Ubicomp and Physical Interaction
Ubicomp?

- Computation embedded in the physical spaces around us
- “Ambient intelligence”
- Take advantage of naturally-occurring actions and activities to support people
  - Input in the real world
  - Output in the real world also
- Culmination of our discussion of natural data types
- “Context-aware computing” -- making computers more aware of the context of the people who are using them
What is Context?

• Any information that can be used to characterize the situation of an entity
  • Who, what, where, when

• Why is it important?
  • information, usually implicit, that applications do not have access to
  • It’s input that you don’t get in a GUI
How to Use Context

- To present relevant information to someone
  - Mobile tour guide
- To perform an action automatically
  - Print to nearest printer
- To show an action that user can choose
  - Want to phone the number in this email?
Case Study: tour guides

- Very popular theme
  - Location is an easy piece of context

How Cyberguide worked
Why is this hard?

- Steps
  - Acquisition
  - Representation
  - Interpretation
  - Storage
  - Delivery
  - Reaction

- Most of these steps repeated in all development.
Early Work on Context Support

- Bill Schilit, Xerox PARC
  - Main software architect of PARCTab
  - Location-aware rules for app behavior
The Context Toolkit


Toolkit available at: http://www.cc.gatech.edu/fce/ctk

- Three main abstractions:
  - Context widget
  - Interpreter
  - Aggregator
The Context Toolkit

- Context component abstraction

![Diagram showing the Context Toolkit architecture with components such as Applicatio, Aggregator, Interprete, Discoverer, Servic, Widget, Senso, and their interconnections.]
Simple Example: In/Out Board

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregory Abowd</td>
<td>10:51am</td>
<td>In</td>
</tr>
<tr>
<td>Jason Brotherton</td>
<td>9:28am</td>
<td>In</td>
</tr>
<tr>
<td>Anind Dey</td>
<td>12:38pm</td>
<td>In</td>
</tr>
<tr>
<td>M. Futakawa</td>
<td>12:30pm</td>
<td>In</td>
</tr>
<tr>
<td>Y. Ishiguro</td>
<td>10:55am</td>
<td>Out</td>
</tr>
<tr>
<td>Rob Kooper</td>
<td>5:26am</td>
<td>Out</td>
</tr>
<tr>
<td>Kent Lyons</td>
<td>12:27pm</td>
<td>Out</td>
</tr>
<tr>
<td>Jen Mankoff</td>
<td>12:08pm</td>
<td>In</td>
</tr>
<tr>
<td>David Nguyen</td>
<td>11:09am</td>
<td>In</td>
</tr>
<tr>
<td>Rob Orr</td>
<td>12:25pm</td>
<td>In</td>
</tr>
<tr>
<td>Maria Pimentel</td>
<td>5:54pm</td>
<td>In</td>
</tr>
<tr>
<td>Daniel Salber</td>
<td>10:14am</td>
<td>In</td>
</tr>
<tr>
<td>Brad Singletary</td>
<td>2:58pm</td>
<td>Out</td>
</tr>
<tr>
<td>Khei Truong</td>
<td>4:25pm</td>
<td>Out</td>
</tr>
</tbody>
</table>
Simple Example: In/Out Board

- Gregory Abowd: In 11:51am, Out 12:05pm
- Jason Brotherton: In 9:28am
- Anind Dey: In 12:08pm
- David Nguyen: In 11:09pm
- M. Futakawa: In 12:09pm
- Maria Pimentel: Out 5:54pm
- Y. Ishiguro: Out 11:57am
- Daniel Salber: In 10:14am
- Rob Kooper: Out 5:26am
- Brad Singletary: Out 2:50pm
- Kent Lyons: Out 12:27pm
- Khai Truong: Out 1:25pm

In/Out Board

Location Widget

Face Recognition

Smart Card Reader

ID to Name Interpreter
What remains hard?

