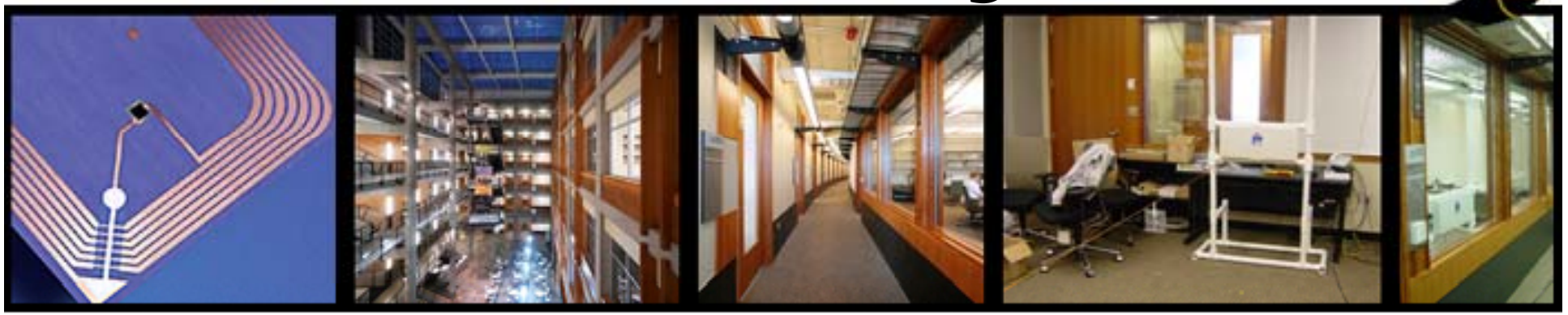
The RFID Ecosystem



Challenges for Pervasive RFID-based Infrastructures

Evan Welbourne, Magdalena Balazinska, Gaetano Borriello, Waylon Brunette
Computer Science & Engineering
University of Washington

PERTEC Workshop, PERCOM 2007
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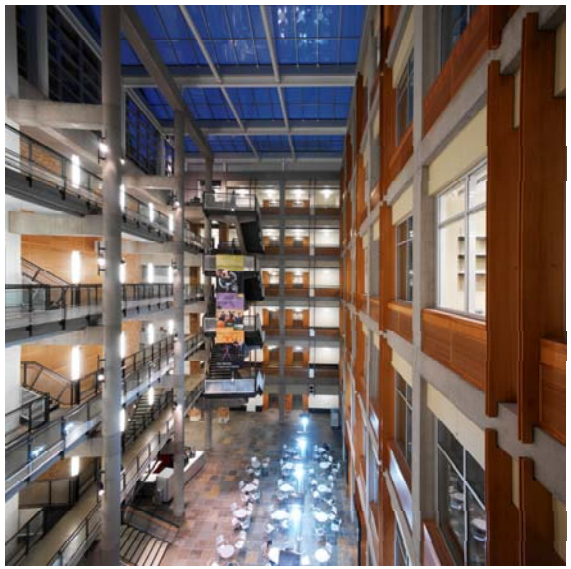
RFID Ecosystem at UW CSE

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

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:

- Yaw Anokwa
- Magda Balazinska
- Gaetano Borriello
- Waylon Brunette
- Garret Cole
- Nodira Khoussainova
- Tadayoshi Kohno
- Karl Koscher
- Travis Kriplean
- Patricia Lee
- Caitlin Lustig
- Vibhor Rastogi
- Robert Spies
- Dan Suciu
- Jordan Walke
- Evan Welbourne

