Implementation of Intelligent Home Network and u-Healthcare System based on Smart-Grid

Tae Yeun Kim and Sang Hyun Bae†

Abstract

In this paper, we established ZIGBEE home network and combined smart-grid and u-Healthcare system. We assisted for amount of electricity management of household by interlocking home devices of wireless sensor, PLC modem, DCU and realized smart grid and u-Healthcare at the same time by verifying body heat, pulse, blood pressure change and proceeded living body signal by using SVM algorithm and variety of ZIGBEE network channel and enabled it to check real-time through IHD which is developed by user interface. In addition, we minimized the rate of energy consumption of each sensor node when living body signal is processed and realized Query Processor which is able to optimize accuracy and speed of query. We were able to check the result that is accuracy of classification 0.848 which is less accounting for average 17.9% of storage more than the real input data by using Mjoin, multiple query process and SVM algorithm.

Keywords: Intelligent Home Network, Smart-Grid, SVM classification Algorithm, u-Healthcare, ZIGBEE

1. Introduction

Smart-Grid is known as next generation electrical grid which is suggested to optimize energy efficiency by managing electricity production and consumption information bilaterally in real time and improves also credibility, efficiency and safety of electrical grid by combining information communications technology into the existing electrical grid[1]. It is expected to induce rational energy consumption through electricity information exchange and provide high quality energy and a variety of optional services if smart-grid is adapted and predicted to be able to create new business through industrial convergence because it will be transferred into open system which is convenient to extend grafted clean and green technology such as new regeneration energy and electric car.

u-Health can be developed to combine in smart grid as soon as possible. Depending on increase of chronic illness patients in an aging society, the existing ‘treatment-oriented medical treatment’ is changed into ‘prevention-oriented medical treatment’, ‘disease management’ is changed into ‘health care’, ‘supplier-oriented’ is changed into ‘consumer-oriented.’ It is no exaggeration to say that new paradigm of health and medical care such as u-Health which is combined with essential medical service and Ubiquitous as the need of consumers are getting increased.

Currently most of u-Health research is about energy efficiency and home networking by using smart-grid, however the research for combination of u-Health is insufficient. Therefore, smart-grid implementation is required on the side of consumer through remote reading of meter system and smart meter development for application of remote reading of meter in apartment building by considering home network as well as home network Wall-Pad of household and EMS depending. There must be many researches about bio data acquisition, data reliability and algorithm in order to realize u-health[2].

In this paper, we considered electricity improvement within household through smart grid and acquired multi-dimensional bio data from wireless sensor for users who need home care at the same time and found the ways to reduce data by using SVM algorithm for effective data processing and planned to monitor. By realizing home system for intelligent home network system based on smart-grid, we will realize health status
of users in real time, not only amount and expense of electricity used within household.

The study is as follows. In chapter 2, it is consisted of the proposed system and design. In chapter 3, it is consisted of experiment and implementation. In chapter 4, it is consisted of the conclusion and research direction for future.

2. System Configuration and Design

We combined largely two kinds of technology for design and realization of Intelligent home network based on smart-grid which is proposed in this study. First, we monitored amount of electricity used of household on smart grid by communicating integrated IHD in the way of ZIGBEE and hybrid modem(PLC method) and managed it in remote reading of meter server of administration center.\[3,4\] We enabled long-distance (control center) to provide service through WEB-oriented system. Wire-wireless communications between integrated IHD and control device is able to control and examine in home as well as integrated supervisory control with combined WEB-oriented.

Second, processor board is a series of Telos platform in u-Healthcare and MCU of MSP430 and CC2420 Radio Chip are used and as well as integrated sensor module such as temperature, pulse and blood pressure sensor. We used 10 sensor nodes including 1 node. It will be saved in database after responding questions and saving stream data. Saved data is classified through SVM algorithm and minimized. Interface will be offered for amount and price of electricity used and users’ convenience within IHD of household. Health status of users can be verified depending ID.

The proposed intelligent home network system based on smart-grid diagram is as Fig. 1.

2.1. Smart-Grid System

Fig. 2 shows remote reading of meter system based on smart grid which can refer energy within household in real-time. It transfers to household terminal by checking amount of energy used in remote reading of meter system of household by real-time. It has functions to check electricity, gas, water, hot water and calorie and is consisted of great electricity as a double real-time.

We utilized block outlets of standby power and added digital energy meter, data receiver of remote reading in household and wall pad wiring for communications (Mainly RS-485 communication, that is UTP-CAT5e or exclusive cable use) on the existing remote reading system. Wireless modules are applied to Tx Module, Rx Module and TRx Module.

Integrated control server controls all the servers as a main server of home network system and performs the role of middle wear. We queried in simple database if data is requested by integrated IHD and Web server. IOS server and remote reading server are interlocked and provided by receiving information of amount of energy used through integrated IHD. For product specification, we constituted Intel Corei3, 2G RAM(DDR), 1T Hard by using Windows 2008 Server and CUBRID.

