Activity and Context for Mobile and Ubiquitous Computing Users

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Abstract

In order to have a principled approach to mobile and ubiquitous systems design, we need to understand the context in which the systems will be used. We discuss the impact of mobile and ubiquitous computing on users' activities. We introduce Activity Theory as a tool to help us understand users' activities in their context. We refine our framework by extending Activity Theory to capture history, which allows us better to understand users' activities.

1. Introduction

According to the Siemens Mobile Phones' December 2003 Asian mobile lifestyle survey, 52% of Thais perceive mobile phones as their "personality's technology extension" [Eskola, 2004]. Mobile phones have become an integral part of our lives. This is not limited to the use of mobile phones; small computer devices such as laptops and personal digital assistants (PDAs) have become very popular too. With new technology such as small computer devices and a wireless network, users are able to use computing devices anywhere and anytime – users are now living in a mobile and ubiquitous computing environment.

Mobile and ubiquitous computing is not limited to the use of small devices but also includes computing devices and services embedded in the environment. Therefore mobile and ubiquitous users are able to access different devices, both personal and public. For example, in the mobile and ubiquitous office, Malee can use her PDA to access client data in the office database while she is rushing off to meet a client. She requests a hard copy of the data to be printed at the nearest printer in the office so she can grab it on her way out. Several examples of a mobile and ubiquitous computing environment have been described in the past [Hopper et al., 1997; Selker and Yan, 2000]. However, there is a lack of a well established design method for developing mobile and ubiquitous computing systems. A key factor in developing a principled approach to mobile and ubiquitous systems design is to understand and design for the context in which the systems will be used. However, the research area of context [Chen and Kotz, 2000; Dey, 2001; Kaenampornpan and O'Neill, 2004] is itself quite undeveloped and does not have well established methods and techniques. We propose Activity Theory [Engeström et al., 1999] as a framework for

providing a better understanding of context in the design of mobile and ubiquitous computing systems.

2. Impact on Human Everyday Life in a Mobile and Ubiquitous World

From the example of Malee's office situation, we can see that mobile and ubiquitous computing has an impact on our everyday lives. Mobile and ubiquitous users are no longer sitting at their desks using the same desktop PC in the same environment every day. This has implications for the ways in which users behave in their everyday lives.

2.1. Activities in Societies: Roles and Rules

In the mobile and ubiquitous computing world, people use computing devices or services while they are on the move. Therefore their environments are changing all the time. In turn, their roles are constantly changing according to their current community and environment. For example, Malee works as a manager at a company where Anan is her secretary. Here Anan has to prepare documents and arrange meetings for Malee using his PDA. However, at home, they are husband and wife. Anan uses the PDA to plan family expenses or the household shopping list. From this example, we see that their roles change according to the context in which they find themselves.

The concept of roles is not the only concern when users are performing their activities while they are in different communities. The concept of rules is another concern. From the Anan and Malee example, the obvious difference in the rules between situations in the office and at home is that, in the office, the rules of the company hold, such as no smoking in the office. At home, they are bound by marriage law and family rules such as Sunday is a household shopping day. To illustrate how the concepts of roles and rules have impact on human behaviour, the shopping example is shown in Table 1. The roles and rules have impact on what items Anan will buy as a secretary or as a husband even though he is doing his shopping at the same supermarket.

	Roles	Rules
Shopping for an office party	Secretary	• Budget is 50,000THB • For 100 people
Shopping for a household	Husband	• Budget is 1,500THB • For 4 people

Table 1 - Shopping example for Anan in different contexts

2.2. Multiple Tools

In addition to constantly changing roles and rules, mobile and ubiquitous users may use various tools. User may have more than one personal device such as a PDA, laptop or mobile phone. A particular device will be chosen by the user to suit his/her current activity. For example, when Malee is alone in her office and has to set a reminder, she chooses to make a note in her PDA as it is easy to do and, unlike her laptop, the PDA is small enough to be taken everywhere with her. While she has a meeting with her secretary in her office, she decides to make notes on a desktop PC with a large display so

that her secretary can simultaneously see the notes.

In addition to multiple personal devices, users may be able to use publicly available devices and services. Examples include a shared printer and database that are used by Anan, Malee or anyone in the office with a valid permission.

