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A Central Repository for Biosignal Data

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***Abstract*— Ubiquitous home health monitoring system requires a repository to archive and maintain biosignal data for further using the data in a close clinical examination. This paper describes a central repository to integrate the biosignal data which comes from different types of sensors or devices in the remote smart homes. Using MFER standard, we propose a web-based approach to transferring the measured biosignal data to the central repository. It shows that MFER standard is useful for communicating and storing the biosignal data. For supporting ubiquitous access to the data stored on the central repository, we developed web services for different types of user groups. The java applet program was developed for proving an interface that allows easily viewing the biosignal data in MFER format.**

I. Introduction

Ubiquitous healthcare is an emerging area of technology that uses a large number of environmental and patient sensors and actuators to monitor and improve patients' physical and mental condition [1]. Among the ubiquitous healthcare applications, one of the promising challenges will be ubiquitous computing for home healthcare [2]. We can easily imagine a smart home equipped with various health monitoring devices. In the smart home, the various measurements are performed tether-freely and pervasively.

However, many researches have tended to focus on the measurement of biosignals, rather than on the management of the measured biosignal data. For the successful ubiquitous home healthcare, the measured biosignal data should be easily assessed and properly maintained. This paper describes a central repository for archiving and maintaining biosignal data monitored in the remote smart homes.

As different types of devices generate different formats of biosignal data, the uniform integration is a big underlying obstacle in the health domain [3, 4]. As a possible solution for this problem we suggest the integration of biosignal data, using the standard format called Medical waveform description Format Encoding Rule (MFER) [5].

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II. Methods

A system for ubiquitous health monitoring in the bedroom has been developed in the Ubiquitous House (u-House) project [6]. In this project, all of the biosignals such as ECG and BCG are supposed to be monitored unconsciously during the daily life of the tenants in the u-House. Within the same project, we aimed at gathering the measured biosignal data from the smart home called u-House into a central repository for ubiquitous access of the data.

Fig 1 shows the architecture for gathering the measured biosignal data from the u-House into the remote central repository. It consists of u-House server and web server. For easy use of our system, we developed it as a complete web-based system.

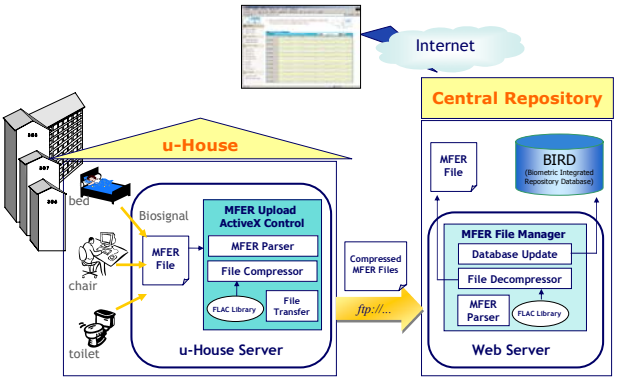

Fig. 1. A web-based architecture for transferring the measured biosignal data from the u-House to the remote central repository.

In the u-House, all of the measured biosignal data were encoded into MFER files and temporarily stored into the u-House server. For a long time measurement of biosignal data such as ECG in bed, the duration of the measurement of each MFER file was assumed to be five minutes in our scenario. The generated MFER files are transferred to the central repository by the MFER Upload ActiveX Control which periodically takes those files and uploads them to the web server.

The MFER Upload ActiveX Control is a client-side web-based control and consists of three modules: MFER Parser, File Compressor, and File Transfer. The MFER Parser decodes a MFER file to get the sampling information and the frame information for waveform data. Based on the information, the File Compressor compresses waveform data

