Context Aware Computing

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Introduction

A system should be context aware, to minimize distractions caused by mobile environments like walking, driving or other real world interactions.

Three areas where context aware systems are implemented:

• In a university which helps students know location of their team members.
• Guide system to develop custom tours and guide them through the tour.
Context aware applications

Services provided by context aware applications:

Spatially aware applications that consider user's relative and absolute position.

Temporally aware applications that consider time schedules of public and private events.
Distraction matrix

To identify types of distraction, the Distraction matrix categorizes activities as information, communication and creation. The interruption durations are categorized as

*Snap:* Completes in few seconds, like checking your watch and does not interrupt the primary activity.

*Pause:* Stopping primary activity, switching to a related one and then switching back.
Interruption durations

*Tangent:* Receiving a medium distraction unrelated to the primary activity. Receiving a phone call.

*Extended:* Long term interruption of a primary activity. Stopping at a hotel and resting for a night.
<table>
<thead>
<tr>
<th>Time</th>
<th>Snoop</th>
<th>Pause</th>
<th>Tangent</th>
<th>Extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receiving</td>
<td>Message arrival</td>
<td></td>
<td></td>
<td>Audio, Walkman</td>
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<tr>
<td>Notifying</td>
<td>Information access</td>
<td></td>
<td></td>
<td>Transferring files from network</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Action</td>
<td></td>
<td></td>
<td>Reading news</td>
</tr>
<tr>
<td>Serendipity</td>
<td>Stocks, sports, matching similar needs</td>
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<td></td>
<td></td>
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<tr>
<td>Free food</td>
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<tr>
<td>Seeking</td>
<td>Line length</td>
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<td>Looking for class notes</td>
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<td></td>
<td>Bus arrival</td>
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<td></td>
<td>Who else is doing this now?</td>
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<td></td>
<td>Locate person</td>
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<td></td>
<td>Access personal data</td>
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<tr>
<td>Browsing</td>
<td>Exam calendar</td>
<td></td>
<td></td>
<td>Web research</td>
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<td>Finding</td>
<td>Software or hardware help</td>
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<td>Reviewing class notes</td>
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<td></td>
<td>Calendaring</td>
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<td></td>
<td>Navigation</td>
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<td>Information on Web or built environment</td>
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<tr>
<td>Verifying</td>
<td>Recall previous queries</td>
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<td></td>
<td>Double-checking information</td>
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<td>Communication</td>
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<td>Initiating</td>
<td>S.O.S. emergency</td>
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<td>Chatting (public or private)</td>
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<td>Participating</td>
<td>Instant messaging</td>
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<td></td>
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<td>Broadcasting</td>
<td>Introductions</td>
<td></td>
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<td>Team building</td>
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<td>Queries</td>
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<td>Collaborative work</td>
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<td>Information exchange</td>
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<td>Event planning</td>
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<td>Scheduling</td>
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<td>Anniversary planning</td>
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<td>Social planning</td>
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<td>Posting information to bulletin board</td>
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<td>Advertising</td>
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<td>One-to-one communication</td>
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<td>One-to-group communication</td>
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<td>One-to-all possible communication broadcast to unknown people</td>
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<td>Firing</td>
<td>One-to-one communication</td>
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<td>One-to-all possible communication broadcast to unknown people</td>
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<td>Creation</td>
<td>Remember the!</td>
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<td>Class note taking</td>
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<td>Add a to-do or call list</td>
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<td>Meeting</td>
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<td>Pondering story</td>
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<td>Filling out survey</td>
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<td>Registration</td>
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<td>New Ideas</td>
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<td>Adding information to existing projects</td>
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<td>Generating messages</td>
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<td>Summarizing lecture</td>
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<td>Mobile-tool building</td>
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Figure 1. The Distraction Matrix. We based each distraction's location on the primary activity it interrupts and that interruption's duration (increasing from left to right).
An application, implementing context aware environment for students using 400 wireless networking access points which cover the entire campus was developed.

**Portable help desk:** Spatially aware application that lets user build where the next meeting is, by observing the team members' location on the campus. It also displays the user's colleague contact information.
Portable help desk

- It can also display printer queues, restaurant hours, stock of carbonated beverages and food in vending machines.
- Both visual and audio interfaces support users in different contexts. Visual for stationary and audio when the user is walking around.
PHD interfaces

PHD delivers information in both proactive and user driven manners.

• Proactive when user begins a print job, and there is a long queue.
• User-driven when a design group uses PHD for locating a missing colleague.
Matchmaker
An application for large projects and design group where no single individual has expertise to perform every task.
Used for finding an expert user who is
• Nearby,
• Available,
• Has a profile listing the skills needed, and
• Has history of answering similar questions.
Matchmaker architecture

Figure 6. Matchmaker system architecture. The system receives the user’s query and matches it to an appropriate expert user. It then locates the expert and notifies him or her of the query.

Privacy Guard

PHD offers valuable service to collaborating working groups, but location sensing is a liability.

Privacy guard enables basic privacy policies describing which users, groups can and cannot report.

Users update the central server with permissions accordingly, the server sends the client the target's location or refusal to answer the
Privacy Guard Architecture

Figure 7. Privacy Guard architecture. By incorporating permissions, Privacy Guard limits a client user’s access to a target user’s contact and location information.

Context-aware agents

When the user is not engaged in important activities, context aware agents display appointments, emails and calendar events.