3. Activity Theory Background

With the new experiences that users are facing in the mobile and ubiquitous computing world, HCI researchers have to face a new challenge in improving the usability of mobile and ubiquitous systems. In order to derive principled design methods for developing mobile and ubiquitous computing systems, we need to understand the context in which such systems will be used. This means that we need to understand what elements have impact on users in performing their activities in the mobile and ubiquitous world. Humans cannot fully understand the full moment-to-moment richness of other humans' activities, states, goals and intentions. Yet they manage successfully and fluently to interact in many highly contextualised ways. Therefore we suggest that a relatively simple model of the influences on users' activities will be adequate for representing context in the design of a mobile and ubiquitous system. Moreover, a simple model has the additional advantage that it is easy to use by the designers of the system.

We have chosen to use Activity Theory as a framework to understand users' contextualised activities. The reason for using Activity Theory is that it uses a simple standard form to represent concepts such as roles, rules and tools, which we noted in section 2 have important impacts on users' activities. Moreover, Activity Theory also maps the relationships amongst the elements that it identifies as having an influence on human activity.

Activity Theory was developed by Russian psychologists Vygotsky, Rubinshtein, Leont'ev and others beginning in the 1920s [Kaptelinin and Nardi, 1997]. Activity Theory is a philosophical framework used to conceptualize human activities. [Engeström et al., 1999] proposed a triangular model of human activity as shown in Figure 1. This full triangular structure is an expansion of the

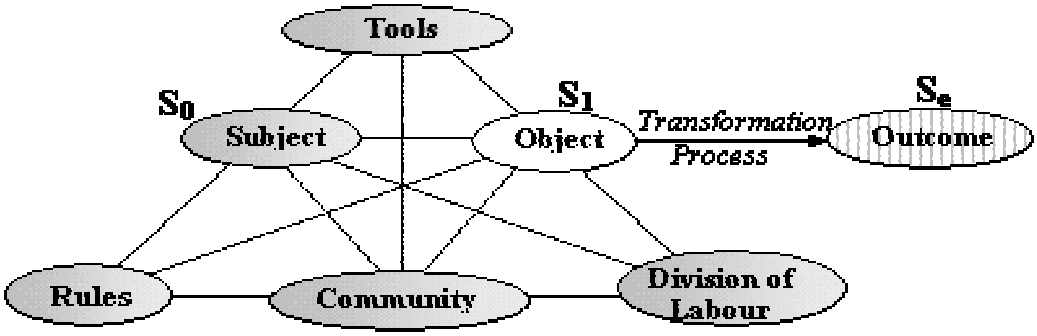

Figure 1 - Triangular structure of human activity introduced by Engeström et al. [1999]

individual activity model introduced by Vygotsky. The individual activity model represents the most basic concepts and relationships: a subject oriented to accomplishing some object using a historically-constructed tool. To this individual activity model, community was added, resulting in more relationships: the subject related to his/her community via rules and the community related to the object via the division of labour.

The main concepts of the full triangular structure model are:

Subject: Information about the individual or subgroup chosen as the point of view in the analysis.

Tools: Information about tools, which means either psychological or physical tools.

Community: Information about individuals or subgroups who share the same object.

Division of labour: The division of tasks between members of the community.

Rules: Explicit or implicit regulations, norms and conventions that constrain action or interaction.

Object: Target of the activity within the system: subject's intention or objective (outward goal, concrete purpose, or objectified motive).

Outcome: The result of the subject's activities, which may or may not achieve the object.

4. Applying Activity Theory in Designing Mobile and Ubiquitous Computing

In this section, the Malee's office example is used to show how Activity Theory can be used as a design tool by designers to understand the important elements in users' activities. Figure 2 shows the scenario when Malee has to access the database and print the customer data using the closest printer on her way out to meet the customer. Activity Theory is used as a framework to develop a unified model of the elements that influence

