Position Paper

Structuring Context Aware Applications: Five-Layer Model and Example Case

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Abstract Structuring context aware applications is important for modularising their implementation. The modularization is necessary for re-use and sharing of software and hardware components. For this end, a five-layer model for structuring context aware applications is presented. The layers are Physical, Data, Semantic, Inference and Application. (An example case involving a context aware mobile terminal in various user roles has been devised and implemented and this case is then mapped on to the five-layer model giving an example of its use. NOT DISCUSSED IN THIS POSITION PAPER)

Keywords: Context awareness, structuring, layer model, architecture, mobile terminal, WLAN, hands-free, spoken commands, speaker recognition, bioidentification, locating.

1 Introduction

Context awareness (CA) is seen as a very important part of various ubicomputing applications and a lot of research effort has been placed in finding ways to use context cues. A large part of this work has been of *ad hoc* nature, the researchers have built demonstration cases showing the feasibility of a particular idea. Even in cases where a large CA experimental environment has been designed and built, there is little tendency towards structuring and modelling. This is a drawback which limits the re-use and sharing of software and hardware components and forms an obstacle for commercial module supply.

In this paper we suggest taking steps towards modelling context aware applications and propose a method for structuring CA applications with a model consisting of five layers. The concept of CA and related work is discussed in chapter 2, the model for structuring CA applications is presented in chapter 3.

2 Related work

Context awareness has been defined by Schilt and Theimer [1] as software adapting to location, collection of people and objects nearby and their change over time. A more general definition of CA by Dey [2] states that "A system is context-aware if it uses context to provide relevant information and/or services to the user, relevancy depends on the user's task".

Context sensitivity or awareness uses such cues as position, sound, video, temperature and location [3,4]. According to a survey [5] almost any information available at the time of an interaction can be seen as context information. Examples include identity; spatial information - e.g. location, orientation, speed, and acceleration; temporal information - e.g. time of the day, date, and season of the year; environmental information - e.g. temperature, air quality, and light or noise level; social situation - e.g. who you are with, and people that are nearby; resources that are nearby - e.g. accessible devices, and hosts; availability of resources - e.g. battery, display, network, and bandwidth; physiological measurements - e.g. blood pressure, hart rate, respiration rate, muscle activity, and tone of voice; activity - e.g. talking, reading, walking, and running; schedules and agendas. Many of the early papers on CA applications include location as a key input cue, see e.g. museum guide [6,7], context sensitive tourist guides of GeorgiaTech [8] and Lancaster University [9]. Pradhan [10], suggests using semantic location as a customisation parameter for mobile services.

Typically, researchers have concentrated on designing and realising CA demonstrations and applications and modelling their structure has been secondary. Major exceptions to this are the layered architecture for the TEA-system [11,12] and the Context Toolkit [2]. The TEA-architecture consists of four layers, sensors, cues, contexts and an applications layer. The Context Toolkit is intended for making it easier to add context awareness to existing non-context-aware applications. The Context Toolkit breaks up context aware systems into three components: widgets, interpreters, and aggregators.

3 Modelling the layers of context aware applications

Modelling context aware applications as shown in Figure 1 is suggested. On the lowest level, the Physical layer, there are sensors and other objects, producing output in raw format. An example of these data are analogue microphone signal or strength of a RF signal sent by a WLAN access point. On the second level (Data layer), there are objects producing processed data, for example spectral information of the phonemes in the audio signal or location co-ordinates computed based on three RF signal strengths. The third level, Semantic layer, contains objects which transform the data into form meaningful for inferring context. These objects could analyse the spectral data and state that the speaker is Peter with confidence of 0.9, or they could state that the co-ordinates computed from the RF signals indicate that the mobile terminal is in Lisa's office.

The fourth level, inference level, uses information from semantic level, earlier information and inference rules, possibly dynamically learned, to make educated guesses what the user (either man or machine) is doing and what kind of services he, she or it might want. For example, if Peter is in Lisa's room and Lisa is his boss, the inference object (agent) might suggest that he is in a meeting. On the uppermost Application level, his personal mobile agent might then decide that he probably don't want calls to his terminal from football team-mates during the meeting and block those calls.

