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Context in Care – Requirements for Mobile Context-Aware Patient Charts

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Abstract

The hospital ward is a highly dynamic work environment, in which healthcare personnel rapidly switch from one task to another. The process is partly planned, and partly driven by events and interrupts.

A mobile electronic patient chart (MEPC) will be an important tool for supporting order entry and accessing, communicating, and recording clinical information. The users need to switch from one context to another with minimal delay and effort. Context-awareness, the ability to sense relevant situational information, can allow the user interface of the MEPC to adapt to various situations.

In this paper, we present a future scenario from the coronary care unit. This scenario is analyzed and discussed in order to develop requirements for design methods, context models, and system properties of the MEPC.

Keywords

Handheld computers; Point-of-care systems; Computerized Patient Records; Context-Awareness; User-computer interface.

Introduction

Emerging information technology is steadily making patient information more widely accessible to healthcare personnel through the migration of paper based records to computerized patient records (CPR). Due to advances in mobile technology, the CPR can now be accessed by healthcare personnel in a wide variety of situations through mobile terminals. The work activities in the wards can be described as a combination of formal procedures, informal practices, and mobility. Despite the number of clinical situations and tasks handheld computers can be used in, most mobile clinical information systems remain unaware of the situation of use, and do not adapt. Navigating such systems, seeking relevant information, can be a process involving multiple and complex steps.

One answer to these challenges suggests imbuing mobile patient chart systems with *context-awareness* – the ability to sense situational information relevant to the interaction between a user and an application [1]. Most research activity within context-aware computing has focused on sensing and making use of situational information such as *location*, *time*, *identity* and *action* for automating services. This paper argues that more abstract notions of context, e.g. task, roles, and plans, will have to be considered when designing mobile context-aware tools for healthcare personnel in clinical settings.

This paper explores some aspects of the rich "context space" of clinical ward activities, and gives an example of mobile clinical computing that is different from most other mobile application areas. Our contribution is a set of requirements for context models, design methods, and system properties.

To illustrate some of the situations where a future *context-aware* mobile electronic patient chart (MEPC) [2] could be useful, we first present a scenario from the Coronary Care Unit (CCU). After presenting the background and motivation of our work, we discuss some aspects of the health care domain and why designing mobile context-aware tools supporting ward activities is challenging. The example scenario is then decomposed and analyzed in terms of contextual triggers and context information. We discuss requirements for realizing the context-aware MEPC based on the decomposition and analysis of the example scenario.

Example: Coronary care scenario

> It is in the afternoon. Dr. Davis is on call and has just arrived at the ward.
>
> Almost immediately she is called upon by nurse Neil (using the MEPC) who asks about patient Palmer's medication – more specifically he asks about the patient's dose of Warfarin (an anticoagulant).
>
> After checking the status of the patient, Dr. Davis is about to enter the medication dose, but then she is called to patient Adams who has had a ventricular tachycardia. She has to go there immediately, leaving the medication of patient Palmer unfinished.
>
> As she is approaching patient Adams, vital information is read into Dr. Davis' earplug from the speech synthesis unit in the MEPC.
>
> While Dr. Davis is working on patient Adams, the alarm goes as patient Taylor gets cardiac arrest. Since Dr. Davis is not available, Dr. Osborn from another ward gets a message on his MEPC. After Dr. Davis is finished treating patient Adams and has arrived in the office, the MEPC automatically displays the unfinished task of patient Palmer's medication.

Figure 1 -

Background and Motivation

The concept of context has been paid much attention to within research on human-computer interaction. Context information can be used to interpret explicit acts, making communication much more efficient [3]. With the introduction of Ubiquitous computing, the term "context-aware computing" has become a key issue in creating user friendly and efficient systems for computing devices of all sizes and for all purposes. The work of Dey, Abowd and Salber [1] represents in many ways the state-of-art within frameworks for context-aware application development. Additionally, several contributors have supplemented, or focused on aspects of context-awareness not covered in this framework.

Context has been considered as both a representational problem, and a problem concerning interaction [4]. These two separate perspectives on context draw on theories usually associated with positivism and phenomenology respectively. We want to point out that the presented requirements assume that these perspectives are different, and not mutually exclusive.