**Notification agent:** Alerts user within a certain distance of a location that a task on his/her to-do-list identifies. Ex: If a user is near his/her mailbox, the agent alerts the user if a package is waiting.
Meeting reminder: Agent alerts a user who is likely to miss the meeting. It identifies the meeting time and determines the travel time from user's location.

Activity recommendation: Agent recommends activities and meetings based on user's interests.
Activity Recomm. agent

Activity Recommending Agent

Current Activities Interested in:
- Computer Science Seminars
- CMU Basketball Games
- AE Films Movie

Keywords Interested in:
- Keyword | Nearest Matching Item
- clusters | None
- food | None
- dessert | None
- pizza | None

Add Activity | ECE Seminars
Add Keyword | Mobile

Distance range for Alerts: 100
Audio: Yes

Figure 8. An example of an Activity-Recommendation Agent’s user interface.

Guide System

The guide system consists of electronic handheld guide that users' use to access information and create tailored tours depending on factors like:

- Time
- Location
- Financial limitations
- Visitors interests
- Weather conditions

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Capabilities

The Guide system provides several capabilities:

*Access to information:* Visitors can use Guide to retrieve information including the present context.

*Tailored city tours:* Tours are generated based on user preferences and interests. It then provides route guidance between locations.

*Access to interactive tools:* Services like booking accommodations, ticket reservations.
Capabilities

*Send and receive messages:* Users can exchange messages with other guide users and also with Tourist information staff for assistance.

*Co-operative tools:* With context sharing members of group can let other members of group know their location. Users' can also leave virtual stick on notes to share their experiences with others.
Guide relies on geographic model which consists of city landmarks and associated set of web pages that provide information about it. Consists of two object types:

- **Navigation point objects** that represent waypoints between locations i.e route guidance.
- **Location objects** represent points of interest in city like landmarks, cafes and shops. They encompass state information (open/closed) about the entity and at least one link associated with the web page.
Relation b/w location objects

The relationships have attributes that model characteristics such as distance between points or travel costs.

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Information model

- Hypertext pages contain tags that let object model information influence the pages Guide displays.
- Guide dynamically interrogates the user to determine location nearest to his current location using tags of object models.
Guide interface model

Keith, the following attractions are near to you at The Tourist Information Centre.

Note: The list is ordered according to closeness and whether or not they are open or closed.

The imposing gateway to the prison is known as the John of Gaunt Gateway and is named after John of Gaunt, Duke of Lancaster. Click here for more information.

This is reputedly Lancaster's oldest town house, built around 1625 for Thomas Covell, keeper of Lancaster Castle for 48 years. Click here for more information.
Location based functionality

Guide initially used GPS but later used network beacons to provide approximate location information and then further use input to refine the position. When end user system cannot receive a beacon signal they notify the device and activates the locator component. The application indicates last location where contact was made and asks (a series of questions) user if he/she is still there. If a change in position occurs, the system asks...
Guide interfaces

Figure 4. When the user activates the locator component, Guide asks a series of questions to help the user identify the specific location.
Guide interfaces

Click on the image below that best describes your location now.

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Custom Tours

Guide allocates numeric values to attractions and to routes between them. Current context like weather, time and user preferences can modify these values. The total scores are then compared to choose quality tour.
Feedback

The users reaction was negative. Effort required to create custom tours was primary reason.

Later, pregenerated standard tours were added.

Users usually selected one of these standard tours rather than creating custom
Physical and virtual context integration using Kimura

Kimura system to design an office that better supports knowledge workers. Kimura system that monitors user's interaction with computer, an electronic white board (montage) and variety of augmented peripherals by integrating independent tools. Kimura also draws from several physical sensors distributed throughout the office.
Kimura separates user's desktop into 2 regions:

- Focal region on desktop monitor
- Background activities are projected as visual montages on peripheral displays.
Montages

- A working context is displayed as montage of images which provide visualizations of past activity to act as reminder of past actions.
Context awareness

Context acquisition: Acquires context information and posts it to activity database.

Context interpretation: Transforms raw activity data into one or more working contexts and augments these with relevant events in the environment.

User interface: Different visualizations of working contexts, like transparent and opaque objects.
Context acquisition

Context acquisition components capture wide variety of information garnered from sensors around the office and from visual-context sources, such as key strokes and mouse monitoring utilities and mail and internet use proxies.

Concerned effort is made to capture users activity while running software applications using documents and interacts with peripherals.
Virtual context

- Desktop monitoring process packages each event (opening, changing windows, pressing key, clicking mouse) in Kimura log entry.
- A screenshot of each window is sent to log every time the focus changes. These are interpreted into montage.
- Metrics like amount of time the window is in focus, number of times the focus switches produce detailed visualizations.
Virtual context

• The size of the thumbnails determine the amount of time the user spent interacting with that desktop application.
• The recency of document is determined though image transparency Most recently used are opaque.
• A process running on user's mail server monitors user's inbox and associates each user in sent list to working context.
• Notifies location monitoring component to look
Physical context

Kimura helps user by providing information about colleagues' location and availability using physical context.

Dallas semiconductor i-button docks are distributed throughout office.

This sensor network detects arrival and departure of known individuals in public areas of office and near peripheral devices.

Granularity of this system is coarse but enough to
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Cheverst Keith Mitchell Lancaster University Alon Efrat University of Arizona

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Stephen Voida, Elizabeth D. Mynatt, Blair MacIntyre, and Gregory M. Corso
Georgia Institute of Technology
Thank You