Secured WSN-integrated Cloud Computing for u-Life Care

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***Abstract*-This paper presents a Secured Wireless Sensor Network-integrated Cloud computing for u-Life Care (SC^3). SC^3 monitors human health, activities, and shares information among doctors, care-givers, clinics, and pharmacies in the Cloud, so that users can have better care with low cost. SC^3 incorporates various technologies with novel ideas including; sensor networks, Cloud computing security, and activities recognition.**

I. Motivation and Proposed Architecture

In recent years, Wireless Sensor Networks (WSNs) have been employed to monitor human health and provide life care services. Existing life care systems simply monitor human health and rely on a centralized server to store and process sensed data, leading to a high cost of system maintenance, yet with limited services and low performance. For instance, *Korea u-Care System for a Solitary Senior Citizen* (SSC) monitors human health at home and provide limited services like 24 hours×365 days safety monitoring services for a SSC, emergency-connection services, and information sharing services. In this paper, we propose a *Secured WSN-integrated Cloud computing for u-Life Care* (SC^3) which monitors not only human health but also human activities to provide low-cost, high-quality care service to users.

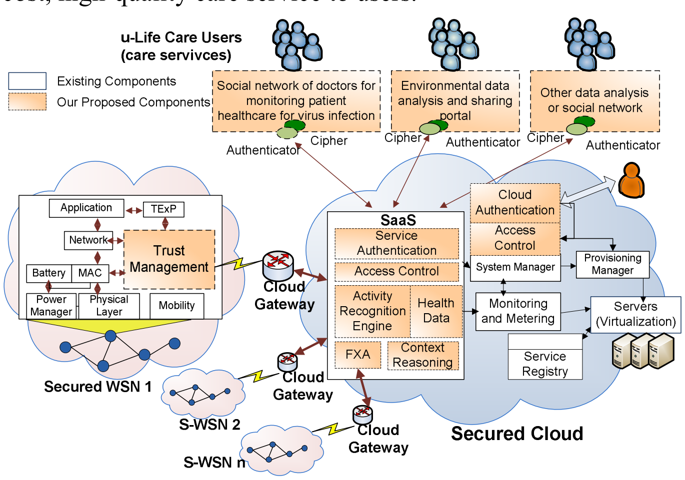

Figure 1 Abstract Architecture of SC3

The abstract architecture is shown in Figure 1. WSNs are deployed in home environments for monitoring and collecting raw data. We have developed successfully a *Mobile Activity Sensor Logger* (MASoL) which is a low cost, low energy consumption sensor device. MASoL is our own sensor logger which contains 13 axis sensors, gathering many kinds of people's behavior and stores it. The software architecture is built to gain data efficiently and precisely. Sensed data is uploaded to Clouds using a fast and scalable Sensor Data Dissemination mechanism [1][2]. In the Cloud, this sensed data is either health data or can be used to detect human activities. For human activity recognition, we have proposed two novel approaches: embodied sensor-based and video-based activity recognition [1]. In the former approach, a gyroscope and accelerometer - supported sensor is attached to human body (e.g. on his/her wrist). By using gyroscope and accelerometer data, an activity is predicted or inferred based on *Semi Markov Conditional Random Fields*. Detected activities could be simple (e.g. *sitting, standing,* and *falling down*) or more complicated (e.g. *eating, reading, teeth brushing*, and *exercising*). In the latter approach, activities are detected by collecting images from cameras, extracting the background to get body shapes and comparing to predefined patents. It can detect basic activities like walking, seating, and falling down. Ontology engine is designed to deduce high-level activities and make decisions according to user profile and performed activities.

To access data on the Cloud, the user must authenticate and granted access permissions. An image-based authentication and activity-based access control are proposed to enhance security and flexibility of user's access [3][4]. Independent Clouds can collaborate with each other by using our Cloud Dynamic Collaboration method [2]. Using these data on the Cloud, many low-cost and high quality u-life cares can be provided to users such as secure u-119 service, secure u-Hospital, secured u-Life care research, and secure u-Clinic.