Recently, context-awareness has also been addressed within the field of health informatics. One example is the Clinical Application Suite (CAS), a multi-tasking software architecture that facilitates the development, deployment, and use of advanced clinical information management applications where the user's context is preserved [5, 6]. The CAS was a precursor for the Health Level Seven (HL7) Context Management Standard specified by the Clinical Context Object Workgroup (CCOW) [7]. The standard describes an architecture (Context Management Architecture – CMA) that serves as a basis for synchronizing and coordinating clinical applications so that they automatically follow the user's context [8]. The CCOW Technical Committee has developed and ratified several versions of the standard, each version adding new specifications. One important area under discussion for a future version of the standard is CCOW/CMA for handhelds, which introduces new and challenging issues.

The report "The Clinical Headings Version 3: Context and Clinical Records" produced by NHS Information Authority has proposed a set of terms to capture the context in which clinical terms are set [9]. These terms were known as the 'context of care' and consist of four groups of terms: Attribution terms, heading terms, status terms, and link terms. The report also describes a formal model of the context terms.

An example of a context-aware clinical system is a prototype of a medicine administration system that has been developed by Centre of Pervasive Computing in Denmark and tested at Aarhus County Hospital [10]. The system is able to register and react upon certain changes of context, such as the presence of a nurse holding a medicine tray for a patient.

The challenges related to design of context-aware tools are multi-faceted. Lack of suitable models and methods, technological issues related to building a context-aware infrastructure, and interaction issues [1] represent challenges which have to be met. Below, we present important issues directly related to design of context-aware tools for clinical settings. These issues have been a central motivation for this paper.

Health care is knowledge intensive: Health care is to a large extent knowledge-driven. Knowledge is seldom an explicit attribute such as location, time or identity. Tacit knowledge, for example, may be difficult to describe and utilize. Intuition is an example of implicit knowledge which plays an important role in healthcare personnel's decision making [11].

Context-aware applications generally make use of explicit and static information, where the detected context information triggers one specific service. These assumptions are not valid for applications supporting health care. It is easy to get context-information wrong, even when building sophisticated context-aware applications. This could have fatal consequences in clinical settings.

Ward activities are situation-driven: Ward activities are also driven by sudden and often unforeseen events, such as the incidents referred to in our example scenario. Determining in advance which services to trigger under which circumstances may prove difficult. Even discovering the right triggers for a specified event are sometimes a non-trivial matter.

Aspects of context in care

Dey, Salber and Abowd defines context as: "Any information that can be used to characterize the situation of an entity, where an entity is a person, place, or object that is considered relevant to the interaction between a user and an application, identity and state of people, groups and computational and physical objects" [1]. In our setting, the entity the chart user. The context also includes information about relevant record content, reminders, orders, or requests.

Formally, we can look at a context as a database of facts that hold in a certain situation. It is this database that a context- aware system will sense, and react on. The database can contain facts about the physical world, user actions, and other information. For any context, there exists a hierarchy of more general contexts, each with less (specific) information. Guha and McCarthy [12] have described various context models according to the lifting (generalization) rules that they employ. For now, we only need a basic understanding of more and less general contexts.

A context will obviously change as things happen in the information system and the real world. Such a proceeding of contexts will be called a context pathway. However, we also want the user to change the context explicitly, i.e. navigate by contexts. For example, the user should be able to:

- Change to a partly specified context that has occurred.
- Spool backwards through a pathway of contexts.
- Jump to any, partly specified, preprogrammed, or explicitly chosen context.
- Send a reminder to someone with an attached context.
- Predetermined reminders can be regarded as part of the context.
- Regard choosing a patient in a menu as conceptually the same as walking close to the patient.
- Block certain (disturbing, irrelevant) context elements.
- Search for contexts.

- Switch to the context of another role at a specific point in time.
- Switch between contexts, stack them, and assign priority.