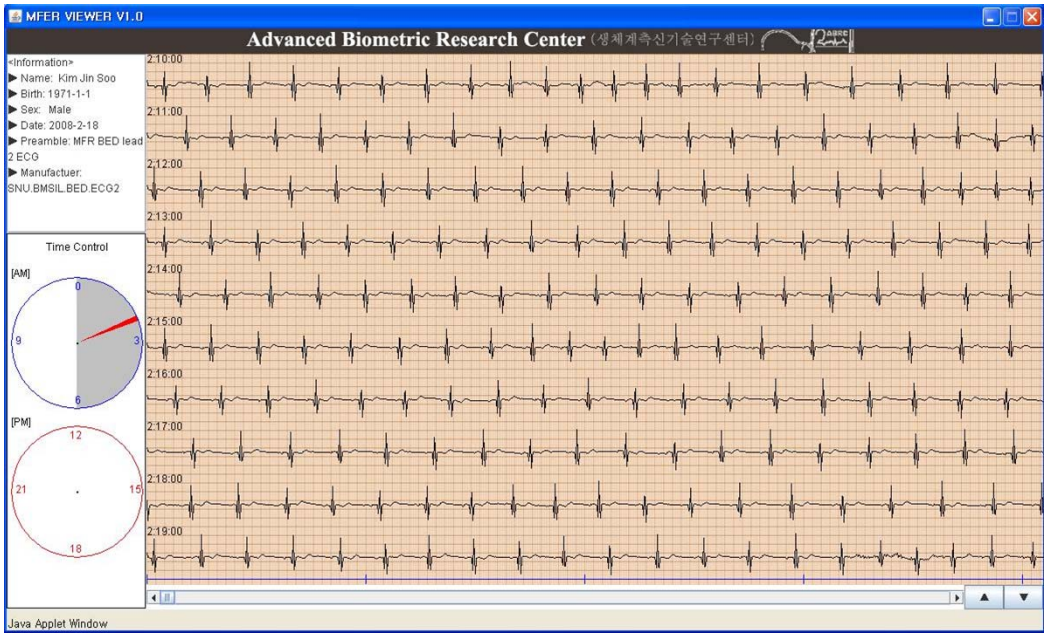

Fig. 2. A java applet for viewing an MFER file. As an example, it shows the MFER file of ECG signal from Lead Ⅱ measured during sleep.

using FLAC (Free Lossless Audio Codec) library [7] to reduce the file size and allow fast transmission. It has been shown that FLAC was effective for compressing biosignal data such as ECG in our previous study [8]. Finally, the File Transfer sends to the web server the MFER file in which waveform data is compressed. Once the compressed MFER file is transferred successfully, it calls the MFER File Manager function on the web server.

In the central repository, we maintained the biosignal data in an uncompressed form for easy handing, accessing and viewing of the data. We developed the MFER File Manager component to handle the compressed MFER file being uploaded. It consists of three modules: MFER Parser, File Decompressor, and Database Update. The MFER Parser extracts the information needed to decompress the waveform from the compressed MFER file. Based on the information, the File Decompressor decompresses it using the FLAC library and produces an uncompressed MFER file as like the original file being sent. The Database Update stores the filename of the uncompressed MFER file and some information useful for retrieving the file into the central database called BIRD (Biometric Integrated Repository Database). The database structure includes the patient's information and the measuring device information as well as the information for the measured biosignal data.

In order to easily handle a series of MFER files from continuous monitoring over a long period of time, for example, ECG in bed during sleep, we recorded them in one single MFER file by combining them as is number of MFER frames. We produced one singed file per day measurement. Filename conventions for the file specified the subject's id, the start date of the measurement and the type of the measurement.

III. Results and Discussion

The MFER Upload ActiveX Control and the MFER File Manager component were developed in Microsoft Visual C++ 6.0. Other web services for searching the measured biosignal data and adding new data for non-waveforms were developed using Active Server Page (ASP) and scripting languages on the web server running Microsoft IIS 5.0. Microsoft SQL Server 2000 was used for the BIRD database.

The java applet program was developed for providing an interface that allows easily viewing the MFER file of long-term biosignal data stored on the central repository. Fig 2 is a screen shot of the java applet, showing a sample MFER file of ECG in bed.

We performed a number of tests to confirm our approach to transferring the biosignal data from the u-House to the central repository. We verified that it was a successful and easy-to-use approach. In addition, we think the complete web-based approach will facilitate the use of the central repository.

As user of the central repository, three different types of user groups were considered: doctors, u-House tenants, and system administrator. Currently, services for u-House tenants and system administrator are only supported. Tenants can manage the biosignal data stored in the central repository. System administrator manages the information for measuring devices and the user of them, and establishes new connections between devices and the user.

IV. Conclusion

This paper showed a possible web-based implementation of a central repository to integrate the biosignal data which

comes from various types of devices in the remote smart homes. MFER standard was useful for communicating and storing the biosignal data in ubiquitous home health monitoring system. The web-based technology allowed ubiquitous access to the data at any moment, from any places.

For future work, we have a plan to evaluate our central repository by running it with a model u-House after recruiting volunteers for tenants in the u-House.

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