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

Simple Example: In/Out Board

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregory Admire</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Jason Brotheron</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Arndt Day</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>M. Fudakee</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Y. Stilgser</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Rob Koopner</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Kent Lytton</td>
<td>In 1:12pm</td>
</tr>
<tr>
<td>Face Recognition</td>
<td></td>
</tr>
<tr>
<td>Smart Card Reader</td>
<td></td>
</tr>
<tr>
<td>ID to Name Interpretor</td>
<td></td>
</tr>
</tbody>
</table>

Simple Example: In/Out Board

- Context component abstraction

- Context Architectures

- 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
  - http://www.stanford.edu/~borchers/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 Workspaces (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

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.

Tangible Video Browser

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

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/](http://grouplab.cpsc.ucalgary.ca/phidgets/) -- research project page
  - [http://www.phidgets.com/](http://www.phidgets.com/) -- online store

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

Phidget Manager

```java
onAttach()
onDetach()

Count
Item

DeviceType
isAttached()

SerialNumber
```

Example: Phidget Servo

- MotorPosition
- NumMotors
- onPositionChanged()
Drawbacks

- Need PC
- Not mobile
- Not easy to deploy