It should be noted that objects on higher layer may combine input from one or more objects on the lower layer with stored information. This is indicated in Figure 1 by input arrows.

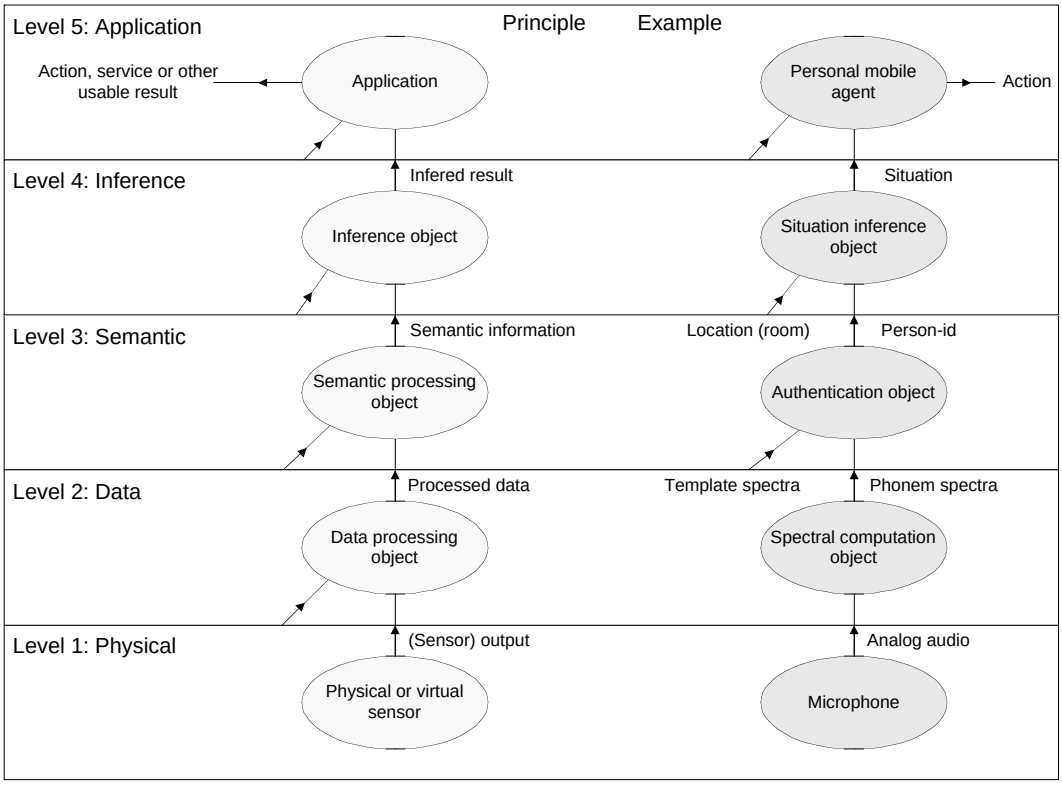

Figure 1. Context aware application model, principle and example

4 Conclusion

It is our belief that some kind of model is useful for structuring CA applications. We have proposed a five-layer model for this purpose. Identifying different components, functions and other objects in a context aware application and relating them to a suitable layer in the model is not only useful for analysis of these applications. It is also a necessary for realising modular solutions and facilitating sharing and re-using software and hardware designs among different CA applications.

In order to assess the feasibility of the five-layer CA application model, an experimental case of a CA mobile terminal for maintanence personnel was mapped on to the model. (NO DETAILS IN THIS POSITION PAPER) The case involved an application supporting the work of a jamitor, which could be mapped on to the context aware application layer model meaningfully. Furthermore, the modules used for the Janitor application were shown to be useful for implementing an other CA application. This indicated the potential of modularity, componenting and re-usability also in CA applications and encourages us to refine and develop our model further.

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