Challenges in Location-Aware Computing

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Origin and background

- National Research Council
  - The Computer Science and Telecommunications Board
- Request from NSF, NASA
- July 2001 ~ January 2002
Contents

- Overview of Location-Aware Computing
  - Hardware for Mobile Computing
  - Location-Sensing
  - Wireless Communications

- Research Challenges
  - Location-Sensing Infrastructure
  - Adaptive resource Management
  - Mobile Information Use
  - Other
Hardware for Mobile Computing

- Fundamental Issues
  - Resource poverty: limitation on power, size, weight...
  - Vulnerability: transmission through open airspaces
  - Variable connectivity: performance and reliability
  - Energy

- These issues are not artifacts of current technology,
  - But are intrinsic to mobility.
Location-Sensing

- The most widely known system: GPS (Global Positioning System)
- But...
  - Accuracy of a few meters: it’s not enough
  - Absolute coordinate: sometimes we need relative coordinate
  - Doesn’t work indoors, steel-framed buildings

- Other mechanisms
  - Active badges, e911, Cricket...
  - Vary in capabilities, infrastructure requirements, costs...
    - Reflecting different trade-offs among device portability, device expense, infrastructure needs
**Wireless Communications**

- **Explosive growth**
  - Voice, IEEE 802.11, Bluetooth, IrDA…

- **Trade-off**
  - Frequency
  - Bandwidth
  - Range
  - Density of wired infrastructure

- **Current Solution: Cell structure**

- **Cheap, high-bandwidth, low-power, ubiquitous wireless coverage…**
  - Systems will have to be designed to cope with hard realities
Research Challenges

- Location-Sensing Infrastructure
  - Technology-independent location sensing...

- Adaptive resource Management
  - Cyber foraging and infostations...

- Mobile Information Use
  - Portable display technologies...

- Other
Location-Sensing Infrastructure (1/2)

- Technology-independent location sensing
  - The choice of technology depends on the usage context and ...
  - => API for location sensing
    - Good for application / new technology

- Calibrating location sensing technologies
  - The costs of deploying and managing location-sensing...
  - => Two approaches
    - Develop modeling and analysis...
    - Retain Physical calibration but speed the proccess
Location-Sensing Infrastructure (2/2)

- Opportunistic Data Acquisition
  - Combine location-sensing technology with other type of sensors
  - Ex) GPS + ABS

- End-to-End control of location information
  - Privacy vs. Transparent use of location information
  - Control the exposure of location information...

- Test bed for experimental research in location-aware computing
  - A key obstacle: the lack of adequate large-scale experimental infrastructure
Adaptive resource Management

- **Cyber foraging and infostations**
  - Cyber foraging: Enhance the limited capabilities of portable computer by guiding users to other resourceful locations
  - Infostations: Provide low-cost, low-power access to information services by using surrogates
  - Issues: Before the use of surrogate

- **Tracking and predicting location**
  - Tracking: The object does not necessarily move in straight lines
    - How should the amount of uncertainty in database be determined?
  - Predicting: The goal should be to detect motion patterns
    - Partially periodic, multiple periodic cycle...
Mobile Information Use

- Portable display technologies
  - Small screen.. But visual display remains the most efficient method
  - HCI challenges
  - Computer Science + Cartography
  - Intelligent mechanisms for transmitting data

- Mobile augmented reality
  - Virtual information representation
    - Firefighters could look at a burning building...
  - Many research problems
    - If the wand is pointed at a building...
  - How about sight-impaired individuals?
Other

- Spatial-temporal databases
  - Need more comprehensive data models and query languages...

- Algorithmic issues
  - Propagation of error due to discrete representation...

- Development of ontology for geospatial data
Further reading

- IT Roadmap to a Geospatial Future