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Healthcare Profile Management System in Smart Cards

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***Abstract*—Nowadays, healthcare profile management systems are essential for ubiquitous healthcare systems in cloud computing environments. However, these profile management systems incorporate user profiles consisting of limited user information associated with user preferences and interests. Thus, it is required the deployment of profile management systems enabling the reliable creation and efficient management of enriched user profiles. Toward to this effort, in this paper, we propose a smart card file system design for the user healthcare smart cards incorporated in a healthcare profile management system applying in a typical ubiquitous healthcare system.**

***Index Terms*— healthcare profile management system, user profiles, smart card file system**

I. Introduction

The current healthcare services are focused on effective treatment, disease prevention and proactive actions; procedures that support a patient-centric approach. The ubiquitous access to healthcare data is considered essential for the proper provision of such procedures. The technology that provides the functionality for managing information data in a distributed and ubiquitous manner is cloud computing. However, many healthcare services are not tailored to user's needs and preferences. Because of this limitation, personalized healthcare systems have been recently deployed. Personalization is realized with the introduction of user profile that stores the user preferences, context of use and additional data related to user's interests. Every service makes use of the data in the user profile to provide personalized services. The deployment of personalized healthcare systems is based on profile management. During the past few years, a lot of effort has been invested in user profile management systems for ubiquitous healthcare systems. However, these profile management systems incorporate user profiles including limited user information associated with user preferences and interests. Hence, it is required the creation of enriched user profiles for efficient ubiquitous healthcare systems. Furthermore, taking into consideration the challenges that a ubiquitous healthcare system faces for the provision of high quality and reliable services, it is essential the creation and management of the profiles of all participating entities of such as system.

For that reason, in [1], we proposed five generic healthcare profile structures that correspond to the participating entities of a typical ubiquitous healthcare system in a cloud computing environment. We considered as participating entities, the entities that are directly or indirectly related to the patient when his health condition is critical and a ubiquitous healthcare service should be delivered. For these entities, we consider profiles created based on the generic healthcare profile structures.

In addition, in [1], we proposed a profile management system integrating smart card technology to increase its efficiency and the quality of the provided services of the ubiquitous healthcare system. In the context of the proposed profile management system, each one of the participating users poses a smart card storing information about the locations of distributed databases where the corresponding user profile data are stored in the cloud computing environment.

In this paper, we carry on our work from [1]. Essentially, we propose a smart card file system design for the user healthcare smart cards integrated in the healthcare profile management system that we presented in [1]. This profile management system is focused on a typical ubiquitous healthcare system (i.e. an e-Health tele-monitoring system) in a cloud computing environment. The main objective of the proposed smart card file system is to enhance the profile management system in order to create user profiles properly and provide more efficient management of the user profiles in a cloud computing environment.

Following the introduction, this paper is organized as follows. In Section II, we briefly present related work of healthcare systems integrating smart card technology. Furthermore, related work of user profile management systems is given. In Section III, a brief overview of the background of smart card file system is given. In Section IV, the proposed smart card file system is presented. In Section V, discussion about possible extensions of the proposed smart card file system is given. Finally, Section VI concludes the paper.

II. Related Work

A. Healthcare Systems Applying Smart Card Technology

In [2], the authors present a reference architecture for developing cost-effective, flexible and interoperable healthcard solutions in Java, that make use of IS0 7816-compliant smart cards, on different target platforms such as Windows, network computers and handheld devices. The architecture addresses all the specific requirements of e-health, covering the whole development and deployment process (end-to-end). It will enable the evolution of innovative healthcard applications and services as well as their consistency with other e-government and e-commerce

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applications.

In [3], a smart card based healthcare information system is developed. The system uses smart card for personal identiûcation and transfer of health data and provides data communication via a distributed protocol which is particularly developed for this study. Two smart card software modules are implemented that run on patient and healthcare professional smart cards, respectively. In addition to personal information, general health information about the patient is also loaded to patient smartcard. Healthcare providers use their own smart cards to be authenticated on the system and to access data on patient cards. System is developed on Java platform by using object oriented architecture and design patterns.

The aim of [4] is to introduce the main software module of the DIABCARD Chip Card Medical Information System (DIABCARD CCMIS) that provides an online, portable diabetes medical record information system based on a high performance object-oriented rapid application development language such as Borland Delphi. A chip card based medical information system was developed as a good possibility to create a portable electronic patient record. In particular the patient data card makes the up-to-date patient's record available whenever needed. The developed DIABCARD Core System, described in this paper, includes a patient record management system that has the ability to handle topics such as administrative and medical data, medical anamnesis, and physical examination data.

