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Wearable Multiple Bio-sensing Process Architecture in Human Healthcare Environments

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Abstract

Today, the interest toward human healthcare free from diseases is being converged as one system frame along with the development of wearable smart computing environments, diversification of remote medical system and aging society. Such IT-converged healthcare system enables implementation of a bioinformatics system created as various collected information by sensing and gathering health conditions and various bio-information of wearable users to set up medical-point information. The existing bio-information system performs single static and identical process without changes after the bio-information process defined at the initial system configuration executes the system. However, such single static process indicates ineffective execution in the application of mobile bio-information system performing mobile computing. This study proposes a dynamic process design and execution method to overcome such ineffective process. Moreover, it presents multiple processes scenarios extended from the single process scenario.

Keywords: *Dynamic configuration, wearable bio-sensing, multiple process-steps, mobile bio-information architecture*

1. Introduction

Recently, the interest toward human healthcare free from diseases, etc is being focalized along with the development of wearable mobile computing environment and the remote home-medical system in an aging society. Moreover, the tendency of such social interests being IT-converged as one healthcare system frame is being accelerated.

Among such converged healthcare systems of IT and wearable patches, there is a bioinformatics system, which senses and gathers the health conditions and the various bio-information of mobile users to set up and utilize medical information. The bio-information devices to monitor the bio-information of wearable users are being diversified and sophisticated according to their used purpose such as wrist type, necklace type, glasses type, garment type and shoe type, etc. The sensing information gathered through such wearable bio-information devices can configure different bio-information processing system depending on the sensing method, transmission channel, storing and filtering process as well as analysis and evaluation method, *etc*. This study will focus on the wearable bio-information sensing architecture and multiple bio-information sensing process as principal factors of bio-information system.

Heretofore, the wearable bio-information system has been gathering individual bio-sensing information through personal-type bio-information devices. To transmit such bio-information for the computing center, it can use the infrastructure communication

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network, or the existing wireless networks such as 3G/4G global wireless network, WIFI, Zigbee and Bluetooth, *etc*. The bio-sensing users can be organized of multi-clients such as a digital bed user and a wearable user within multi-sensing devices. In addition, the role of monitoring and managing the bio-information of each individual user has been performed through personal computer or bio-information server located at the infrastructure network. The data type of bio-information transmitted here is the analog signal data or digital conversion code as raw data. Otherwise, the filtering data of original bio-information data has characteristics of specific peak data, specific interval data or specific event data.

This paper is described as the following sequences. First, Chapter 2 describes the related works about multiple bio-sensing information systems. Chapter 3 describes the wearable bio-information sensing architecture. Chapter 4 describes the multiple dynamic bio-information sensing processes. Chapter 5 describes the analysis and issues of multiple bio-information computing. Finally, Chapter 6 describes the conclusion of this paper.

2. Related Works

The sensing information process of bio-information system is composed of raw sensing, data transformation, data filtering, data transmission, data saving, data analysis and statistics of the sensing device [7].

The existing bio-information system structure and the characteristics of process aspect are examined as follows. [4] improves the performance of bio-information specialized individual process as the agent technique supporting individual functions including the multi-agent technique is supported but shows the characteristics of lowering system structure and operation ability. [5] has described the structural issues of data mining which supports various bioinformatics workloads. Especially, the characteristics of memory hierarchy structure considering the execution time, extensibility and bottleneck conditions have been analyzed. [6] has presented the necessity of implementing a software system supporting large scale framework, distributed computing engine, sequential analysis module, microarray analysis module, etc for biological data and processing. [7] configures six phases for the knowledge discovery of bioinformatics process. Such analysis process is selectively and adaptively used depending on the system requirement or circumstances. Such analysis method can be restrictively used at the global station or open station where the analysis server is located. [8] The necessity of an architecture which considers user access method, performance scheduling, load balancing, QoS and fault tolerance has been presented. [1, 2, 3] have showed the dynamic process configurations and single process scenarios without considering multiple processes scenarios.

The existing bio-information process performs single static and identical process without changes after being defined as default and optional process at the initial stage of system configuration. However, such static process indicates ineffective execution in the application of mobile bio-information system performing mobile computing. Especially, an inconvenient way to perform initialization of new definition and execution is accompanied during the process configuration of bio-information system.

This study attempts to propose a dynamic multi-process design and execution method as a plan fundamentally to solve this problem similar to [9] and [10]. This paper describes the basic wearable bio-information sensing architecture and the multiple dynamic process configuration method for setting up the dynamic process.

