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 use 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
Simple Example: In/Out Board

<table>
<thead>
<tr>
<th>Name</th>
<th>In/Out Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregory Abowd</td>
<td>In 9:51am</td>
</tr>
<tr>
<td>Jason Brotherton</td>
<td>In 9:20am</td>
</tr>
<tr>
<td>Anind Dey</td>
<td>In 12:08pm</td>
</tr>
<tr>
<td>M. Futakawa</td>
<td>In 12:00pm</td>
</tr>
<tr>
<td>Y. Ishiguro</td>
<td>Out 10:55am</td>
</tr>
<tr>
<td>Rob Kooper</td>
<td>Out 5:26am</td>
</tr>
<tr>
<td>Kent Lyons</td>
<td>Out 12:27pm</td>
</tr>
<tr>
<td>Jen Mankoff</td>
<td>In 12:08pm</td>
</tr>
<tr>
<td>David Nguyen</td>
<td>In 11:09am</td>
</tr>
<tr>
<td>Rob Orr</td>
<td>Out 1:25pm</td>
</tr>
<tr>
<td>Maria Pimentel</td>
<td>Out 5:54pm</td>
</tr>
<tr>
<td>Daniel Salber</td>
<td>Out 10:14am</td>
</tr>
<tr>
<td>Brad Singletary</td>
<td>Out 2:56pm</td>
</tr>
<tr>
<td>Khai Truong</td>
<td>Out 1:25pm</td>
</tr>
</tbody>
</table>
Simple Example: In/Out Board
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

- 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/IPS, Germany)
  - House_n (MIT)
    - [http://architecture.mit.edu/house_n/](http://architecture.mit.edu/house_n/)
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

![Tangible Video Browser Image](Image)
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

SerialNumber

Item
Example: Phidget Servo

- MotorPosition
- NumMotors
- onPositionChanged()
Drawbacks

- Need PC
- Not mobile
- Not easy to deploy