Explaining the example scenario

Returning to our ward example, figure 1 depicts the context pathways of different persons in the ward. We assume that all healthcare personnel have MEPCs connected to an advanced clinical information system with plans, reminders, and sufficiently rich record representation. The narrative underneath gives an outline of context changes, events, notifications, and the behavior of the user interface for Dr. Davis' MEPC.

1. Time, identification, location

It is in the afternoon. Dr. Davis is on call and has just arrived at the ward.

As she arrives at the ward, she logs onto the information system. Based on current time (start of the shift), her role and identity, and the location (CCU), the display of the MEPC shows a list of patients that are new to Dr. Davis, new test and examination results for already known patients, and other relevant information.

2. Notification, identification, context change

Almost immediately she is called upon by nurse Neil who asks about patient Palmer's medication – more specifically he asks about the patient's dose of Warfarine (an anticoagulant).

The query from the nurse is in form of a standard request for an assessment. The context of the assessment consists of an identification of patient Palmer, and the relevant part of his medication plan for Warfarine that nurse Neil was studying on the MEPC when sending the request. Dr. Davis is notified by the request (being part of her context). She accepts it, and immediately changes to the context that nurse Neil had when sending the request. Dr. Davis' former context is pushed, and can be resumed at a later stage. Her actual decision with regard to Warfarin depends on several factors, for instance, the diagnosis of the patient (e.g. atrial fibrillation or deep vein thrombosis), if the patient is set up for surgery, and new blood test results. All this information is automatically shown on her MEPC.

3. Notification, identification and context change

After checking the status of the patient, Dr. Davis is about to enter the medication dose, but then she is called to patient Adams who has had a ventricular tachycardia. She has to go there immediately, leaving the medication of patient Palmer unfinished.

Yet another predefined request is issued by monitoring equipment, or by nurse Neil. This time the request only refers to the context of the apparatus, i.e. physical location. The MEPC may find out who the patient is from background knowledge.

4. Task, identification

As she is approaching patient Adams, vital information is read into Dr. Davis' earplug from the speech synthesis unit in the MEPC.

Dr. Davis accepts the request and the MEPC switches context appropriately. If the patient is known, new or relevant information may be displayed or read through her earplug.

Along with the alarm, important patient information (e.g. name, location, date of birth) and the tachycardia procedure is shown.

5. Task – role filtering of request

While Dr. Davis is working on patient Adams, the alarm goes as patient Taylor gets cardiac arrest. Since Dr. Davis is not available, Dr. Osborn from another ward gets a message on his MEPC.

The system detects that Dr. Davis is busy helping patient Palmer. The request is routed to Dr. Osborn from another ward, who is the nearest available doctor on call.

6. History reminder, location

After Dr. Davis is finished treating patient Adams and has arrived in the office, the MEPC automatically displays the unfinished task of patient Palmer's medication.

Dr. Davis gets a reminder about the unfinished medication task.

Based on the decomposition of our scenario, the proposed underlying MEPC system seems to fit its purpose in terms of ward activity supportive context functions. Communication between healthcare personnel is supported (messaging), as well as coordination of activity (alarm routing, reminder function). In other words, from a system perspective the proposed MEPC system might seem to meet all the requirements we have discussed.

Requirements for context models

In addition to the basic features of a context model from the user's point of view, some global system requirements must be met in order to have a sound and safe system:

1. All important information must be visible in some context within reasonable time.
2. Reminders must be captured and handled within a reasonable time limit: The higher priority, the shorter delay.

Requirements for design

In order to discover which context information is essential for healthcare personnel, and in what way the specific context information is used, deep insight into daily ward activities is necessary. Design methods which are characterized by a high degree of user involvement, such as user-centered design is therefore appealing. Especially, iterative design where the users take part of all stages, like within the Scandinavian tradition, is a promising alternative within system design [13]. Techniques like role-playing can be used to explore important aspects of mobility and the role mobile electronic tools play when they are introduced in an activity. Such techniques may also prove valuable for designers of mobile context-aware tools in clinical settings, especially during the early phases of requirements gathering.

System properties

The following system functionalities represent the most important considerations to be taken into account when designing mobile context-aware tools for healthcare personnel.

