The RFID Ecosystem

Experimenting with a Pervasive RFID-based Infrastructure

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Create a microcosm of a world saturated with uniquely identifiable objects

100s of readers and antennas, 1000s of tags

Explore applications, systems, and social implications

Do it while there is still time to learn and adapt

Groups: Ubicomp, Databases, and others

Participants include:

- Magda Balazinska
- Gaetano Borriello
- Waylon Brunette
- Brian DeRenzi
- Nodira Khoussainova
- Karl Koscher
- Patricia Lee
- Robert Spies
Overview

- Review of RFID Basics
- Applications
- Research Questions
- System Architecture
- Evaluation
- Future Work
Radio-frequency identification
- Uses radio frequency (RF) signals to identify (ID) an object
- Wireless, does not require line-of-sight

Tags are attached to an object
- ID *uniquely* identifies an object, not just its class
- Can include other information:
  - Current state
  - Location
  - History
- Tags are *active* (battery) or *passive* (no battery)

Readers interrogate tags
- Readers and their antennas are installed in a fixed position
- Readers are equipped with networking and power
RFID Applications

- RFID in the supply-chain
  - Boosts throughput, makes for an agile supply chain

- Pervasive computing applications based on RFID
  - More consumer-oriented
  - Use a pervasive deployment of RFID technology
    - Everyday life setting
    - Personal objects and people are tagged
    - Seamless merging of the virtual and physical worlds
Research Questions

How to design an infrastructure for pervasive RFID apps?
- Applications grow and evolve over time
- People and objects are less predictable than the supply chain
- Privacy and security are first class concerns

How is the mass of data managed?

How are applications with real-time demands supported?

Implications for technology, business, and society?
Overview

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Goals:
scalable, reliable, extensible, secure, and privacy-oriented

Node Servers
- Low-level filtering; forward tag reads

Cluster Servers
- Store tag reads, forward if appropriate

Interface servers
- Event generation, stream processing

Application
Laboratory Benchmarking

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- Characterize performance of equipment in optimal conditions
- Evaluate equipment in various deployment configurations
Pilot Study

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

- Participants could query the data with a web application
  - “Where is object X?”
  - “Where is person Y?”
  - “How much time have I spent in the building this week?”

- A web diary and annotation system provided ground truth
Challenge: Reliability

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- Consider tag mounting/orientation and antenna configuration
- Exploit redundancy among antennas

- Consider erroneous data and unpredictable streams

**Benchmark results**

- **Tagged object**:
  - backpack, purse, purse, metal, power cord

**Pilot study results**

- **Tagged object**:
  - backpack, purse, power cord

**Pilot study redundancy results**

- **Number of antennas reading the tag**:
  - at least one, at least two, all three

- **Read success rate (%)**
Other Challenges

- Remember health regulations
- Aesthetics matter
- Test each installation point
- Plan for broken tags

- Much can be inferred from objects carried and time of day
  - A simple script could detect lunch breaks with > 75% accuracy

- Typical location privacy concerns
- Must allow participants to delete any of their data at any time
- Must protect non-participants (RFID tags already pervasive)
Future Work

- Continue to develop techniques for increased reliability
- Refine the privacy model
  - Access control
  - Data anonymization and perturbation techniques
  - Location privacy techniques
- Incorporate phones with NFC technology for mobile readers
- Conduct longitudinal studies with a variety of applications
- And more…
Thank you!

Also see our posters

- Ubicomp lab:
  - *RFID Ecosystem: Experimenting with a Pervasive RFID-based Infrastructure*
  - *Towards Privacy and Security in the RFID Ecosystem*
  - *A User Interaction Model for NFC Enabled Applications*

- Database lab:
  - *StreamClean: Near Real-Time RFID Data Cleaning*

- Questions…

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