3. Human Healthcare Bio-information Sensing Architecture

The following Figure 1 shows the architecture of digital bio-information system. The architecture of the figure shows the process of gathering bio-information using the hospital digital-bed mat of a hospitalized patient as a form available at static hospitals or recuperation facilities. As a mobile healthcare component, a wearable user with multiple bio-sensors can be united to the bio-sensing architecture for mobile human healthcare.

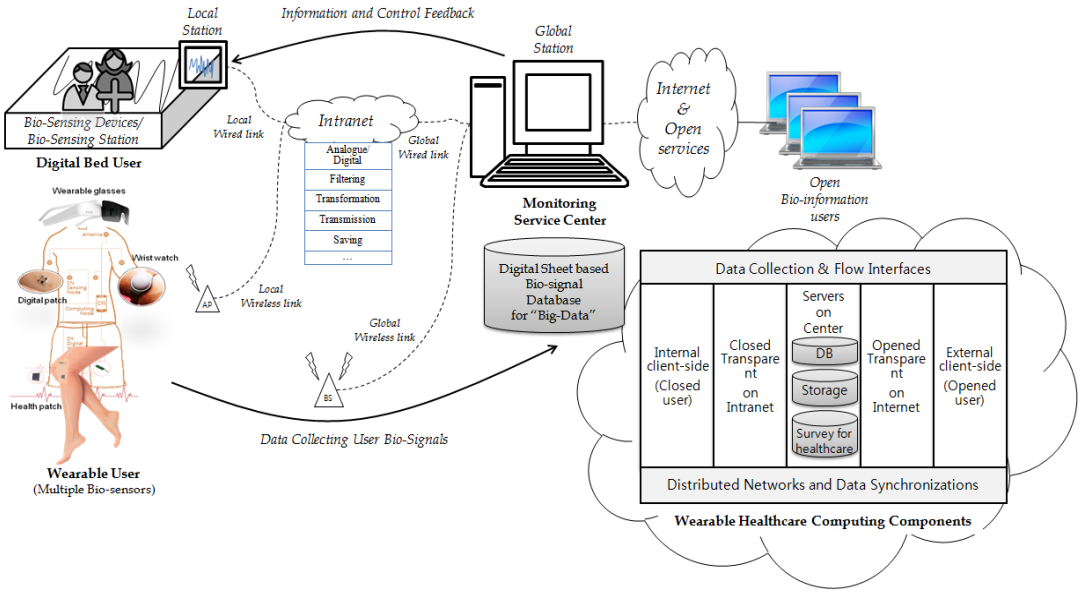

Figure 1. Expanded Architecture for Multiple Bio-sensing Information System

The multiple bio-information sensing system architecture has gathers the bio-sensing information of each individual user through a personal-type bio-information device. While it gathers such bio-information after configuring a local infrastructure network using wire networks such as LAN and PSTN or using the wireless networks such as WIFI, Zigbee and Bluetooth. As well as, it can transmit the bio-data using an internet interworked network through wire IP network or wireless 3G/4G global network. Also, the role of monitoring and managing the bio-information of each individual user has been performed through personal computer or bio-information server located at the infrastructure network [4]. The sensing information gathered through such mobile bio-information devices configure different information processing system depending on the sensing method, transmission channel, storing and filtering process as well as analysis and evaluation method, *etc* [5, 6].

The following sequences describe the healthcare information computing components based on bio-information devices as shown in Figure 1.

First, clients produce and consume bio-information in wearable healthcare computing environments. The computing system provides various collection and distribution interfaces to the client users that interact with bio-information. It can also provide various health-guide services and information services to users. The healthcare terminals can provide the closed secure channels just only for specific users. The open users on Internet receive the standard sharing information served from servers. Here, they can also upload user's requirements and the related additional information to the servers for sharing the opened healthcare information with any others. For applying the

wearable user healthcare, the models and patterns for user mobility should be defined. Also, the display interface of health analysis information for a user should be designed for the following events such that the outbreak event of danger and warning signals, the display event of real-time health information analysis, the display event of respiration and health related signals, and the display event of physique status analysis information. The bio-information input/output interface required for controlling and monitoring bio-information is defined.

Second, as the networking layers of Intranet and Internet between users and servers, the components of transparent process deliver the collected information from a user to a server. Or they deliver the feedback control and information from a server to a user. This layer is based on the secure authentication service for protecting the health-information of the registered users. Specially, the opened transparent layer delivers the standard sharing health-information received from the servers to open users on Internet. And it relays the requirements of users on Internet to the servers.

