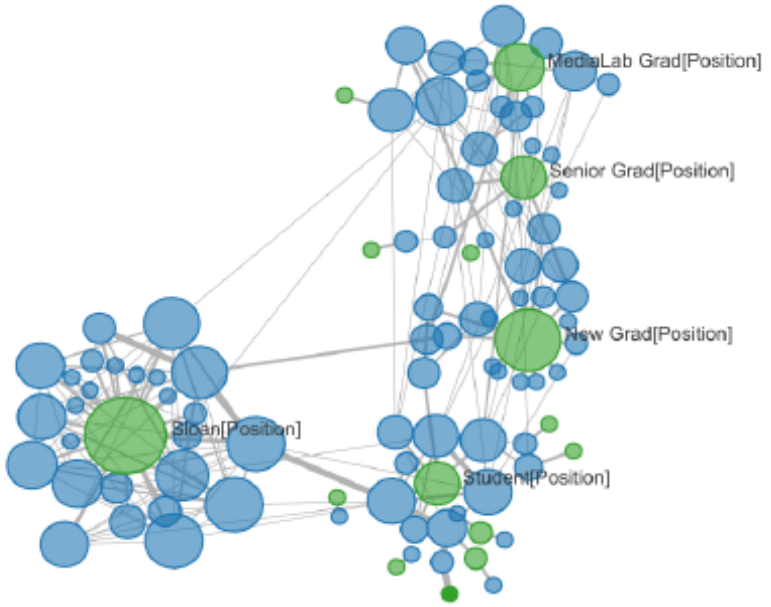
Social networks

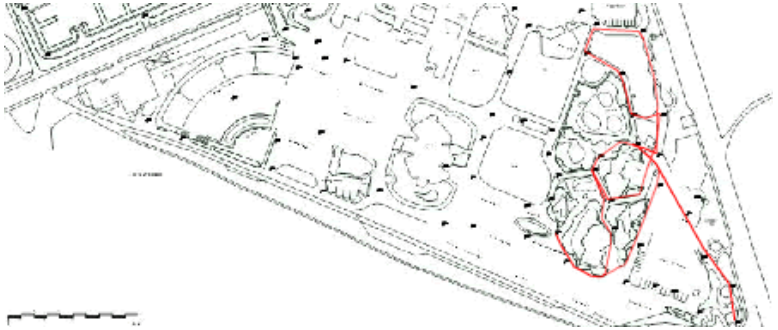
- Observe social networks in the real world
- Tag and rank location of individual
- Identify meetings through collocation or device-to-device interaction
- Create social network graph
- Conduct analysis
- Reality mining data set



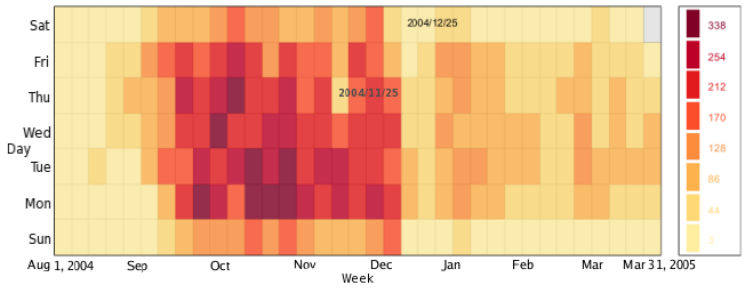
Shen *et al*, UC Davies

Patterns of behaviour

- Identify typical behaviours
- Possibly context and task specific
- Applications in navigational assistance, personalisation, recommendations
- Best-trails i.e. most popular pathways followed
  - GPS data from London Zoo
- Daily activity patterns
  - Reality Mining data



Experience Recorder



Shen *et al*, UC Davies

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Prediction

- Predict driver destination
- Use dense grid to identify locations
- Metric representations of space extremely costly
- Machine learning to identify common behaviours
- Used for navigational assistance