In the first phase, we have designed and developed WSN-Cloud integration mechanism, activity recognition algorithms, access control protocols and a sample care service for solitary Alzheimer's disease patients. The functional architecture is shown in Figure 2. First of all, human activity data is captured from sensors and cameras, then being transmitted to the Cloud Gateway. The gateway classifies data into health data, gyroscope and accelerometer data and imaging data, and store in a local database. The Filtering Module filtered redundant and noise data to reduce communication overhead before sending to the Cloud. The filtered data is also updated to the local database. If there is a query requested from a service/application, the Query/Response Manager fetches data from the local database and sends it to the requester. Data is transmitted to the Cloud so that the Activity Recognition engine in the Cloud can infer user activities. Activity and context are forwarded to the Ontology engine for representation and inferenceing higher level activities and context. It also makes decision to respond to different situations. For example, if patient is reading a book, then TV

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should be turned off. When doctors, nurses want to access data, they must authenticate themselves first. After successful authentication, the Access Control module makes decision whether his/her access permission is allowed or not. If yes, it allows him/her to access to the Cloud data. Data is forwarded to authentic nurses and doctors.

We have implemented a sample scenario for solitary Alzheimer's disease patient. SC^3 monitors patient's health condition and daily activities such as taking medicine, doing exercise, taking teeth brushing, reading book, and watching TV. Doctors and nurses at the hospital can access to the Cloud data to observe patent progress and behaviors through Web2.0 interface.

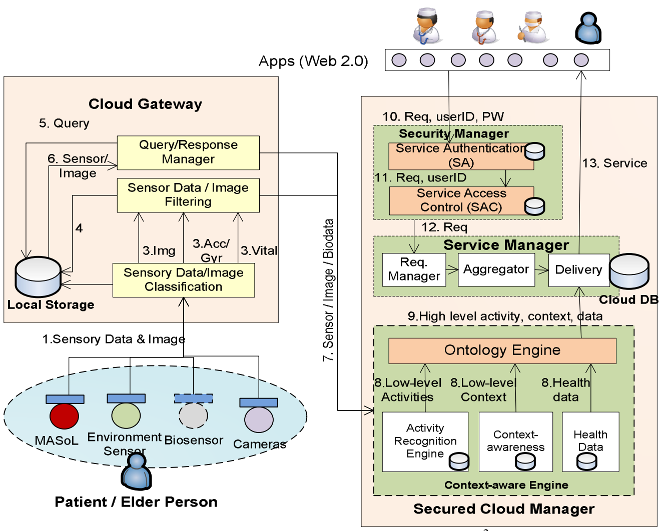

Figure 2 Functional Architecture of SC^3

II. DISCUSSION

Although the project is still on-going, our primary results have shown a good performance of SC^3. The implementation results have shown that it took maximum of two seconds to response to patient's actions. Accuracy of activity recognition was from 76% to 99.23% depending on different activities. We do believe that the accuracy will be much improved, even almost 100%, if we apply multiple activity recognition methods for each activity, where these enhancements will be unfolded in the next phase.

The proposed SC^3 can be deployed for various u-Life care services, including but not limited to:

1) **Safety monitoring services for home users:** SC^3's WSN can monitor home user's movement, location by using various sensors. The sensor data is then disseminated to the Clouds. From that, SC^3's Life care services such as emergency service, caregivers can monitor and has immediate response in case of emergent situations like heart attack.
2) **Information sharing services:** With SC^3, patient information and data can be accessed globally and resources can be shared by a group of hospitals rather than each hospital having a separate IT infrastructure. Cloud computing would help hospitals to achieve more efficient use of their hardware and software investments and increase profitability by improving the utilization of resources to the maximum. The SC^3 can provide a flexible platform for public-health departments to upload real-time health data in a timely manner to assist state and national health officials in the early identification and tracking of disease outbreaks, environment related health problems, and other issues.
3) **Emergency-connection services:** SC^3 can be deployed for real-time monitoring of home environments, including gas, fire, and robbery. Through SC^3, an alarm system connects to users, u-119, police department can give an emergency alert in case any emergent situation occurs.
4) **Users can monitor their home, their family health anywhere, any time with any device:** SC^3's Clouds and WSN enable user to monitor their home environment, their family's health information with any kind of connected devices over Internets such as; cell phone, PDA, laptop, and computer.

III. CONCLUSION AND FUTURE WORK

This paper presented *Secured WSN-integrated Cloud computing for u-Life Care* (SC^3). SC^3 monitors human health as well as activities and shares this information among doctors, care-givers, clinics, and pharmacies from the Cloud to provide low-cost and high-quality care to users. Our proposed system is a combination of various technologies with novel proposed ideas.

We are planning to work on and provide more services to different kind of disease patient's such as; Stroke, and Parkinson disease patients. A number of wireless medical sensors are under development for more sophisticated collection of health data of patient's. Improving the security and privacy of data available on Cloud is also in the pipeline. Another extension to our work is to extend its services for manufacturing, and military services.

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