CS 525M – Mobile and Ubiquitous Computing Seminar

Context-Aware Mobile Communication in Hospitals

presented by

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The Problem

• Hospitals are tough to manage
  • Staff rotates
  • Multiple locations
  • Varied communication paths
• Existing solutions are inadequate:
  • Video conferencing
  • Two-way pagers
The Solution

- Context-aware communication devices
- Context is:
  - Role (not just identity)
  - Location
  - Timing
Instant Messaging

• Extends instant messaging paradigm to add context-awareness
  • Devices can communicate
    • “The X-Ray results are complete”
  • Roles incorporated
    • “The nurse on duty”
    • “The doctor on the next shift”
  • Location-sensing added
    • “Tell the next doctor to visit this room to…”
  • Map of nearby users
  • Time-sensitive data
    • “In 24 hours, give the patient more drugs”
“Buddy Lists”

- Keeps track of users who are online and offline
- Additions to normal buddy lists:
  - Devices as buddies
  - Roles as buddies
  - User location
Messages

- Can send IMs to other users
- Additions to normal paradigm:
  - Send at date/time
  - Send to an abstract role
    - “All” or “Any”
  - Send to a specific place
Map

- Shows where available resources are
  - People
  - Printers
  - Displays
Agents

- Purpose:
  - Act on the user’s behalf,
  - Represent devices,
  - Wrap the functionality of a system
- Registered with Agent Directory
- Sends IMs using XML
- Not related to The Matrix
Agent Modules

- Modules
  - Perception
    - Data from sensors or users
  - Reasoning
    - Determines actions
  - Action
    - Triggers events
Agent Modules

- Modules
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**PRINTER AGENT**

**PERCEPTION**
Determines that the printer jammed based on signals from printer

**REASONING**
Needs to redirect print queue, then tell a technician and users

**ACTION**
Redirects print queue, sends IM messages to technician and users
Technology

- Jabber
  Open-source IM client/server
- XMPP
  Extensible Messaging and Presence Protocol
- Salsa
  Simple Agent Library for Seamless Applications
- 802.11b
  Wireless communication protocol
- PDA
  Compaq iPAQ
INSTANT MESSAGING SERVER
- Mediates traffic
- Sends Instant Messages back and forth
System Diagram

**Agent Directories**
- Keeps track of active agents
- Essentially, "who's online?"

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**Hospital IS proxy agent**
- Context perception
- Reasoning
- Action
  - Initialize and register

**Public display proxy agent**
- IM client
- Device interface
  - Context perception
  - Reasoning
  - Action
  - Initialize and register

**Location-estimation agent**
- Perception
- Reasoning
- Action

**Access point**
- Agent directory

**Agent directory**
- Wireless network
- 802.11b

**Context-aware client**
- GUI interface
- Context
- IM client
System Diagram

802.11b Access Point
- Sends & Receives Data
System Diagram

CONTEXT-AWARE AGENT
- Monitors environment
- Knows everyone and everything
- Delivers context-sensitive messages

Hospital IS proxy agent
- Context perception
- Reasoning
- Action

Context-aware agent
- Context perception
- Reasoning
- Action

Hospital Information System

Public display proxy agent
- Context perception
- Reasoning
- Action

Location-estimation agent
- Perception
- Reasoning
- Action

Agent directory

Access point

Wireless network

802.11b

Context-aware client
HOSPITAL IS PROXY AGENT
- Manages documents (like test results)
- Notifies users when relevant documents are created or modified
- Interfaces with hospital database
HOSPITAL INFORMATION SYSTEM
- Manages patient records, medical histories, etc.
PUBLIC DISPLAY PROXY AGENT
- Keeps track of publicly available UI devices
- Printers
- Computer terminals
- Conference rooms
LOCATION ESTIMATION AGENT

- Uses 802.11b signal strength to locate self
System Diagram

Hospital IS proxy agent
- Context perception
- Reasoning
- Action
  - Initialize and register

Context-aware agent
- Context perception
- Reasoning
- Action
  - Initialize and register

Agent directory
- Wireless network 802.11b

PDA
- Interface to user

Public display proxy agent
- IM client
- Device interface
  - Context perception
  - Reasoning
  - Action

Agent directory
- IM client
- GUI interface
- Context
- IM client

Perception
- Reasoning
- Action
Scenario – Printing

A user wants to print a set of patient’s records at a nearby printer
Get identity from Agent Directory
Process – Printing

Sign on to IM Server

Handheld computer
Agent directory
Agent
Printer
IM server
Hospital IS proxy agent

connect() 
send(agentRef)
subscribe()

subscribe() 
subscribed(presence)
subscribed(presence)

Message(toPrinterAgent)
Message(getInterface)
Message(interface.xml)
Message(interface.xml)
Message(print.doc)
Message(print.doc)

get(docId)
msq(print.doc)
getStatus()
sendStatus(status)
presence(status)

Response(doc)

Presence

System Status Help

IP Agent

Contact Aware Message XML

Paper 1

Number of Copies:
Process – Printing

Notify other agents of availability
Notify user of other agent’s availability
User is now signed on
Process – Printing

Asks IM Server for printer interface
IM Server retrieves interface from the printer’s Agent.
Process – Printing

IM Server sends printer interface to user
Print dialog can now be displayed
User tells IM Server it wants to print the document
IM Server tells the Printer Agent to print the document.
Printer Agent retrieves the document from the Hospital Information Service agent.
Printer Agent finally tells the printer to print
Printer Agent continually polls printer for status, and sends status to the user via the IM Server.
Process – Printing
Scenario – Messages

A user is walking around the building, and is updated with information about particular rooms/patients nearby.
Process – Messages

Client requests the position from the Location Agent (also residing on PDA)
Process – Messages

Location Agent gets the signal strength from the Wireless Access Point
Process – Messages

Location Agent estimates position and tells user interface
Process – Messages

Map continually updated using the location data.
Client notifies the IM Server of its new location
IM Server notifies other Agents of the user’s new position.
IM Server notifies the Context-Aware Agent of the new location.
Process – Messages

Context-Aware Agent determines if any new context-sensitive messages should be sent.
If there are context-sensitive messages, they are sent via the IM Server to the user.
Evaluation

- Tested at a public hospital
  - Methods:
    - Observations
    - Interviews
    - Analysis
  - NO actual field use
- Users:
  - 28 hospital members

Table 1. Results of a questionnaire measuring user acceptance of scenarios and the system’s context-aware features.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neither</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is useful to know who is in the hospital and where they are in relation to me</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>It is useful to send messages that depend on context for their delivery</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>It is useful to have access to the patient’s medical records through a handheld computer</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>Receiving messages can distract me from my daily work*</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*One person did not respond to this question.
Results

- 91% would use the system
- 84% believe it would enhance their job performance
- 78% perceived it easy to use

- No actual field use to test if it actually works
- No analysis to determine if technology is capable of handling the requirements
- No mention of battery life concerns
- No discussion of fault tolerance & reliability
Questions?
My thoughts

• Major contributions:
  • Shows how context-aware systems can be applied to specific areas to solve problems
  • Good extensions of IM paradigm
• Likes:
  • Good user interfaces
  • Extensive study before designing system
  • Well-written and easy to read
  • Very nice diagrams
  • Appropriate solution for the problem
• Dislikes:
  • Only simulations performed
  • Missing discussion of system’s faults
  • Some parts (like Agent Directory) poorly explained
  • Sequence diagrams were not explained at all
  • Evaluation details were a bit sketchy