

Challenges for Pervasive RFID-based Infrastructures

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An infrastructure for RFID-based pervasive applications

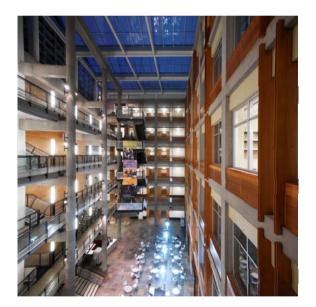
- Create a microcosm of a world saturated with uniquely identifiable objects
- 7 floors, 90,000 sq. ft.
- 100s of readers, 1000s of tags
- Explore applications, systems, social implications
- Groups: Database, Security, Ubicomp, and others

Participants:

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- Waylon Brunette
- Garret Cole
- Magda Balazinska
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 - Tadayoshi Kohno
 - Karl Koscher

- Travis Kriplean
 Robert Spies
- Patricia Lee
- Caitlin Lustig

- Dan Suciu
- Jordan Walke
- Vibhor Rastogi
 Evan Welbourne

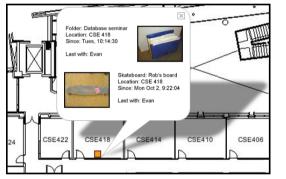




- Applications
- System Architecture
- Benchmarking & Pilot Study
- Results
- Update & Work in Progress
- Conclusion



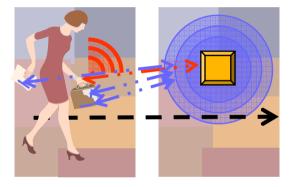
- What can we do if we tag everything?
- Seamless merging of the virtual and physical worlds



Personal Object Tracking and Search

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Personal Time Use Diary with Analysis



Proactive Reminder Systems



Smart Spaces



Activity Recognition



- How to design an infrastructure for pervasive RFID apps?
- Key Problems:

Shared with supply chain:

- Many data sources
- Unreliable sensors
- Massive amounts of data

<u>New:</u>

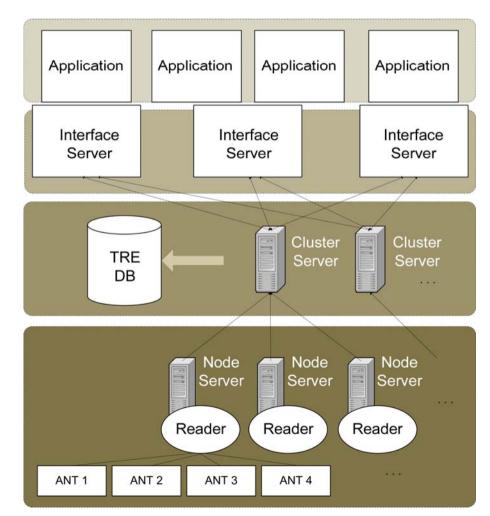
Diverse, evolving applications

- □ Many more distinct users
- □ Data sharing and privacy
- □ Less predictability

System Architecture

- Goals: Privacy-oriented, Reliable, Extensible, Scalable
- Application
- Interface servers

 Streams and event detection
 Provisioning
- Cluster Servers
 Privacy policies enforced
 Storage
- Node Servers
 Low-level smoothing





- 2 week pilot study to gain insight
 - □ Gen 1 technology
 - □ 11 readers, 34 antennas hung in hallways
 - □ 6 participants
 - □ 54 tags registered

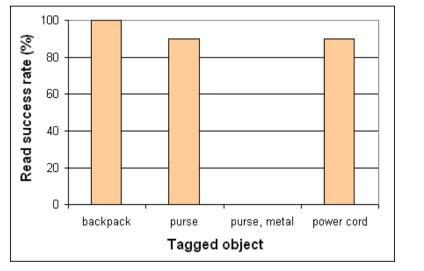
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- Participants could query the data with a web application
 - □ "Where is X?"
 - □ "How much time have I spent in the building this week?"
- A web diary and annotation system provided ground truth



