Ubiquitous Computing using Wireless Broadcast

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Ubiquitous Computing Applications

- Adapt their behaviors based on the user’s current situation
  - e.g., current location, nearby devices
- Source of the situation information
  - Sensors
  - Services in the environment or the Internet
Building Applications – Infrastructure-based Approach

- Basic idea
  - Applications and data sources live in the infrastructure

- Advantages
  - Users carry minimal devices
  - A variety of data sources are readily available
  - Works well for applications in engineered spaces

- Problems
  - Privacy
  - Complexity/scalability
  - Re-authentication required when crossing domains
Building Applications – Wearable Approach

- **Basic idea**
  - Applications and data sources (sensors) are all carried by the user

- **Advantages**
  - Privacy
  - No infrastructure cost

- **Problems**
  - Size and form factor
  - Battery life
  - Access to connectivity
Our Approach – **Ubiquitous Broadcast Computing**

- Combining the best of both approaches
  - Applications on the client device for privacy
  - Data sources in the infrastructure
  - Use of wireless broadcast for the communication between applications and data sources
Example Application – Location System

- Infrastructure-based approach
  - Bat ultrasonic location system
    - Users carry ultrasound transmitter
    - Networked sensors in the infrastructure
Example Application – Location System

- Wearable approach
  - Scene analysis
    - Camera worn by users
Example Application – Location System

- UBC approach
  - GPS
    - Signal transmitted from satellites (infrastructure)
    - Receiver carried by the user
Ubiquitous Broadcast Computing

- Characteristics
  - Privacy
  - Scalability
  - Universality
  - Incremental deployment
  - Upgradeability
  - Comprehensibility
Ubiquitous Broadcast Computing

- **Characteristics**
  - Privacy
  - Scalability
  - Universality
  - Incremental deployment
  - Upgradeability
  - Comprehensibility

Clients receive broadcast information silently without revealing anything about the user.
Ubiquitous Broadcast Computing

- Characteristics
  - Privacy
  - Scalability
  - Universality
  - Incremental deployment
  - Upgradeability
  - Comprehensibility

Broadcast can support many users simultaneously without requiring more bandwidth
Ubiquitous Broadcast Computing

- Privacy
- Scalability
- Universality
- Incremental deployment
- Upgradeability
- Comprehensibility

Clients do not need authentication, thus can work seamlessly across administrative domains.

Infrastructure providers do not have to worry about compromising their network.
Ubiquitous Broadcast Computing

- Characteristics
  - Privacy
  - Scalability
  - Universality
  - Incremental deployment
  - Upgradeability
  - Comprehensibility

Infrastructure cost can be minimal (e.g., simple wireless sensors can be deployed in any environment without requiring connectivity)
Ubiquitous Broadcast Computing

- Characteristics
  - Privacy
  - Scalability
  - Universality
  - Incremental deployment
  - Upgradeability
  - Comprehensibility

Broadcast data is self-describing and clients can easily find the appropriate parsers and applications for the data.
Ubiquitous Broadcast Computing

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Broadcast communication provides easy-to-understand mental model
Application 1 – Place Lab

- Computes users’ current position
- Data source: WiFi APs periodically broadcast their unique SSIDs
- Client device: computes its current position by looking up APs’ SSID in client-cached database
Application 2 – RFID-based Reminder

- Alerts users when something is left behind
- Data source: long-range passive RFID readers in the environment read tags and broadcast the list of tags IDs
- Client application: checks if all the user’s items that should be present are all there
Application 3 – Printer Queue Reminder

- Reminds users to pick up printed documents when they pass by a printer closet
- Broadcast data
  - Printer queues
  - RFID tags read in printer room
- Client app alerts the user if the list contains the user’s documents
Broadcasting Infrastructure

☐ Broadcast data
  ■ Sensor data
  ■ Information from non-sensor sources
  ■ Capability tokens
  ■ Broadcast channel guide information

☐ Broadcast medium
  ■ Short-range wireless technologies
    ☐ WiFi, RF, ZigBee, UWB, ...
Client Toolkit

![Diagram of Client Toolkit]

- Application
- WiFi MCast Sniffer
- Place Lab Sniffer
- Mote Sniffer

Data from the environment

Client Toolkit

pub/sub

Listen only

WMCSA 2004 20
Related Work

- TV, radio
- Microsoft SPOT: broadcasting digital data over sidebands of FM radio frequency
- Broadcast file systems
- HP Cooltown: URLs received over local IR channel and use to access object’s web page over WiFi
- Location systems: passive listening
  - RightSPOT: FM radio version of Place Lab approach
  - RADAR: Place Lab approach with signal strength
  - MIT cricket: RF + ultrasound time of flight
Conclusion and Future Work

- Ubiquitous Broadcast Computing
  - Wireless broadcast of locally-relevant data
  - Privacy-friendly, scalable

- Future work
  - Building more applications
  - Scalability: coordinated use of bandwidth
  - Privacy for two-way communication
Question?