Krumm *et al*
Microsoft Research

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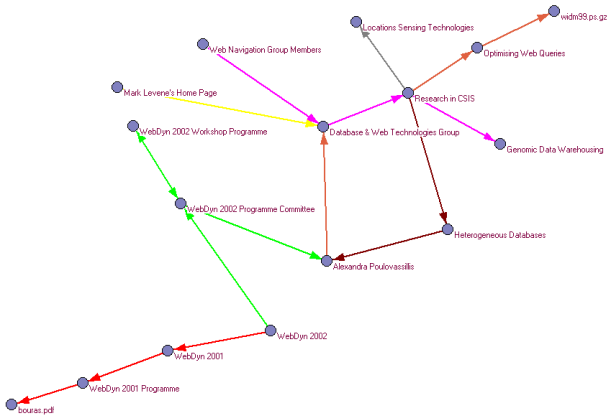
Navigational assistance

- Find best route between two places
- Use data from an expert data set
- Taxi drivers are considered experts in this task
- Navigate like a cabbie
- Similarities of geographic navigation and web navigation

Ziebart *et al*, CMU



Navigationzone.net

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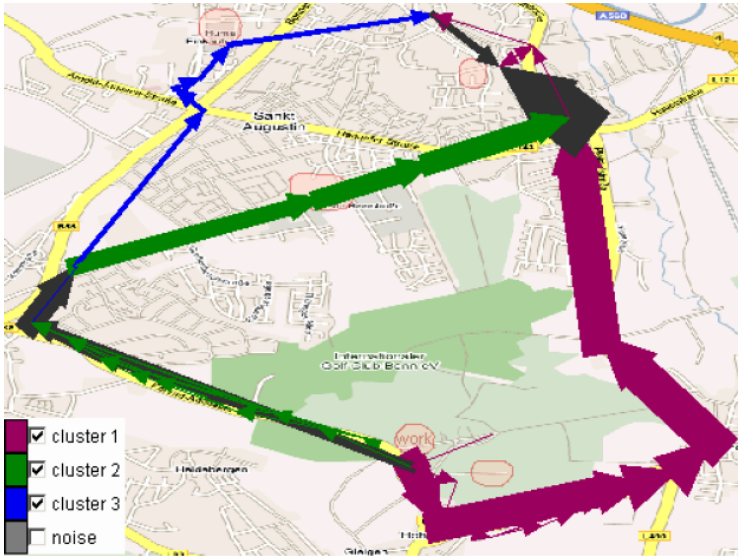
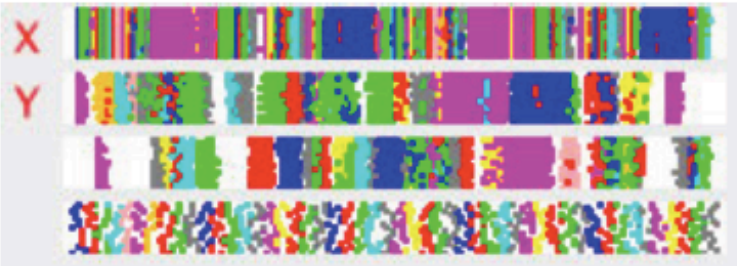
Summarization