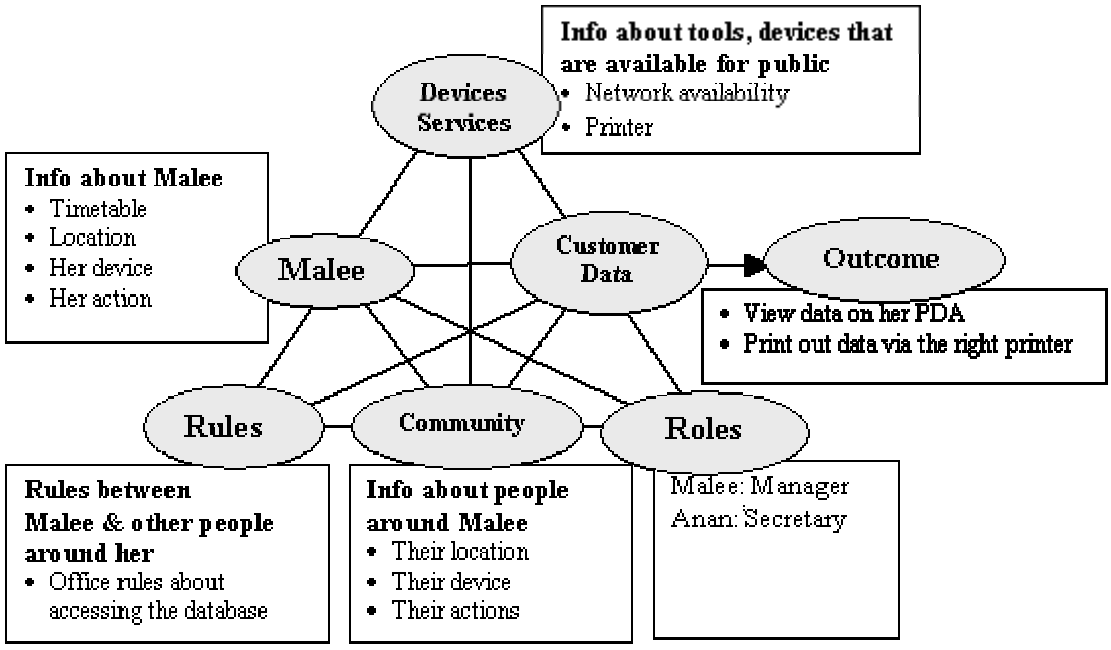

Figure 2 - Malee is trying to print customer data on her way out of the office

Malee's activities in this situation. For example, through the Tools element in Activity Theory, we can focus on information about the printers that are closest to the exit and information about availability of the network.

Figure 1 shoes that Activity Theory allows us to capture information about the current situation, (S_0) and the outcome (S_e) once the activity is performed. However, it does not provide an adequate account of a user's current object or intention (S_1). People often refer to experiences in the past while performing their current activity. Therefore, we have extended Activity Theory by adding the concept of History, illustrated in Figure 3. History is modelled as a set of states in the past. Each past state is represented as an Activity Theory model, which captures the context of past activities. This information includes the initial state (S_0), intention (S_1) and outcome (S_e) of the activity.

In developing a model of the user's context, we first collect information on each element in the Activity Theory model. This information may be collected from sensors or databases. At this stage, the Activity Theory model (Figure 1) is used as a guide for the designers to what types of information to take into account. Secondly, this information is used to model the context of the user's current activity (S_0). This model does not include the user's intention or goal (S_1), as we cannot sense such information. Thirdly, the context model references the history, which records the user's context in achieving his/her goals in the past, in order better to infer the user's current goal. This results in a refined context model that includes an understanding of the user's goal or Object (in Activity Theory terms); see Figure 4.

In the Malee's office example, she has a meeting with the same client at the same time every week. The designers use the extended

