Distributed Information Processing

12th Lecture

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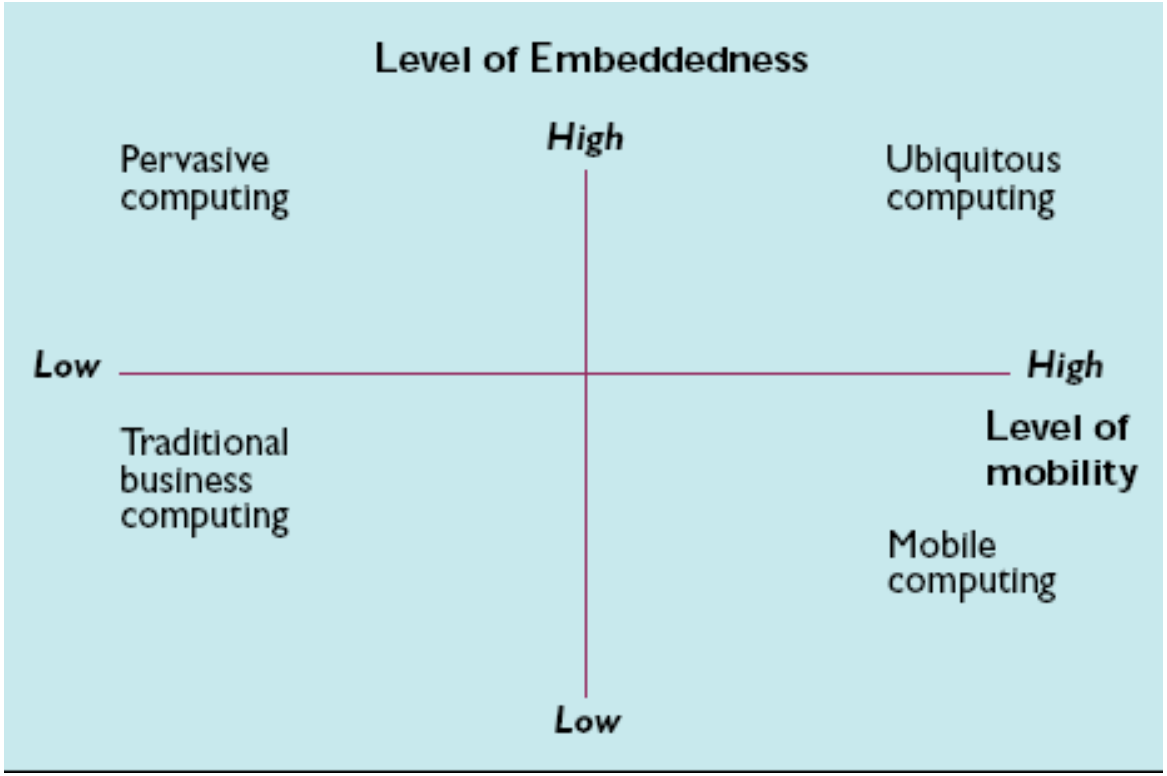
Outline

- Ubiquitous Computing
  - Introduction
  - Some Computer Science Issues
  - Examples
- Q&A

Ubiquitous Computing

- Ubiquitous
  - Existing or Being Everywhere at the Same Time [webster]
- Definition
  - Computing Embedded in Our Movements and Interactions with Our Environments
- Important Characteristics
  - Availability
  - Invisibility
- Research Method [Weiser93]
  - Standard Experimental Computer Science
    - Construction of working prototypes of the necessary infrastructure in sufficient quantity

Dimensions of Ubiquitous Computing [Lyytinen02]



Mobile & Pervasive Computing

- Mobile Computing
  - Increasing Our Capability to Physically Move Computer Services with Us
    - Issue: seamless and flexible context-information obtainment and adjustment by devices
- Pervasive Computing
  - Obtaining Information from Our Environment and Utilizing It to Dynamically Built Models
    - Issue: unlimited scope and small effort to teach a computer about its environment

Main Challenge of Ubiquitous Computing: Integrating Large-Scale Mobility with Pervasive Computing Functionality

Some Ubiquitous Computing Themes

- Implicit User Interaction
  - Transparency
  - Coherence
- Context Awareness
  - Context (Including Location)
    - Models for Interaction and Prediction
  - Dynamic Adaptation
- Infrastructure
  - Fault Tolerance
- Discovery
- Security