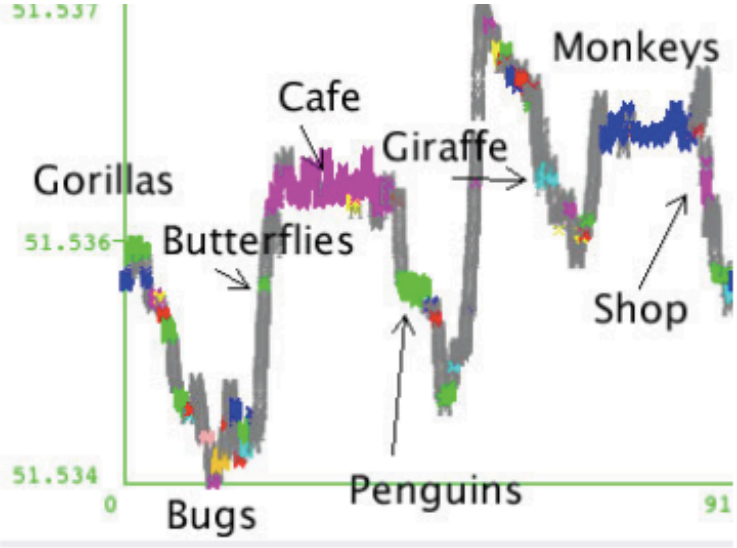
- Reduce a complex data set to typical behaviours
- GSM tracks over metropolitan area
- Cluster typical behaviours in profiles
- Use road graph to identify sequences
- Topological descriptions of space are more efficient



Adrienko *et al*
Fraunhofer IAIS

Points of Interest analysis





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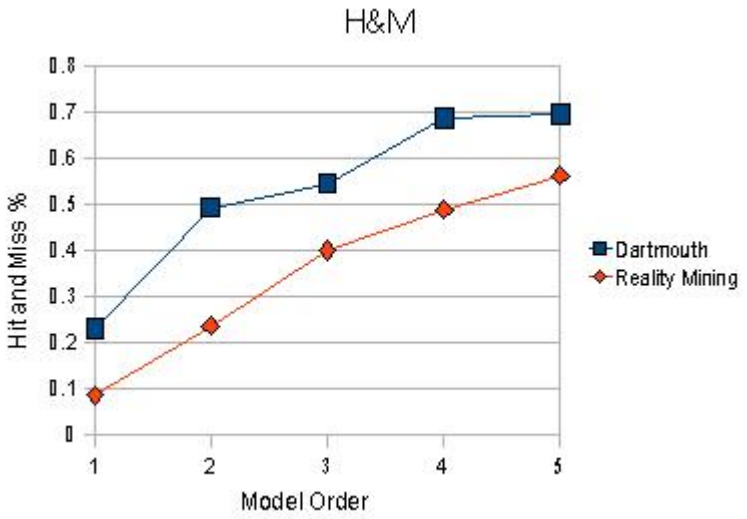
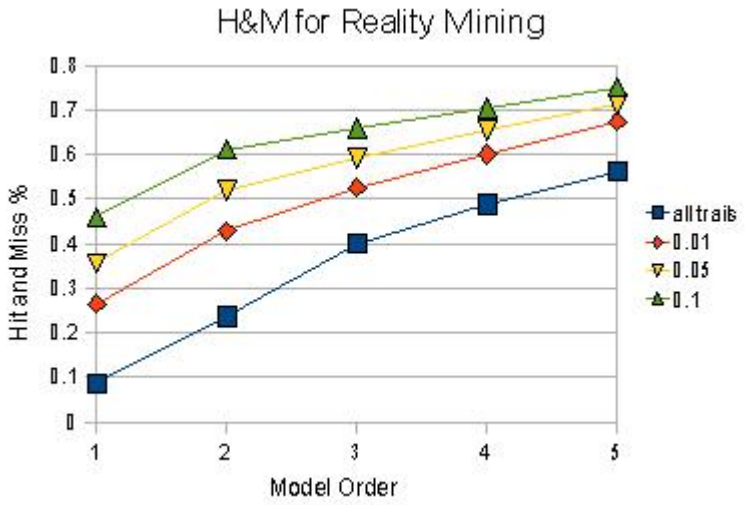
Location inference



Using all trails in the data set.



Using best trails only.