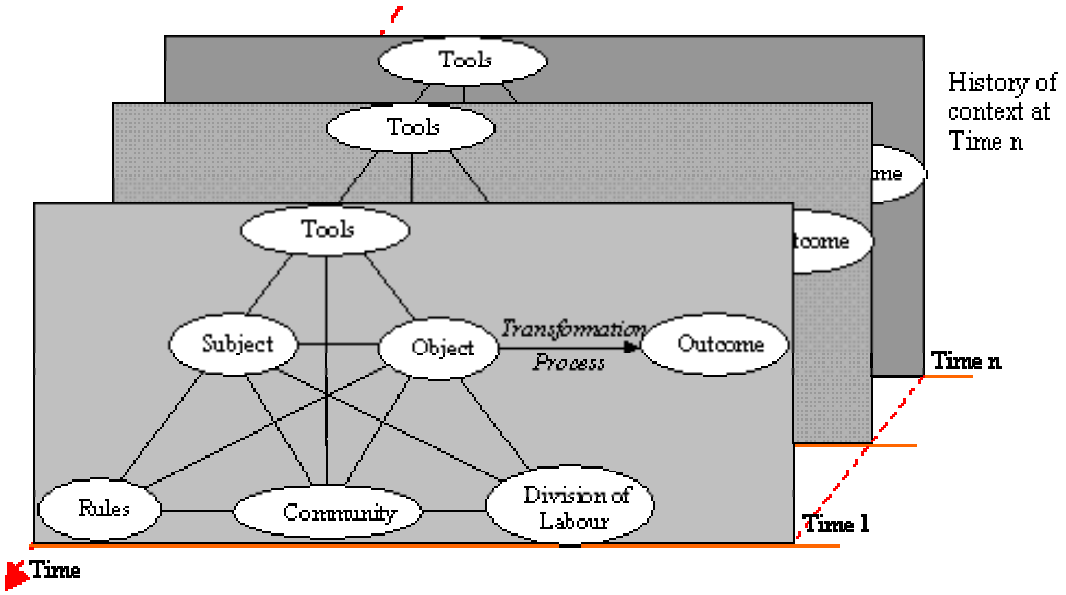

Figure 3 - Extending Activity Theory to represent history

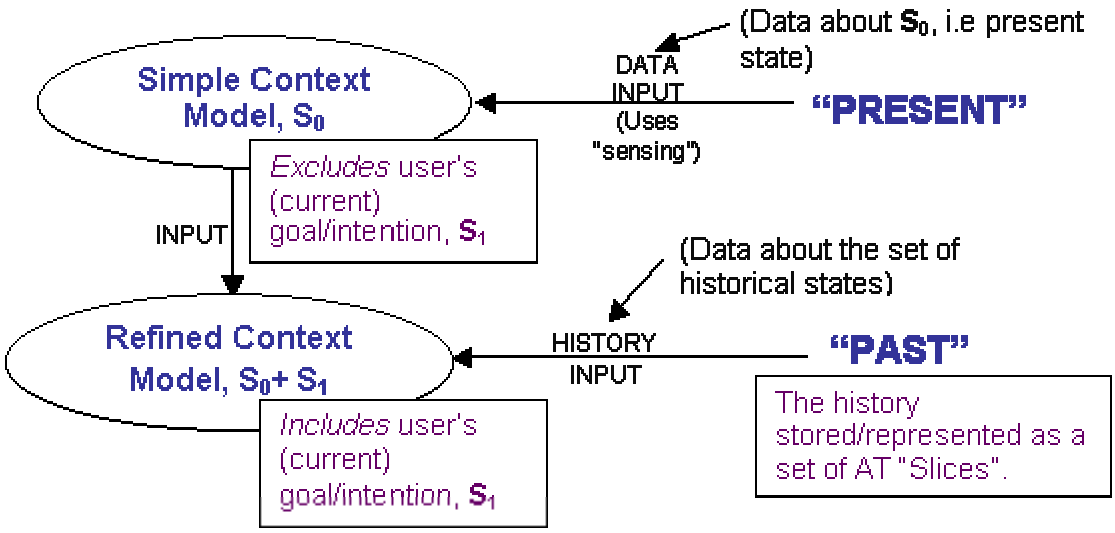

Figure 4 – Refining context models

framework to develop a better understanding about her current activity by first collecting information on each element in the Activity Theory model. Secondly, the information is organised as shown in Figure 2. At this point we do not know Malee's current goal (S_1) or the outcome (S_e). Thirdly, the context model references the history, which records Malee's context in achieving her goals in the past. This allows the system to infer her current goal. As a result, the system is able to provide the service to Malee without her undertaking all the input explicitly on her PDA. This reduction in the need for explicit input can contribute to the design of more usable, context aware applications for mobile and ubiquitous computing users.

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