Overview

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

Pervasive RFID Applications

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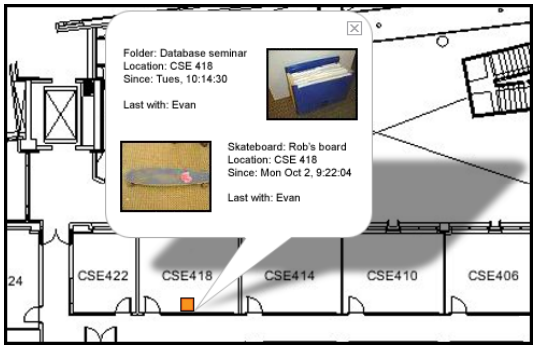
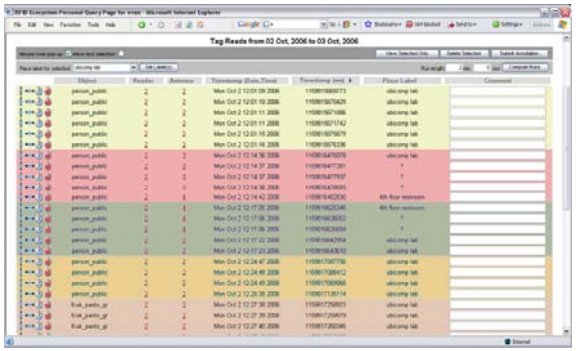
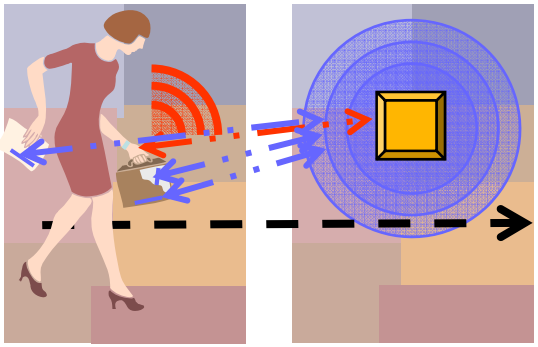
- *What can we do if we tag everything?*
- Seamless merging of the virtual and physical worlds



Personal Object Tracking and Search



Personal Time Use Diary with Analysis



Proactive Reminder Systems

Smart Spaces

Activity Recognition

What's New?

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

Shared with supply chain:

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

New:

- Diverse, evolving applications
- Many more distinct users
- Data sharing and privacy
- Less predictability

System Architecture

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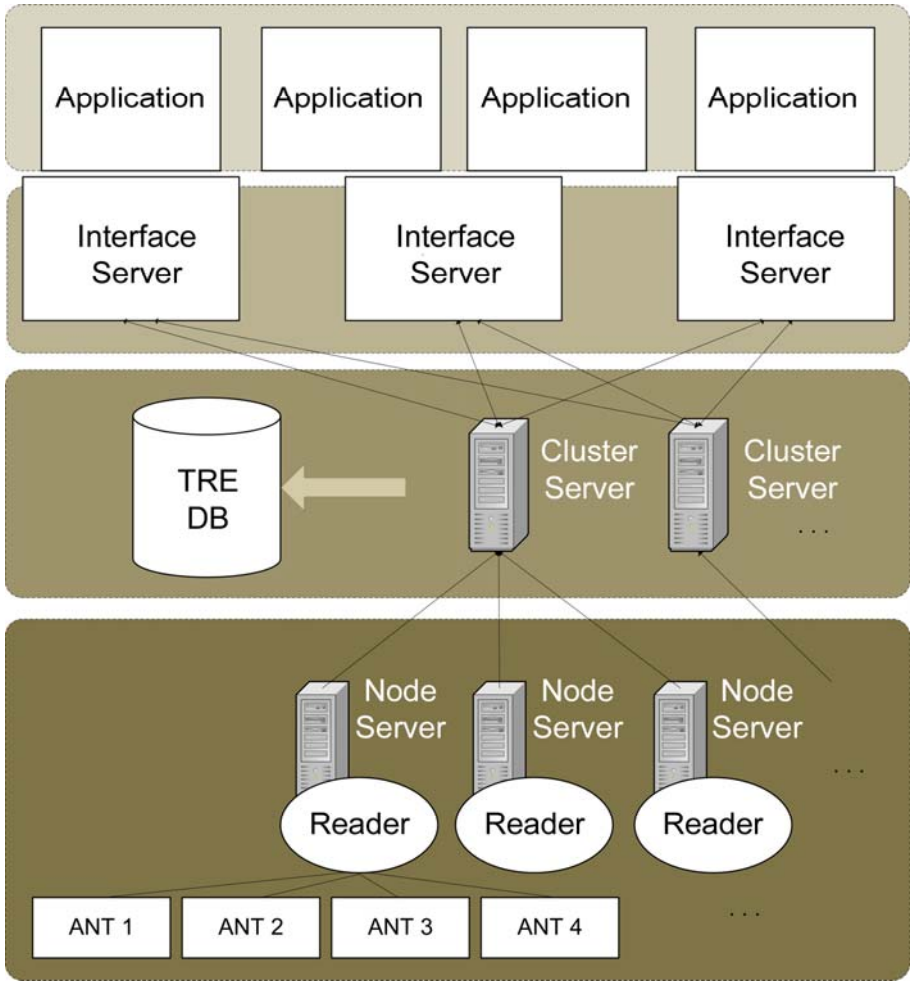
- ***Goals: Privacy-oriented, Reliable, Extensible, Scalable***
- Application
- Interface servers
  - Streams and event detection
  - Provisioning
- Cluster Servers
  - Privacy policies enforced
  - Storage
- Node Servers
  - Low-level smoothing