- Sensing…
- Actuation…
- We’ll get back to how to address these (Phidgets)
Example: Intelligent Spaces

- Stanford Interactive Workspaces Project: iRoom
- Since 1999
- [http://iwork.stanford.edu](http://iwork.stanford.edu)

- Focus:
  - Single room
  - Collection of large/small displays
  - Synchronous, collocated, small workgroups
Guiding Principles

- Rely on social conventions
  - User control vs. automatic “smart” behavior
  - The Semantic Rubicon
- Wide applicability
  - Think about variety of interactive spaces
- Simplicity
  - From user and developer perspective
Displays

- Tiled SmartBoards
- Interactive Mural
- Table top
- Laptops
Interaction Techniques

- Point Right

- Simplified control of mouse/keyboard input focus across multiple displays
Interaction Techniques

- **Flow Menu**

- Smooth integration of command selection and parameter input for pen-based interaction.
Interaction Techniques

- Multibrowsing

- Technique for integrating Web content with multiple displays.
Interaction Techniques

- Scaling behavior in interactive mural
Infrastructure

- Services for
  - Data
  - Control
  - Coordination
- iROS
  - Interactive Room Operating System
Infrastructure

- Event Heap
  - B. Johanson and A. Fox. The Event Heap: A Coordination Infrastructure for Interactive Workspaces

- Tuple space implementation
  - Minimize application coordination dependency
Infrastructure

- **iCrafter**

- **Flexible I/O interaction with services in an interactive workspace**
Infrastructure

- iStuff

- Simplifying use of physical I/O devices
  - Similar in spirit to phidgets
Related Work

- **Spaces**
  - CoolTown (HP Labs)
  - eClass, Aware Home (GT)
  - Intelligent Room (MIT)
  - Easy Living (Microsoft Research)
  - Ambient Workpaces (Fraunhofer/IPSII, Germany)
  - House_n (MIT)
    - [http://architecture.mit.edu/house_n/](http://architecture.mit.edu/house_n/)

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What about sensing and actuation?

• Would like to be able to sense activities in the physical world and then present feedback/actions in the physical world also

• **Tangible User Interfaces**
Tangible User Interfaces

- Hiroshi Ishii (MIT)

  **Tangible Bits**
  - physical form to digital information

  **Tangible User Interfaces**
  - physical objects, surfaces, and spaces that act as tangible embodiments of digital information
Triangles

- Pieces are connected together to trigger digital events
  - influence the progress of a non-linear story
  - organize media elements in order to create their own story space
LumiTouch

- Two interactive picture frames
  - User’s touching of a local frame translates to a glow on remote frame
    - She’s thinking of him
    - He’s thinking of her
Tangible Video Browser

- Tokens are used to:
  - Act as container for videos
  - Select a video
  - Navigate within the video
What remains hard?

- Well... *everything* according to the paper

  - While an exciting new area, everyday programmers still face considerable hurdles if they wish to create even simple physical user interfaces. Perhaps the biggest—but we believe easily solved—obstacle is the sheer difficulty of developing and combining physical devices and interfacing them to conventional programming languages.
Related Work

Tools for working with physical input/output devices

iRX Board
Digital I/O boards
Tini boards
Problems

- Hard to build
- No API
- API at wrong abstraction level
- Oriented to different markets
- Difficult to write/debug w/o actual devices

- We’d like to have something that is
  - Simple so developers concentrate on overall use, modification, and recombination
  - Easy for average programmer
Phidgets!

- “Physical widgets”
  - Easily composable hardware devices
  - Provide sensing and actuation
- http://grouplab.cpsc.ucalgary.ca/phidgets/ -- research project page
- http://www.phidgets.com/ -- online store

- Basis concepts:
  - Connection manager
  - ID
  - Simulation mode
Phidget Manager

onAttach()
onDetach()

DeviceType
isAttached()

Count

Item

SerialNumber
Example: Phidget Servo

- MotorPosition
- NumMotors
- onPositionChanged()
Drawbacks

- Need PC
- Not mobile
- Not easy to deploy