Software Infrastructure and Design Challenges [Banavar02]

- Task Dynamism
  - Adaptation to the Dynamism of Users' Environments and the Resulting Uncertainties
- Heterogeneity and Constraints
  - Approaches to Mobility
    - Device itself that is mobile
      - Constraints: physical ones limiting resources (e.g., battery power, network bandwidth, etc.)
    - Application that follows the user
      - Constraints: dynamic adaptation of applications to changing hardware capabilities and variability in software services

Software Infrastructure and Design Challenges (Cont'd)

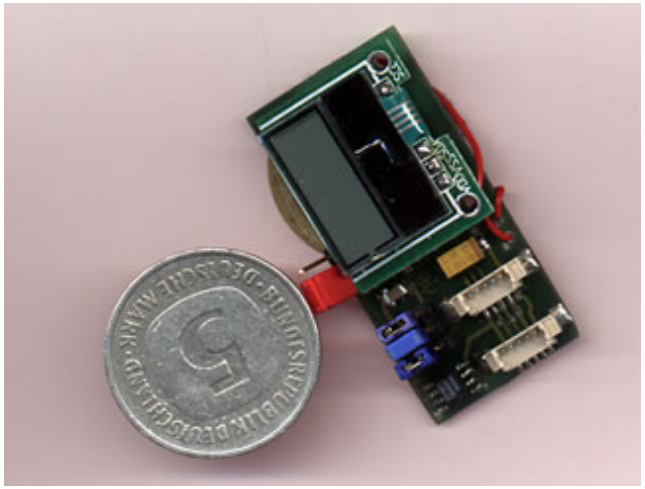
- Research Challenges
  - Semantic Modeling
    - Developing a modeling language to express the rich and complex nature of ontologies
    - Developing and validating ontologies for various domains of user activity
  - Building the Software Infrastructure
    - Developing an effective software infrastructure capable of finding, adapting, and delivering applications based on the user's context
      - Determining which tasks are most relevant to the user
      - Seamlessly synthesizing software components and services

Software Infrastructure and Design Challenges (Cont'd)

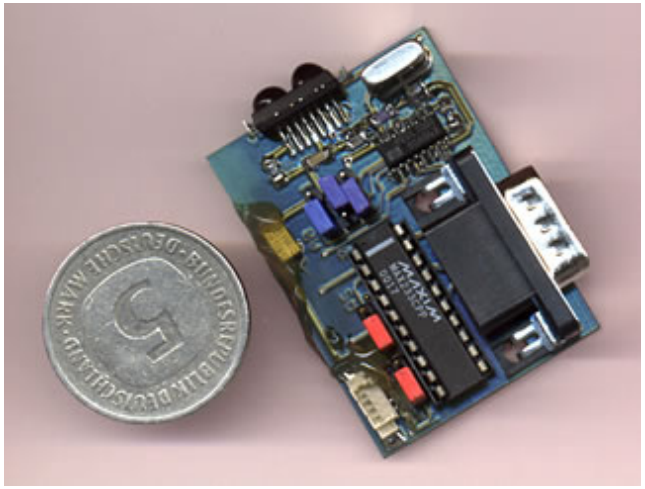
- Research Challenges
  - Developing and Configuring Applications
    - Providing reusable functions such as components or services to improve productivity
    - Providing easily configurable components or services for other developers
    - Composing services and applications into larger applications
  - Validating the User Experience
    - Developing effective methods for testing and evaluating the usage scenarios

Smart-Its: Computers for Artifacts in the Physical World

- This Project Is Part of the European Initiative *The Disappearing Computer*
  - Lancaster University and Others
- Smart-Its
  - Small-Scale Embedded Devices that Can Be Attached to Everyday Objects to Augment Them with Sensing, Perception, Computation, and Communication
  - Enabling Technology for Building and Testing Ubiquitous Computing Scenarios



