Home Care Support from the Database Point of View

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ABSTRACT

Supporting ambulant care through information technologies will assist the care personnel in their everyday routine resulting in more time for their patients. Therefore the MARIKA project focusses on developing an assistance system for facilitating the care documentation process through pervasive technologies. In this context, various data need to be handled which requires database techniques for different aspects of the assistance system. Thus a general five layer architecture for assistance systems is introduced and adapted according to the requirements of data management. With the focus on the layer of *Mobile Content Management* it is explained how a part of the distribution of the data in the MARIKA project is handled.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

distributed database design

Keywords

assistance systems, home care support, architecture for assistance systems, database support for assistance systems

1. INTRODUCTION

Recent statistical studies in the USA as well as in European countries estimate a dramatic increase in the group of the elderly in the next decades [13]. Presumably, the number of people in need for care and therefore the demand for ambulant care will also grow. To facilitate the care processes, support through information technology systems is an essential aspect. Especially the accurate documentation process takes up a large amount of work (around 40 % of the working time). To support the care personnel in their documentation of care activities "along the way" through pervasive technologies is one of the main goals in the MARIKA[1] project. In this project the care personnel is equipped with a mobile device when visiting the patients. With the help of sensors the care activities are recognized and digitally documented on the mobile device.

With respect to assistive care systems, low level data which are only stored temporarily for efficiency as well as high level data for the actual care documentation need to be handled. Additionally already known information can contribute to the analysis of the situation for the assistance system. To manage all these data, different database techniques are applicable. After a short introduction on assistance systems for home care support, this paper proposes database techniques for different purposes in an assistance system on the basis of a general five layer architecture for assistance systems. Focussing on the requirement to offer the correct information needed at the right time in the right place, the subsequent section deals with the distribution of data in the MARIKA scenario. After that the conclusion is presented. Finally an outlook will be given in the last section.

2. ASSISTANCE SYSTEMS FOR SUPPORT IN HOME CARE ENVIRONMENTS

Considering the demographic change, support for the elderly and those who care for them is inevitable. Assistance systems can help the elderly to live longer at home independently. Various research projects deal with environments to offer assistive technologies, e.g. via a mobile device which needs to be carried [9], as a platform to locate the indoor position of a person [12] or by supporting the elderly taking into consideration their individual situation [3]. In the clinical environment, support for the doctor during their wardrounds has been investigated [1]. This can also be supported by implementing a mobile-based clinical information system like proposed in [2].

In the area of home care support the MARIKA project deals with the development of an assistance system for supporting home care personnel [13]. One of the aims is to automate the documentation of the care process and therefore facilitate the work of the home care personnel so that they have more time for their patients. Therefore the nurse is equipped with a mobile device which contains all necessary

[1]The acronym MARIKA stands for the German title "Mobile Assistenzsysteme für RoutenInformation und KrankenAkte" which could be roughly translated as "Mobile Assistance for Route Information and Electronic Health Record".

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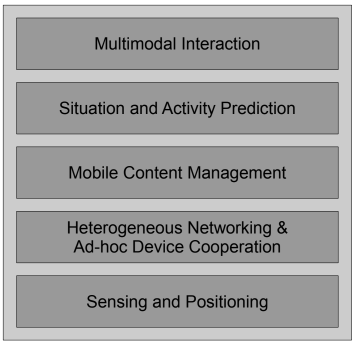

Figure 1: Architecture for assistance systems

information about the patients and the planned care activities. The performed care activities are recognized with the help of sensors and matched to the planned activities.

Other projects also aim to support the care personnel. One example is the SAMDY project which intends to establish an early warning system for the care personnel by monitoring the elderly through sensors. It also supports care documentation with sensors but is intended to be used for stationary care mainly [6]. Another project called VitaBIT deals with the design of a platform to offer mobile information services for the purpose of home care nursing [11].

3. GENERAL ARCHITECTURE FOR ASSISTANCE SYSTEMS

To emphasize the charectaristica of a general assistance system, a general architecture for assistance systems as shown in figure 1 has been proposed in [7]. Each layer has its own purpose in the whole assistance system but still they can not be considered separately because they depend on each other. In this paper, the architecture is extended with appropriate database techniques as shown in figure 2 which will be described in detail below.