Pilot Study

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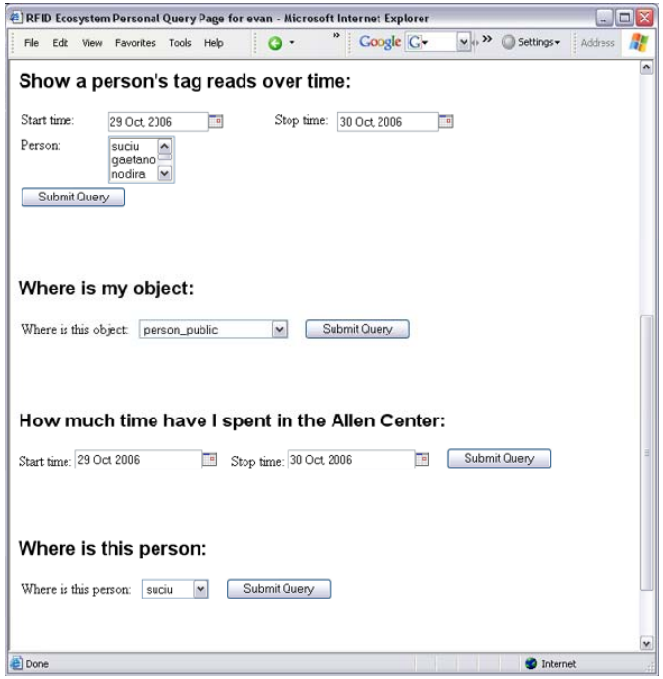
- 2 week pilot study to gain insight
  - Gen 1 technology
  - 11 readers, 34 antennas hung in hallways
  - 6 participants
  - 54 tags registered



- 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

Finding: Deployment Logistics

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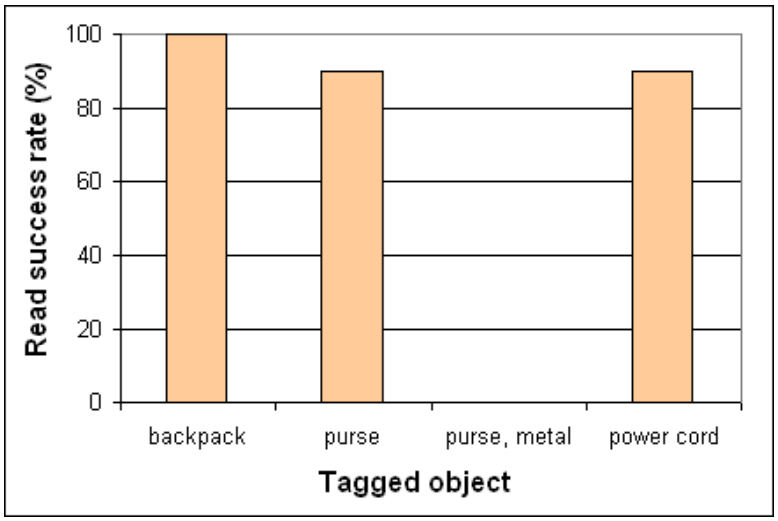
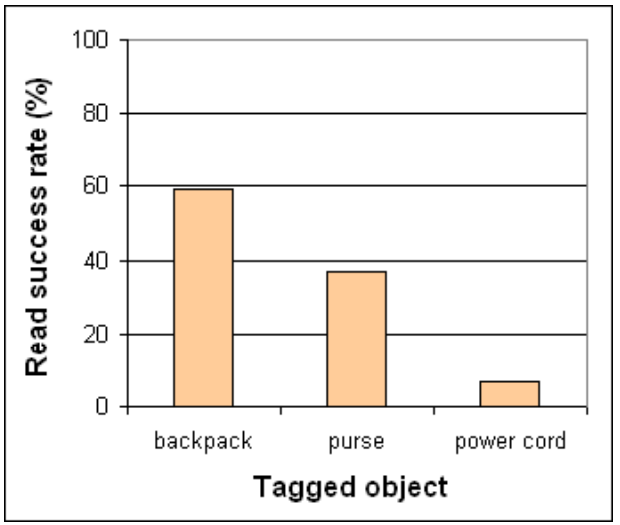
Laboratory vs. Reality