Fig. 3 shows interface which confirms data of energy control in real time from integrated control server.
2.2. u-Healthcare System

u-Healthcare system of this study is used by sensor module which is integrated with sensors of weight, pulse and blood pressure sensor. We used the total 10 sensor nodes including 1 sync node. It will be saved in database after responding questions and saving sensing stream data. Saved data are classified and minimized through SVM algorithm.

Fig. 4 shows the entire diagram of u-Healthcare system.

u-Healthcare system of intelligent home network system based on smart-grid is used with several sensors in order to acquire stream data(body heat, pulse, systolic blood pressure, diastolic blood pressure). Used data for analysis is progressed in the same environment, therefore we transmitted it in one packet. If it is transmitted by each packet, additional traffic and energy consumption may be occurred, therefore we transmitted by one packet for energy efficiency. The Table 1 shows the packet of sensing data. The total length of packet is 36 bite, fixed header is 10 bite, sensor node ID and channel is 6 bite and buffer 20 bites. Among these, buffer is designed to receive sensing value in order of weight, pulse, systolic blood pressure and diastolic blood pressure by each 3 bite for 12 bite.

The structure of data is as Fig. 5 and each combination shows 1 bite. 7-8th value shows communication method, 15-16th value shows the channel, 17-28th value shows weight, pulse, systolic blood pressure and diastolic blood pressure from the left side. Stream data management (DSM) is conducted multiple successive processing for multiple stream data.

Stream data management (DSM) is conducted multiple successive processing for multiple stream data. We divided data storing into three parts as the picture 6 because the system data capacity may be exceeded due to overload of input data. First, it is temporary working storage. Second it is summary storage. Third it is static storage.

Query will be stored in query repository and executed with optimal work depending on input data amount and query processing through query processor and the purpose is set to reduce excess phenomenon due to overload of input data.

To acquire overall information of u-Healthcare sensor

![Fig. 3. Energy management programs and interfaces.](image)

![Fig. 4. Configuration of u-healthcare system.](image)

Fig. 5. Structure of sensed data.

| Table 1. Packet configuration of stream data |
|---------------------------------------------|
| Header (10) | Sensor node ID & Channel (6) | Body weight (3) | Pulse (3) | Contraction period (3) | Relaxation period (3) (8) |

J. Chosun Natural Sci., Vol. 9, No. 3, 2016
network, join calculation on basis of certain time or position will be performed and the results must be found. For join calculation, there are hash table, join-based calculation, window-based calculation and hash table window-based join calculation. Among these, table window-based join calculation can be operated within limited memory and it is the most appropriate method in data stream environment in terms of rapid matching speed.

In this paper, we established query planning with table window-based join and the method of Mjoin. In data stream environment, potentially infinite amount of data will be recorded on system continuously, therefore input stream sampling or load-shedding is required because query executive planning may be exceeded over amount of memory.

MJoin is proposed as effective join processing method of multi-dimensional stream data which is able to have many streams as input and beyond over a binary join-based form. MJoin is developed form from traditional symmetric hash join. It may be able to have many kinds of input, far from the existing symmetric hash join therefore intermediate findings will not be delivered to the next operator but the join findings of various stream will be delivered.

Fig. 7 shows processing structure of MJoin. If a new tuple is set in input stream S1, tuple which is set in hash table must be inserted and table for the following input stream must be invested. If newly settled tuple matches the values of other hash table, the results will be transmitted.

The algorithm which is applied to this paper has the role of classifying whether given data of dual SVM is applied in certain category or not. The data which is applied to certain category will be stored in database. If not, it will be deleted automatically and the purpose is to raise effectiveness of database. SVM classification is the method of finding hyperplane which is dividing into two groups well[5]. SVM has good expandability more than existing linear classification method shows superior performance constantly far from classification of nerve networking which is changed in every lesson. In this paper, we constituted SVM classification algorithm as the Table 2.

The used data of this experiment is consisted of linear data structure such as weight, pulse, systolic blood pressure and diastolic blood pressure, therefore we use SVM classification algorithm which can solve the problem by multiple perceptron structure. SVM algorithm is able to control weighted value of hidden layer number and higher rate can be acquired compared to other learning algorithm. SVM algorithm can provide output(y) by multiplying and adding weight of nerve networking repeatedly. The output(y) is different from output(o) which is desirable in learning data. Eventually, error(e=y-o) may be occurred as much as (y-o) in nerve networking and weighted value of output will be

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Table 2. Configuration of the SVM classification algorithm

| Algorithm     | SVM |
|---------------|-----|
| The number of Data for Study | \( N \) |
| Inputs: sample x to classify Data Sets | \( I_i \) |
| \( I_i \) : body weight, \( I_2 \) : pulse, \( I_3 \) : Contraction period, \( I_4 \) : Relaxation period |
| Output: decision \( y \in \{-1, 1\} \) |

Classify using SVM, get the result in the form of a real number.
renewed compared to the error as well as weighted value of hidden layer number. The direction of renewing weighted value is the opposite direction from processing direction of nerve networking[6,7].