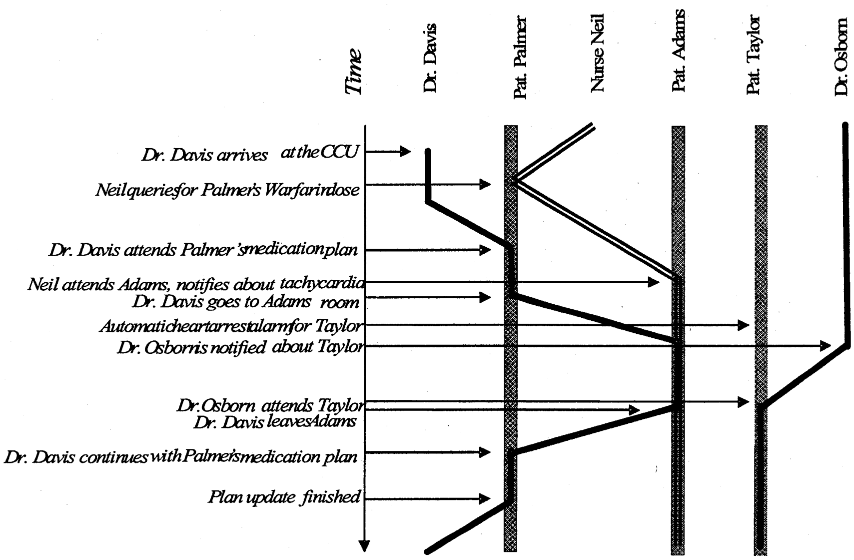

Figure 2 - Context pathways in ward example

1. Caution concerning automatic execution of services

Greenberg [14] suggests that context-aware systems generally should be "fairly conservative in the acts it takes". This principle certainly holds for context-aware tools supporting ward activities. In particular, services the system can perform which directly concern the treatment of the patient should always be confirmed by the authorized healthcare personnel before execution. As a result, the context-aware functions related to a MEPC should focus on supporting *presentation of information* and *attachment of context information for later retrieval* as described in the conceptual framework of Day, Abowd and Salber [1].

2. User control

User control does not simply imply that the user should be notified, or that he should have to confirm every action the system intends to take. Rather, for seamless integration with day-to-day ward activities only potentially "risky" actions should have to be explicitly confirmed by the user. An additional aspect of user control is giving healthcare personnel the option of configuring both the user interface and context-aware functions of the MEPC.

3. Coordination of perspectives

By giving healthcare personnel the option of configuring the user interface and context-aware functions, there is also potential danger which calls for special attention. Enabling the individual user to put his perspective on "the world", may result in that some context information filtered out by everyone at the same time. Consequently, information concerning a patient may be lost. If every member of a care team, for example, is able to disable all notification regarding a certain patient, the result could obviously be disastrous. An important system property is therefore to support coordination mechanisms guaranteeing that no information remains "unseen" by all healthcare personnel simultaneously.

4. Navigating in context

A MEPC that is aware of its own location, as well as surrounding healthcare personnel, patients, and medical devices allows location-based automatic or user-controlled navigation in the patient chart. This may be supplemented by physical actions like scanning tags on a particular patient.

Tagging of information for later retrieval is a central function for many context-aware devices. Time-stamping information in itself, however, does not make the MEPC more user-friendly. The MEPC should provide means for navigating between different chart contents classified according to episodes of use, for example location, activity, roles, and other context attributes. Important parts of gathering requirements are to discover and classify relevant episodes of use. The MEPC could even allow for healthcare personnel to define their individual classification of episodes.

Conclusion

We have discussed various requirements for realizing a mobile electronic patient chart (MEPC) which can sense and utilize different sorts of context. In order to illustrate the rich "context space" of clinical settings, an example scenario from the Coronary Care Unit was explained and analyzed in terms of context changes, events, notifications, and the behaviour of the MEPC user interface. The analysis points out particular requirements on context models, design, and system properties for the context-aware MEPC. We have elaborated on these requirements to make them usable for designing mobile devices that support healthcare personnel in a user-friendly, efficient and safe way.

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