Third, the servers on a healthcare center save the collected bio-information into themselves, execute the evaluation and analysis about the collected information, and provide feedback controls and guide services to client users depending on the evaluated results. Also, they create the standard sharing health-information for providing the opened bio-information services on Internet. They define a user bio-information signal based user health condition model as the following definitions. The threshold value function and values are defined to classify satisfactory/warning/danger, *etc*. The constraints management processes of bio-information devices should be defined. The identification system and status information management of digital devices should be defined. The unit statistical analysis and evaluation models of individual user should be defined.

Such bio-information system structure and components closely linked to the multiple bio-information sensing processes described in Chapter 4. Especially, an execution environment for multiple bio-sensing processes is provided.

4. Multiple Dynamic Bio-sensing Information Processes

The system bio-information process of Figure 1 gathers various bio-information of a patient using piezoelectric sensor and respiration sensor at the bio-information device. The bio-information gathered this way gets sampled or transformed as various digital bio-information such as peak information, amplification information, location information or body type information, etc. Such process is called the *forward collection process*. This interacts with the *backward control process* such as the clinical trial for controlling and guiding the bio-information devices and the bio-information patients or analysis, evaluation and feedback of gathered health information.

The bio data gathered and transmitted at such bio-information system build up different bio data process depending on the optional configuration of analog and digital data format, various optional transmission channels or the saved location and data processing method. Furthermore, different bio-information process is shown depending on the analysis, evaluation and feedback method of detailed clinical trial and gathered health information.

The form of bio-information transmitted here is the analog bio-information signal data or digital conversion code date as raw data. Otherwise, the filtering data of source bio-information data has characteristics of specific peak data, specific interval data or specific event data.

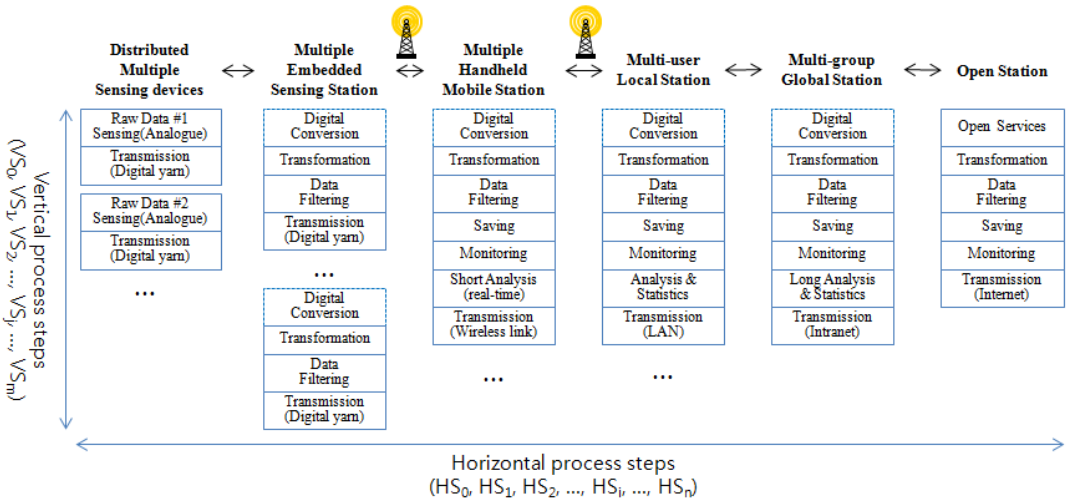

Figure 2. Distributed Information Process in Multiple Bio-sensing Systems

The sensing information process of bio-information system can be composed of a process scenario such as raw sensing, data transformation, data filtering, data transmission, data saving, data analysis and statistics , etc. as shown in Figure 2. The first wearable sensing devices are configured of multiple sensing devices and embedded sensing networks with different kinds of biosensors. The second embedded sensing station supports distributed collecting logics and snapshot synchronizations. In the third mobile station, we need to provide the real-time composite-monitoring technology. In the fourth and fifth steps, they provide new methods for analyzing the composite-sensing modules. Moreover, they require the backup and replay synchronization technology that reproduces the specific human monitoring data. The final step can support various bio-information applications.

The existing bio-information process performs single static and identical process without changes after being defined as default and optional process at the initial stage of system configuration. However, such single static process indicates ineffective execution in the application of mobile bio-information system performing mobile computing. Especially, an inconvenient duty of having to perform initialization of new definition and execution is accompanied during the process configuration of bio-information system and change of method.

This study proposes the design and execution method for a multiple dynamic process as a plan to fundamentally solve this problem. Figure 2 shows the overall process of bio-information system. Such bio-information process may be executed after being dynamically selected depending on the system configuration environment. The method of selecting dynamic process can be classified as horizontal selection and vertical selection.