Sensing and Positioning

The first layer which delivers the basic data for analysing the user's situation and acitvities is named *Sensing and Positioning*. Sensors (e.g. acceleration sensors, RFID tags) and positioning systems (e.g. GPS for outdoors) collect raw sensor data which are parsed and prepared for the situation and activity analysis on a higher level. For supporting these processes a tiny database system may be used to manage the sensor data, like the smallest version possible of FAME-DBMS [10].

Heterogeneous Networking and Ad-hoc Device Cooperation

The *Heterogeneous Networking and Ad-hoc Device Cooperation* layer is responsible for integrating the heterogeneous devices and connect the necessary subsystems. The devices may not only differ in their type, but also in their communication technology and their protocol specifications. Additionally it is possible that the needed and the available devices are not known in advance. This adhoc device cooperation can be realized with a service-oriented approach (e.g. SOA). One idea to solve the heterogeneity in the communication technology of a service consumer and a service

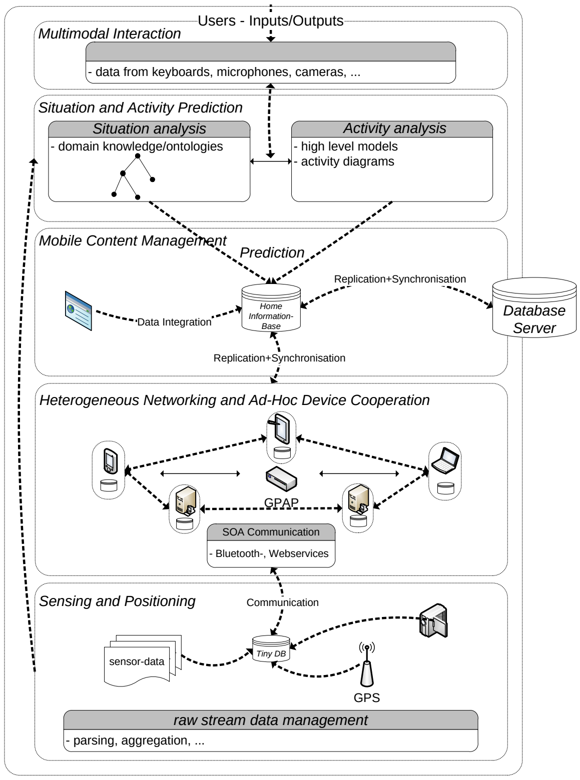

Figure 2: Database techniques in assistance systems

provider is to introduce a tier of abstraction. It converts the used precise technology into an abstract one and transforms this into all other present technologies. One example is the General Purpose Access Point (GPAP) which is developed by Dressler et.al.[5]. In this layer small or even tiny (embedded) databases might be used to store device profiles either on the device itself, on a service broker or even after usage on the consumer side.

Mobile Content Management

The main purpose of the *Mobile Content Management* is to provide the correct information needed in the right place at the right time. This requires a prediction about which information may be needed at which place in the future. Therefore the analysis and prediction of situations and activities, which is done in this layer, is highly important. Furthermore the *Mobile Content Management* comprises the management of all multimedia documents and the replication of those to fulfill the main purpose. Therefore a medium to very large[2] database system, which will probably be distributed or federated to ensure the information to be in the right place when needed, is recommended. The integration of necessary other information, database or assistance systems is another task of this layer.

Situation and Activity Prediction

The *Situation and Activity Prediction* layer is the key layer of an assistance system. Only if the situation or activitiy of the user is understood and the possible future situation or activity is recognized then the system can offer assistance.

[2]depending on the amount of multimedia documents

So, this layer is responsible for analysing the user's situation or activity with the help of the data from the *Sensing and Positioning* layer and calculates probabilities for the future situations or activities. It utilizes high level models and/or ontologies. Surrounding conditions and prior knowledge additionally help identify the situation. Because the situation analysis runs permanently the necessary models and ontologies need to reside in the memory all the time. Therefore a database system at this point is only helpful for storing some background information which is not constantly needed and can be queried if required.