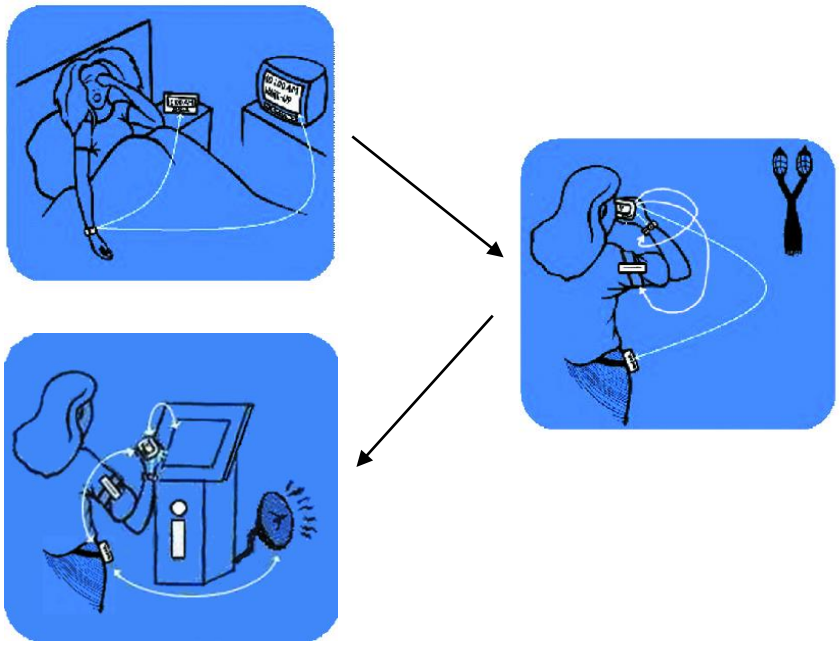
(a) I/O Add: Temperature, Display, Sound



(b) RS232 Add-On

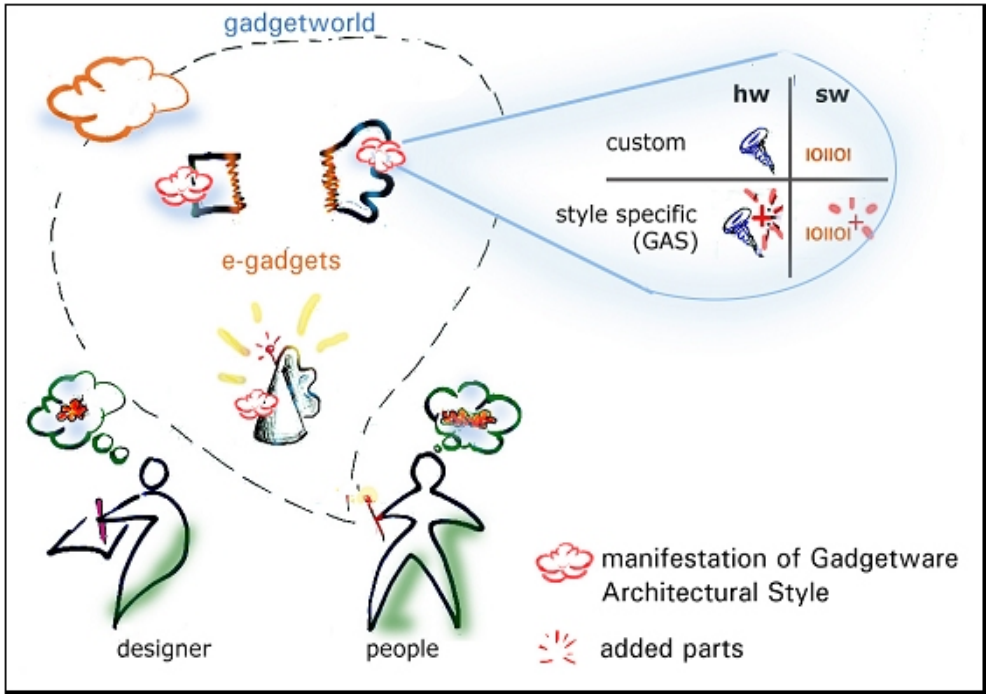
2WEAR : Ad-Hoc Composition in Wearable and Mobile Computing

- This Project is Funded by EU IST and European Initiative *The Disappearing Computer*
  - The 2WEAR Project Was Started in Jan, 2001, and Was Successfully Ended in Dec, 2003
- 2WEAR
  : A Personal System That Is Formed by Putting Together Computing Elements in an Ad-Hoc Fashion Using Short-Range Radio
  - Certain Elements are Embedded into Wearable Objects
    - Wristwatches
    - Small general-purpose computers (including PDAs, mobile phones)
    - Storage modules