Using wifi traces from the Dartmouth and RM datasets

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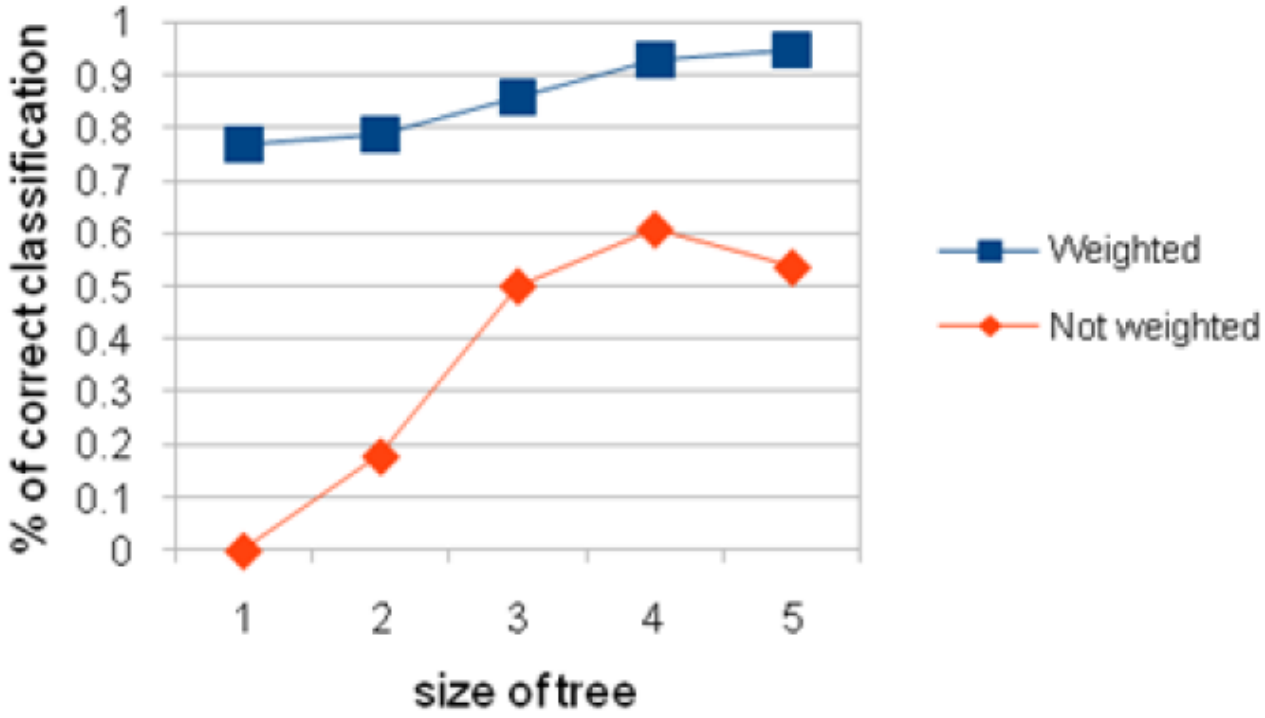
Identify individual without ID



Reality-mining data set

Identify user 39 using 2 months for training and test on next month

Privacy in the US

The right to be Let Alone:

The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

Fourth amendment of the Bill of Rights

Privacy in Europe

- Honour and dignity in the public sphere

Everyone has the right to respect for his private and family life, his home, and his correspondence

European Convention of Human Rights

Two Major Issues

- System operation is transparent
  - invisible, everywhere computing
  - guarantee the rights of consumers
- Trust is an emotional process (trust is different to trustworthiness)
  - overall acceptance of MUC depends on whether it is perceived as used fairly
  - strategy cannot be based on expected public apathy because this can backfire cf. nuclear power

Trusting RFID: Assessment

- Privacy Impact Assessment Framework
- A principled method for assessing threats to privacy for the general public
- Initial stage of EU mandate on RFID
- Very limited uptake
  - often accused as too onerous or costly
- Includes provisions for RFID emblem
  - similar to CCTV notification

Regulation

1. Initial entitlement:
   - Allocation of property rights
   - Who should get the initial right to control the information generated by RFID?
2. Coercion and choice:
   - If you want discount you will get the chip.
3. Societal overrides:
   - When does society, regardless of your preference, get access to the data anyway?