For this reason, it is called SVM algorithm. In other words, the process of nerve networking will be performed in order from input layer -> hidden layer number -> output layer and learning direction of renewing weighted value will be performed in order from output layer -> hidden layer[8,9]. In this paper, we constructed nerve networking which has two kinds of level output in order to process the rate of error depending on size change of window by using input data(weight, pulse, systolic blood pressure, diastolic blood pressure)

1) The number of node of input layer must be 4 items of each data.
2) If the first node is selected depending on learning weighted value through input data, it will be applied to level 1.
3) The number of nodes of hidden layer must have more than 1. If hidden layer number is increased so learning time will be increased therefore selecting the number of hidden layer is important.

The Table 3 shows the flow of SVM algorithm.

### Table 3. Flow Chart of SVM classification algorithm

| Step | Description |
|------|-------------|
| i | Initialize weights and counter |
| 2 | Set learning rate $\alpha$ and $E_{\text{max}}$ |
| 3 | For each training pattern pair do Step 4-10 until $k = p$ |
| 4 | Compute output of hidden layer |
| 5 | Compute output |
| 6 | Compute output error |
| 7 | Compute error signal of output layer |
| 8 | Compute error signal of hidden layer |
| 9 | Update weights |
| 10 | Increase counter and goto Step 3 |
| 11 | Test stop condition |

3. Implementation and Performance Evaluation of System

3.1. Implementation of System

The proposed intelligent home network system based on smart-grid is able to monitor change of blood pressure such as weight, pulse, systolic blood pressure, diastolic blood pressure through the result of sensing data classification and numerical value. It is also realized to be able to check price change depending on amount of electricity used monthly. Fig. 8 shows initial screen and query screen of amount of electricity used monthly of intelligent home network system based on smart grid.

It is shown as graph by the hour of a day to confirm users easily and amount of electricity consumption can be confirmed by comparing the last year and the same year in order for users to confirm easily.

Fig. 9 shows IHD screen of data by processing body heat and pulse sensor of intelligent smart grid-oriented system.
home networking system. We divided into morning and afternoon in order for users to confirm easily about connection status of sensor, change of body heat and pulse change in real-time.

3.2. Performance Evaluation of System

We conducted experiment rate of reduction of model data and accuracy by applying SVM algorithm in order to estimate u-Healthcare system performance within intelligent smart grid-oriented home networking which is proposed in this paper.

We measured accuracy of Query in Tiny DB for u-Healthcare system experiment. Processor board which is used for experiment is a series of Telos platform and we conducted experiment by using MCU of MSP430 and CC2420 Radio Chip. We transmitted calculated data of weight, pulse, systolic blood pressure, diastolic blood pressure in Stream Data storage by using 1 Sink node and 9 intermediate node, the total 10 nodes.

Collected data will be stored in database through SVM classification after conducting query in DSMS. To test realized system, we used sensor data such as collected 33,448 body heat, pulse, systolic blood pressure, diastolic blood pressure. We used irregular data which is reflected reality, not linear connection for experimental data, therefore the rate of error must be measured.

In this experiment, we measured the rate of error depending the size change of sliding window. To measure the rate of error of experiment, we used RMSE (Root Mean Square Error) as (1).

\[
RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (y_i - y_i^*)^2}
\]  

We proceed the query on basis of sliding window for efficient input stream processing and established multiple query planning. After we established the planning, we used 33,448 data according to the number of Tuple and divided the size of window into 1000, 3000, 5000 and minimized the data through SVM algorithm. As result of experiment, the most efficiency was revealed by minimizing 18.3% of storing space when the size of window is divided into 5000. For the accuracy of division, the most efficiency was revealed as 87.2% when the size of window is divided into 5000.

The Table 4 shows the minimized result of data by dividing into 3000, 5000 depending on the number of tuple. The picture 10 and picture 11 show the graft of data minimized result.

4. Conclusions

Friend-environment electricity IT-based technology for future generations such as smart grid can be said as necessary technology. Energy efficiency must be optimized by grafting information technology into electricity networking through smart-grid and u-Health system combined technology is necessary according to change of real-time home network system paradigm in order to keep a good health through increase of old age, physical management and life management.

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In addition, we minimized the rate of energy consumption of each sensor node when living body signal is processed and realized Query Processor which is able to optimize accuracy and speed of query. We were able to check the result that is accuracy of classification 0.848 which is less accounting for average 17.9% of storage more than the real input data by using Mjoin, multiple query process and SVM algorithm.

For future studies, we will analyze analog signal before changing the existing analog electricity meter into digital electricity meter therefore we will study about efficient algorithm by considering conditioning time and analyzing analog signal which is digitalized. In addition, we will Implement integrated professional monitoring system based on smart-grid which is significant by special medical worker's judgment by studying efficient processing method about variety of living body information such as positional information, body fat, not only sensor data that is limited within space about sliding window query processing of time-oriented for data processing which is reflected by the passage of time.

Acknowledgments

This study was supported by research funds from Chosun University, 2014.

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