Extrovert Gadgets

- EU IST Future Emerging Technologies Research Project
- e-Gadgets
  : Objects with Communicative Abilities
  - Developing and Validating an Architectural Style for Tangible, Communicating Artifacts [= a Gadgetware Architectural Style (GAS)]
  - Designing and Developing an Infrastructure and Sample Artifacts Enabling the Architectural Issues and the GAS Evaluation



Extrovert Gadgets are *objects* ***with communicative abilities***. The objects and/or their environments can be enhanced by intelligence. A multitude of loosely coupled gadgets can be bound into ad-hoc interacting clusters which display collective function, thus forming a gadgetworld.

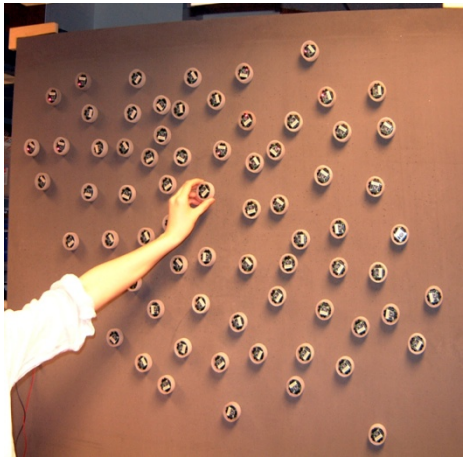
The vision of e-Gadgets is to give users the ability and knowledge to ***configure and reconfigure*** objects and allow for their creativity to emerge in a ubiquitous environment.

Examples of Commercial Applications

- Railcar Telematics
  - Large Chemical Companies Often Deliver Their Products in Railcars with the Lack of Timely Information About the Location and Physical Condition of Their Cars
  - Company Instrument Their Railcars with Sensors That Track the Car's Position, Temperature, Acceleration, and Weight, and Report That Data via a Satellite Link
    - Just-in-time billing
    - Railcar handling
    - Security
- Multimedia Response Center
  - Camera Phones Represent the Ability to Contact an Organization in a Visual Manner
  - To Handle the New Media, Organizations Must Redesign and Re-Equip Their Call Center
    - Technological and organizational changes required to enable call centers to accommodate and incorporate media into 911 Call centers as well as databases used in investigations

Sensate Media

- MIT Media Lab Project
- Sensate Media
  : Multimodal Electronic Skins as Dense Sensor Networks Taking Basic Inspiration from Biological Skin
  - Pushpin Computer
    - Easily configurable array of over 100 sensor nodes
    - Pushpin node has a modular, stacked architecture comprised of four circuit boards, one each devoted to power, communication, processing, and sensing
  - Tribble
    - Research platform for the application of decentralized control and distributed sensor processing



(a) The Pushpin Computer and Its Power Plane

(b) Tribble Single Cell Element

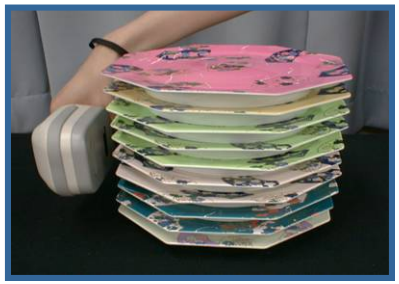
(c) Tribble

(d) Completed Tribble with All Patches and Whiskers

RFID: Tagging The World

There are various types of su-shi and its price
☞ Long calculation per dish
☞ Frequent calculation mistakes

- RFID
  : The Latest Technology to Be Useful for Precisely Identifying Objects
  - It Uses Radio Waves to Read an Object's Markings in the Form of a Unique Identifying Number Stored on an Attached or Embedded Silicon Chip
  - It Will Make It Possible to Tag Almost Everything Spurring a Revolution in How Physical Objects Interact with Information Services
  - There Are Two Types of RFID Tag
    - Active
    - Passive



RFID tags in dishes

Reader reads tags (dishes) after dinner

Information (No. of dishes) delivered from reader to credit card (or receipt)

Exact, autonomous, and fast calculation

RFID in Su-shi Restaurant (Japan)

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