Multimodal Interaction
The layer of *Multimodal Interaction* deals with the communication of the assistance system with the user via several input and output devices. The received input data via different devices, e.g. keyboard, microphone, camera, may influence the situation analysis. A camera can for example detect the movement of a person which helps identify their situation. Concerning the input, a natural interaction should be intended to avoid the feeling of awkwardness. If gestures are necessary, they should be socially accepted ones, like mentioned in [1]. The output's task is to support the user in their situation or during their activity. In some cases the output signals a warning to make the user (or another person) realize that something is wrong. Databases can be used here as a kind of cache to store data temporarily before output or after input.

Another architecture for assistance systems consisting of only three tiers (*Context Sensing Tier*, *Context Processing Tier*, *Context Application Tier*) has been introduced by Kurschl et al. [8]. Compared to the architecture described above the *Context Sensing Tier* can be seen as the *Sensing and Positioning* layer, the *Context Processing Tier* corresponds to the *Situation and Activity Prediction* layer and the *Context Application Tier* is similar to the *Multimodal Interaction* layer. The layer of *Heterogeneous Networking and Ad-hoc Device Cooperation* can be seen within the transition zones between the *Context Sensing* and *Context Processing Tier* whereas the *Mobile Content Management* is only considered marginally in the *Context Processing Tier*. The above introduced general architecture therefore considers two aspects more detailed while those aspects are only contained implicitely in the architecture of Kurschl et al.

4. MOBILE CONTENT MANAGEMENT IN HOME CARE SCENARIOS

While the architecture presented above can be applied for any kind of assistance system, this chapter focusses on one specific layer in the scenario of home care support only: the *Mobile Content Management* in the MARIKA project. In this scenario the relevant content to be managed consists of the care documentation and all of its related data concerning care plan, care providers, patients, health and so on. These data comprise sensor data streams to recognize the activities, text and multimedia documents (e.g. pictures, videos, recorded speech) for complementing the documentation as well as temporal and spatial data. To manage these data a distributed database system is used which mainly consists of two parts: a central database which is installed for instance in the office of the care provider and several mobile databases which are located on the mobile devices of the care personnel. More databases may be included in this scenario, even a federated approach is possible if other independent database systems will be involved. But for the purpose of this paper the scenario with the above described two-sided distributed database system is sufficient.

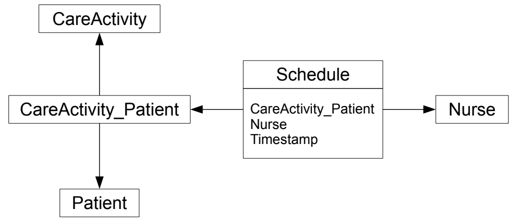

Figure 3: A sketch of the database scheme

The care provider has created a care plan for each patient that defines which care activities have to be performed and how often. Based on that a working schedule for all nurses is developed which is stored in the central database. The schedule can be seen as the set $S \subset \{N, T, P, C\}$ where N is the set of all nurses, T is the set of all timestamps, P is the set of all patients and C is the set of all care activities. Each tuple $(n, t, p, c) \in S$ with $n \in N$, $t \in T$, $p \in P$ and $c \in C$ is unique. One nurse only needs a subset of this schedule for one working shift to be replicated on their mobile device. This subset $R \subset S$ is defined by the specific nurse $n_a \in N$ as well as the start time $t_{start} \in T$ and end time $t_{end} \in T$ of their working shift for that day and contains all tuples (n, t, p, c) which correspond to the following condition: $n = n_a$ *and* $t_{start} \leq t \leq t_{end}$ where $n \in N$ and $t \in T$. This subset and all corresponding data (like health information about the client) need to be replicated to the database on the mobile device. During their shift the nurse can consult their mobile device for information about the patient and the care activities. With the help of sensors the care activities are recognised and the information on the mobile device is updated. Eventually new health information about the patient and some additional care information is added by the nurse. Ideally, after each patient the updated mobile database will be synchronised with the centralized database in order to ensure that the information about the patient is up-to-date for a possible other nurse who may be visiting the patient a little later. Because the schedule itself contains timestamps determining when each care activity is planned to be performed with a patient, the synchronisations are expected around a particular time. If one synchronisation is missing, e.g. because of no network connectivity, the system needs to handle that. A late synchronisation might lead to conflicts which need to be resolved. Classical replication techniques like the Read-One-Write-All technique are not suitable for a mobile replication. Düffer et. al. [4] suggest techniques based on primary copy methods and progressive methods to handle the replication in mobile scenarios like the MARIKA project.