The work in [5] deals with selection of appropriate indexing techniques applied on MySQL database for a healthcare system and its related performance issues. The proposed Smart Card based Online Health Care System deals with frequent data storage, exchange and retrieval of data from the database servers. Speed and accuracy is of primary concern of the system.

In [6], the authors describe personal requirements of global information systems such as passport, health care, financial, and driving license applications. Analysis of these requirements identified common and application-specific attributes. Based on these requirements, a proposed structure for a global multipurpose smart card is discussed.

B. Profile Management Systems

In [7], it is presented a user profile management approach for service platforms that supports context-aware personalized applications in ubiquitous computing environments. In particular, this approach supports the decoupling of application development from context management and context processing. This is achieved by a context-related decision making process for finding the best matching user preferences that is carried out within the profile management component instead of in applications.

In [8], the authors propose an innovative user profile management that allows the creation of an instance of the user profile for each application and for each instance of context.

In [9], a wider view of personalization and user profiles is presented. It focuses on the architecture work within the standardization activities in the personalization and user profile management area. The ongoing work develops an architectural framework covering network and terminal issues, as some of the functionality could be implemented in the network and some in the terminals and smart cards.

III. Background of Smart Card File System

Smart card File System is always based on a tree structure with a root directory. The root directory is called Master File (MF). There is only one MF in the file tree of the smart card. The MF can contain dedicated files and elementary files (i.e. data files).

The smart card directories are called Dedicated Files (DFs). A DF is a subdirectory in the file system hierarchy and can consist of other DFs and elementary files. In applications, three or four levels of DFs are usually used. Besides, there are the Application Dedicated Files (ADFs). An ADF is a special type of DF for a specific application and stores all the files of a particular application.

Furthermore, there is another type of smart card files called Elementary Files (EFs). They are data files where the actual application data and operating system data are stored. EFs are always located in the directories (DFs) of the smart card file system. There are two types of EFs: working EFs and internal EFs. The working EFs store application data which are accessible to the outside world via smart card commands. On the other hand, the internal EFs are used by the smart card operating system to store data for internal purposes. For instance, the internal EFs can store keys or seeds for a random number generator.

Additionally, EFs have internal structures. Thus, the stored data can be arranged in various ways in the EFs. Based on their internal structure there are the following types of EFs: Transparent EFs, Linear EFs and Cyclic EFs. The Linear EF has two subtypes. These subtypes are the following: fixed-length linear EFs and variable-length linear EFs.

Smart card operating systems provide the common set of file operations such as creation, deletion, read, write and update. When a file is created it should be created to support the maximum size that it is expected to be. However, smart card file systems do not provide garbage collection or compaction. Thus, when a file A is created first and a file B is created second, then when file A is deleted the occupied space by A is still occupied till the file B is deleted too [10].

IV. Proposed Smart Card File System

A. Profile Management System Scenario

We consider the healthcare profile management system introduced in [1] for an e-Health tele-monitoring system in a cloud computing environment. The main characteristic of this healthcare profile management system is the use of smart card technology as a key solution for efficient management of the user healthcare profiles in a cloud computing environment. Each user (e.g. patient, doctor, nurse, family number) of the e-Health tele-monitoring system poses a smart

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card, called User Healthcare Smart Card, storing the necessary information referencing to large amount of stored profile data for the creation of enriched user profiles. In other words, each User Healthcare Smart Card stores URL locations pointing to databases where the user profile data are found in order the corresponding user profiles to be created. The user profiles should follow the generic healthcare profile structure, called User Healthcare Profile and proposed in [1].

To enable the creation of user profiles properly and ensure their efficient management is essential to define an appropriate smart card file system for the User Healthcare Smart Card.

B. Proposed Smart Card File System Design

Considering a typical smart card file system following the hierarchical structure, we propose a particular implementation design for the file system of the User Healthcare Smart Card. The proposed file system consists of three levels of hierarchy. In the first level (i.e. highest level) of hierarchy, there is the MF. The second level of hierarchy consists of a number of DFs and the third level of hierarchy includes a wide range of data files (i.e. DFs).