- 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*

Finding: Deployment Logistics

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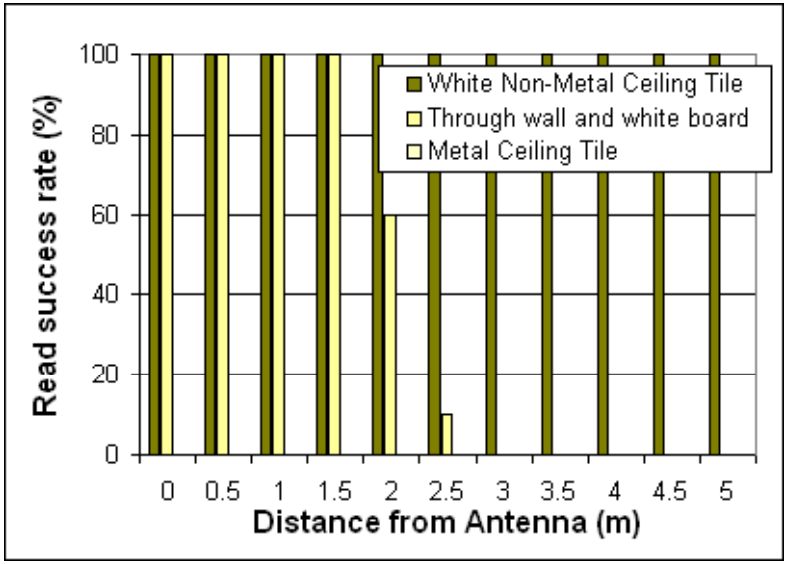
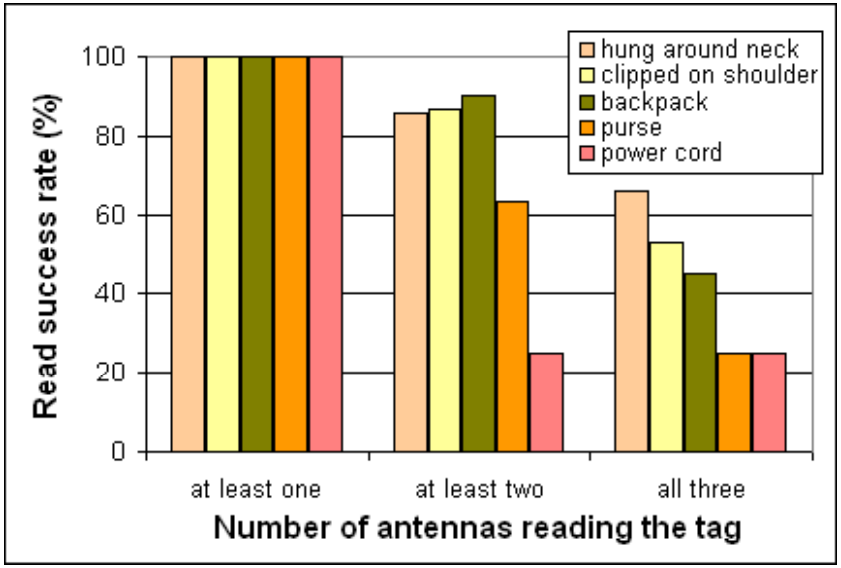
Antenna Mounting Configurations

Data from Benchmarking



Data from Pilot Study



- Consider the material properties of mounting configurations
- Leverage different kinds of redundancy

Finding: Privacy

- 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

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- ✓ 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

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- 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

Conclusions

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- 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?

Thank you!

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- Please see http://rfid.cs.washington.edu for more details

- Questions?

Additional Slides...

- Possibly for use in discussion.

Initial Privacy Policy

(with Travis Kriplean)

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- 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 Access Control

- 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

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