The key characteristic of the database scheme is the realization of the schedule. Figure 3 shows a sketch of the database scheme involving five relations (the whole database scheme contains more relations, for simplicity the figure only shows the ones needed to explain the implementation of the above described schedule). The care plan which describes which care activity is performed on which patient is contained in the relation *CareActivity_Patient*. The schedule is represented by the relation *Schedule* and contains two foreign keys, one relating to the *Nurse* relation and one relating to the *CareActivity_Patient* relation, as well as a timestamp. For replicating the relevant data to the nurses' mobile devices, a horizontal partitioning based on the specific nurses and their working shifts as stated above serves as the main concept. Therefore every working day each nurse only carries the necessary information about their patients and the planned care activities.

5. CURRENT RESEARCH CHALLENGES

All documentation about the performed care activities need to reside with the patient at least until the end of the month. Currently this documentation is paper-based. With the introduction of an assistive system to support home care like in the MARIKA project all information about the documentation is digitalised. Instead of printing it out and leaving the documentation on paper with the patient, a home information base can be installed in the patient's home to replace the paper work. The data on the device needs to be replicated from the central care information system or the mobile device (or both) and can be accessed via a display like the television. The relevant care information is considered as read-only. Therefore one question is whether it should be materialized on the home information base or whether it should only be integrated virtually.

Additionally, health data like vital data can be collected on the home information base. Furthermore, in the future it can also be used by other stakeholders like relatives or medical staff to store and access patient-related information. The home information base can be used as a integration platform for other possible services for the elderly. For integrating assistance systems the research area of information integration needs to be investigated to find out whether and how these techniques can be utilized. Several special aspects have to be considered for assistance systems, e.g. how the functionality is integrated and whether the combination of different assistive functionality can cause some malfunctional or contradictory behavior. Another aspect is privacy of the patient's sensitive data. First of all the data itself needs to be encrypted. Also the access to the data needs to be restricted. Each stakeholder is only allowed to access a certain amount of data after authentication. So data security is one major issue when installing the storage device.

6. CONCLUSION

Home care support through assistance systems has been elaborated as an important issue regarding the demographic change. While various projects support the elderly directly ([9], [12], [3]) or the medical staff in stationary environments only ([1], [2], [6]), the MARIKA project focusses on assisting in the care documentation process for ambulant care. As there is no adequate architecture for assistance systems in general yet, in this paper, a five-layer architecture has been introduced and extended with suitable database techniques considering the demands of every layer separately. Fulfilling the requirement of the *Mobile Content Management* layer to provide the correct information needed at the right time at the right place, a distributed database approach has been proposed to manage the data of the care documentation. A central database which acts as the main care information system on the one hand and a mobile device for every nurse that only has a replicate of those information needed for one working shift on the other hand serve as an initial database system for assisting the nurse in the MARIKA scenario. Implementing a home information base at the patient's home extends this database system.

7. FUTURE WORK

In the MARIKA project, activities of a home care nurse are detected in order to automate documentation of the home care process. To respect the privacy of the nurse, the sensor data has to be reduced as early as possible in the process of replication and distribution. If possible, the tiny DBMS managing the sensor data should perform as much aggregations and selections to only distribute those sensor data being important to detect a given home care activity. On the other hand, the tiny DBMS has not the power to derive the important home care activities: the data has to be distributed to other computers, e.g. the home information base. In the upcoming phase of the MARIKA project, we have to bridge the gap between good activity detection and preserving privacy of the home care personnel.

Another important future direction of research is the federation and evolution of assistance systems. The home information base mentioned above is primarily planned to be a basis for AAL (ambient assisted living) systems, i.e. it should support the people in their homes and not the nurses visiting their homes. If one computer system and one set of data is the basis for more than one assistance systems, the federation of the data has to be performed without having conflicts with the privacy preservation for both user groups to be assisted. And if activities and home care standards change, the activity detection has to change and the aggregeation, selection and distribution of data has to automatically be adapted.

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