Laboratory vs. Reality

Significant difference between laboratory studies and reality



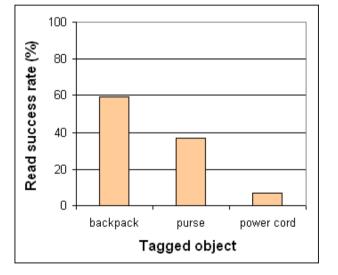
Benchmark results

Pilot study results



Consider erroneous data and unpredictable streams

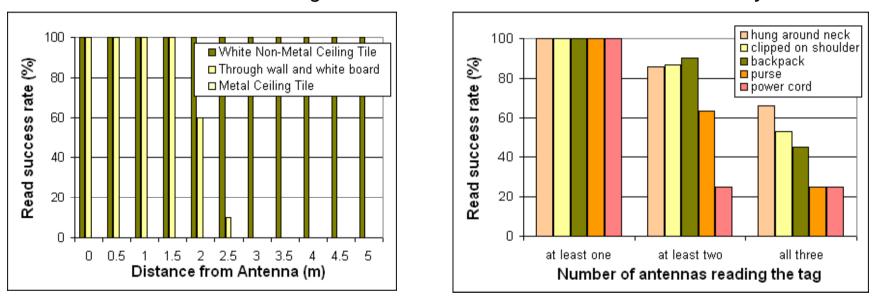
StreamClean system for probabilistic smoothing of data





Antenna Mounting Configurations

Data from Pilot Study



Data from Benchmarking

Consider the material properties of mounting configurations

Leverage different kinds of redundancy



- Easy inference using objects carried and time of day
 A simple script could detect lunch breaks with > 75% accuracy
- Location privacy concerns
- Users want control of their data
- Must protect non-users as well!

Really need a privacy policy in place during data collection

Physical Access Control (PAC) Policy

Project Status Update

http://rfid.cs.washington.edu/

✓ Deployment phase 1

- □ Gen 2 technology
- □ 35 readers, 150 antennas
- □ 100 tags
- □ Floors 2 6
- □ 200,000 TREs per week

✓ Web application framework

✓ Asset tracking application



Ongoing Projects

http://rfid.cs.washington.edu/

- Applications

 Design and evaluation
- Privacy
 - Policies
 - □ Formal methods for data privacy
 - Evaluation through user studies
- Reliability
 - Data cleaning
 - Probabilistic data management

Performance

- □ Stream processing
- Data model and warehousing



Requirements are much different than supply chain

- RFID research grounded in the real world pays off
- Physical challenges:
 - □ Greater than expected
 - □ Specific to the environment
- Privacy challenges:
 - Many possible models/controls
 - Difficult to find evaluation metrics
- System challenges:
 - Inaccurate data
 - Long-lived applications
 - Historical data need to summarize How?



- Please see <u>http://rfid.cs.washington.edu</u> for more details
- Questions?



Possibly for use in discussion.

Initial Privacy Policy

(with Travis Kriplean)

- Goal:
 - Reasonable peer-level privacy policy that allows user studies
 - Practical to implement
 - □ Extensible for greater utility
- Physical access control (PAC)
 - □ Each user carries a personal ID tag
 - Users can only obtain information about events that occurred when & where the user was physically present
 - □ Constrains privacy concerns to those found in wearable computing
 - □ *This is a baseline policy*: additional permissions may be granted



- Fine-grained (row-level) access control is necessary for PAC
 Human activity is inherently fine-grained
- Standard techniques:
 - Access control lists
 - □ Virtual Private Database (Oracle 9iR2)
 - □ Authorization views (Rizvi, Mendelzon, Sudarshan, and Roy)
- We introduce materialized authorization views
 Hybrid of access control lists and authorization views

Materialized PAC Views