First, the horizontal selection based on horizontal process steps, HS_i, of Figure 2 is selectively operating the computing station by each stage depending on the necessity of applied environment. As an example, the bio-information system based on the wearable bio-sensing of wireless network environment performs process by selecting the third personal mobile station. In case of the wire based bio-information system, the processes of the third station may be skipped. As another example, the elimination of processes at the open station, which is the last station, becomes required in order to perform an exclusive intranet service. As other example, the instance of connecting a local wireless

network at the third personal mobile station selects the fourth local station while the instance of connecting a wireless wide area network performs the process as the fifth global station after skipping the fourth group local station.

Next, the vertical selection based on vertical process steps, VS_j, of Figure 2 is an operation that optionally selecting and disabling some computing processes at the station of each stage to support different event scenarios. More specifically, multiple sensing modules can be selected by user requirements or environmental parameters. For example, the instance of performing digital conversion at the embedded sensing station disables the digital conversation process at the follow-up stations, in other words the mobile station, local station and global station. Then as the sensing data gathered at the first wearable sensing device is sent so that the data filtering process can be performed selectively depending on the application through the second embedded sensing station to the last open station.

5. Analysis of Multiple Bio-sensing Computing

The proposed configuration of multiple dynamic processes can select each computing station dynamically depending on the mobile user's environments.

Figure 3. Comparisons of Required Bandwidth with the Multi-sensors for Mobile Station

Figure 3 is a comparison of the bandwidth requirements when the multiple sensors through the internal wired links in Figure 1 and Figure 2 access the wearable embedded station. Experimental assumption is that random processes are based on. We can confirm the fact that the bandwidth requirement of multi-sensor signaling is greater than that of single-sensor signaling because of data volume.

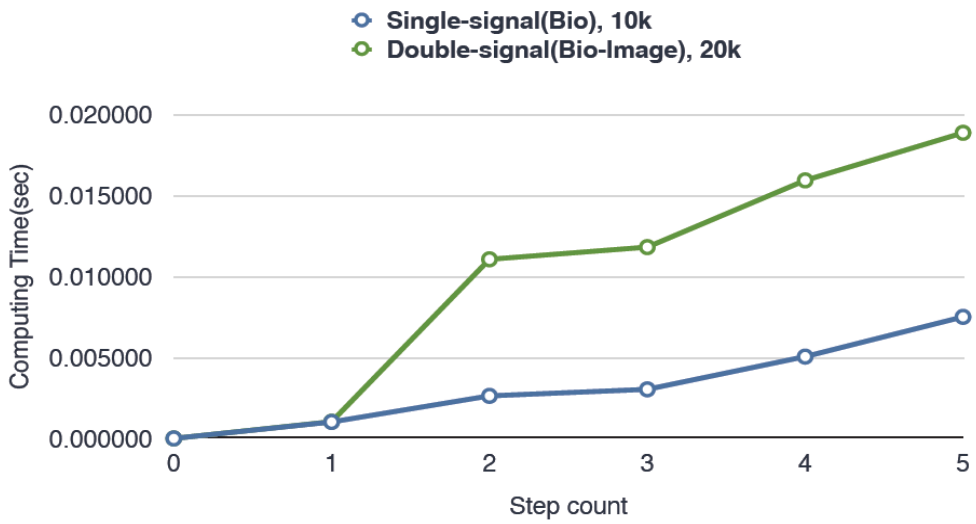

Figure 4. Comparisons of Timing Delay based on Step-counts

Figure 4 illustrates the expected computing times depending on the station-step count based on the number of sensors (for examples, Single-sensor mode 10k and Double-sensor mode 20k) when the bio-signal is transferred from sensing devices to open station in Figure 2.

6. Conclusion

This paper has proposed an architecture of multiple dynamic healthcare-information process-steps and the multiple-execution method to overcome the problems followed by single static process configuration of multiple bio-sensing systems. This has proposed the expanded multiple bio-information sensing architecture and the dynamic information-process configuration method for setting up the multiple dynamic computing process.

Such multiple dynamic process configuration carries an advantage of supporting the adaptability followed by dynamic change of system environment such as user environment, multi-bio-information gathering type and method, *etc.*, without initialization process or cutoff of system execution while executing the system.

Such multiple dynamic bio-sensing process architecture has been proposed as function or method of a multi-bio-sensing information system platform in the future. Especially, the decentralized computing for analyzing and evaluating bioinformatics may be considered to maximize the bio signal analysis or usability of bio information.

Finally, we have considered the important factors of the multiple bio-information computing issues as described in Chapter 5.

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