In our smart card file system the MF defines the User. The name of the MF corresponds to the User Name enabling the profile management system to identify the owner of the smart card. The MF contains nine DFs as descendants. The nine DFs located directly below the MF correspond to the nine categories of profile information included in the User Healthcare Profile proposed in [1]. Thus, the MF contains the following DFs: Personal Information DF, Preferences DF, Terminal Capabilities DF, Required for Third Party DF, Current Activity DF, Current Context Information DF, User History DF, Rules DF and Policies DF. Each DF (e.g. Personal Information DF) includes all the required information in order the user profile data of the corresponding category of profile information (e.g. Personal Information) to be accessed easily and handled efficiently by the healthcare profile management system proposed in [1].

To achieve this, each DF holds a number of EFs storing the URL locations pointing to databases where the corresponding user profile data are stored. Actually, each EF of a specific DF stores a URL location pointing to a database including part or all the required information. Hence, the EFs incorporated in all DFs of the proposed file system store the essential information (i.e. URLs) in order a User Healthcare Profile to be created.

In the following Fig. 1, we present an example of the structure of the proposed smart card file system in case that the Personal Information DF, the Preferences DF, the Rules DF and the Policies DF consist of *N* EFs, *M* EFs, *K* EFs and *L* EFs respectively. It means that the Personal Information data are stored in *N* different locations, the Preferences data are stored in *M* different locations, the Rules data are stored in *K* different locations and the Policies data are stored in *L* different locations. Consequently, each EF of the Personal Information DF includes one of the *N* URLs. Additionally, each EF of the Preferences DF incorporates one of the *M* URLs. Moreover, each EF of the Rules DF stores one of the *K* URLs and each EF of the Policies DF consists of one of the *L* URLs.

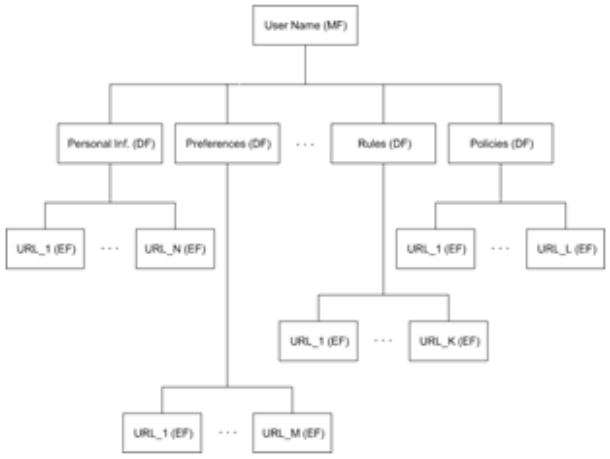

Figure 1. Structure Example of the Proposed Smart Card File System

In the proposed smart card file system, the EFs storing URLs are Working EFs, since they should be accessible to the outside world via smart card commands.

V. Discussion

The smart card file system that we propose in this paper is focused on a healthcare profile management system integrating only user smart cards (i.e. User Healthcare Smart Cards).

Besides, we believe that smart cards can be used by all possible participating entities of a typical ubiquitous healthcare system for the creation and management of their profiles. For example, in [1], we have considered that in an e-Health tele-monitoring system the participating entities are not only the users (i.e. patients, doctors, nurse, family members) but also a healthcare center, a smart home, an office and a vehicle. Thus, a smart card can be assigned to each participating entity and not only to users. In other words, the healthcare profile management system will integrate a Healthcare Center Smart Card, a Smart Home Smart Card, an Office Smart Card and a Vehicle Smart Card. All these new smart cards will enable more efficient management for the profiles of all the participating entities.

Similar to the User Healthcare Smart Card, an appropriate smart card file system should be deployed for the Healthcare Center Smart Card, the Smart Home Smart Card, the Office Smart Card and the Vehicle Smart Card respectively. Based on the smart card file system design proposed in this paper, the corresponding file system for the Healthcare Center Smart Card, the Smart Home Smart Card, the Office Smart Card and the Vehicle Smart Card can be designed properly.

Conclusion and Future Work

In this paper, we have proposed a smart card file system design for the User Healthcare Smart Cards integrated in the

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healthcare profile management system proposed in [1]. We intend to continue our research in this direction in order to deploy the proposed healthcare profile management system. The initial step toward this direction is the deployment of the User Healthcare Smart Cards incorporating the proposed smart card file system design. Thus, as future work, we plan to implement the User Healthcare Smart Cards using Java Cards.

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