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Development of a Self-adapting Intelligent System for Building Energy Saving and Context-aware Smart Services

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ABSTRACT

Recent advances in ubiquitous technologies facilitate context-aware systems which can offer situation based services. Wireless sensor networks (WSNs) have become increasingly important in recent years due to their ability to monitor and manage situational information for various intelligent services in ubiquitous environments. However, existing energy management systems are not effectively implemented in home and building environments due to their architectural limitations, such as static system architecture and a finite battery lifetime. Therefore, in this paper, we propose a Self-adapting intelligent system used for providing building control and energy saving services in buildings. Our system consists of a gateway (self-adapting intelligent gateway) and a sensor (self-adapting intelligent sensor). In addition, we also propose an energy efficiency self-clustering sensor network (ESSN) and a node type indicator based routing (NTIR) protocol that considers the requirements of WSNs, such as network lifetime and system resource management. In order to verify the efficiency of our system, we implemented our system in real test bed and conducted experiments. The results show that autonomous power saving using our system is approximately 16-24% depending on the number of SIS1.

Keywords: Self-Adapting, Pattern Generation, Intelligent Sensor, Adaptive Middleware, Wireless Sensor Networks

I. INTRODUCTION

Recent advances in ubiquitous technologies facilitate context-aware systems which can offer situation based services. Wireless sensor networks (WSNs) have become increasingly important in recent years due to their ability to monitor and manage situational information for various intelligent services in ubiquitous environments. However, existing energy management systems are not effectively implemented in home and building environments due to their architectural limitations, such as static system architecture and a finite battery lifetime. Therefore, in this paper, we propose a Self-adapting intelligent system used for providing building control and energy saving services in buildings. Our system consists of a gateway (self-adapting intelligent gateway) and a sensor (self-adapting intelligent sensor). In addition, we also propose an energy efficiency self-clustering sensor network (ESSN) and a node type indicator based routing (NTIR) protocol that considers the requirements of WSNs, such as network lifetime and system resource management. In order to verify the efficiency of our system, we implemented our system in real test bed and conducted experiments. The results show that autonomous power saving using our system is approximately 16-24% depending on the number of SIS1. A context-aware technology [4] is aware of the user's state and surroundings and modifies system behaviour based on this information. Various sensors or sensor networks are generally utilized to recognize the user's state and surroundings.

II. METHODS AND MATERIAL

A. Problem Statement

1) Centralized system architecture:

The existing systems have centralized system architecture. That is, the sensor is only able to sense and transmit contexts. All of the context analysis, reasoning, and management processing are done by the management server. Centralized system architecture has a number of well-known drawbacks such as single point of failure and performance bottlenecks. Furthermore, it takes a long service response time, because all the data gathered by the sensor nodes travels to the central server through multi-hop communication, and the command data generated by the server travels to an actuator in a likewise manner.

2) Fixed Rule-Based Control:

The existing system has a fixed (or static) threshold. So, if the sensed data is below the threshold, the system directly controls the appliance. This mechanism has limitations in providing intelligent services and effective energy management of sensors. Furthermore, this system is not able to deal with complex events and situations.

B. Block Diagram

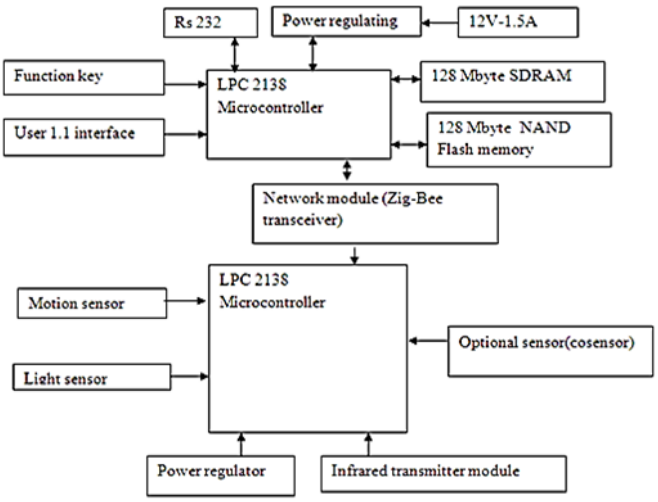


Figure 1. Self-Adapting Intelligent System for Building Energy Saving and Context Aware Smart Services

Fig. 1 shows a block diagram of self-adapting intelligent system for building energy saving and context aware smart services. This diagram is based on our developed, complete self-adapting system.

The aim of a Self-adapting intelligent system used for providing building control and energy saving services in buildings.

1) The system consists of a gateway (self adapting intelligent gateway) and a sensor (self adapting intelligent sensor)
2) An energy efficiency self-clustering sensor network (ESSN) and a node type indicator based routing (NTIR) protocol that considers the requirements of WSNs, such as network lifetime and system resource management
3) The results show that autonomous power saving using our system is approximately 16-24% depending on the number of SIS.

1) A Review on a Self Adapting Intelligent System

A Self adapting intelligent system can be separated in two classes by describing what type of architecture will be used in it.

1.1 The Self-adapting Intelligent Gateway (SIG).

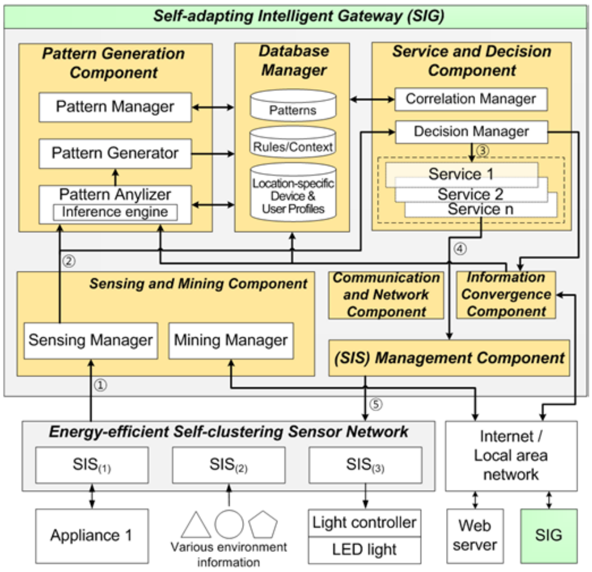


Figure 2. Self-adapting Intelligent Gateway (SIG).

- User and device recognition and management: The SIG has a device information table which includes device identifiers (devIDs), the device types, and the device characteristics. The SIG can control each device through its devID. The SIG also has a user information table which includes user identifiers (useID), the user's mobile device, and the user's profile. If a user with a smart phone enters the room, the SIG recognizes the user using the MAC address of the smart phone and sends the list of manageable devices and the real time energy consumption to the user's smart phone.

- Sensor node management:
  An adaptive middleware scheme in order to decrease the energy consumption of the battery-based sensors, the SIS. The SIG is aware of the battery state of the SIS because its packet includes a battery state field. By using this information the SIG is able to balance the battery of each node resulting in an increase in the network lifetime.
- Information gathering and analysis:
  The SIG gathers information about the power and the environment from the SIS. It then analyzes and classifies the gathered information.
- Pattern generation, and Service decisions and provisions:
  The SIG uses learning mechanisms for pattern generation. On the receipt of a packet from the sensor node, the SIG generates the proper pattern. If the specific event periodically occurs in the same situation, the relation between this event and situation becomes a pattern. The SIG can predict and provide the appropriate service in the given situation by using the pattern.

1.2 The Self-adapting Intelligent Sensor (SIS):

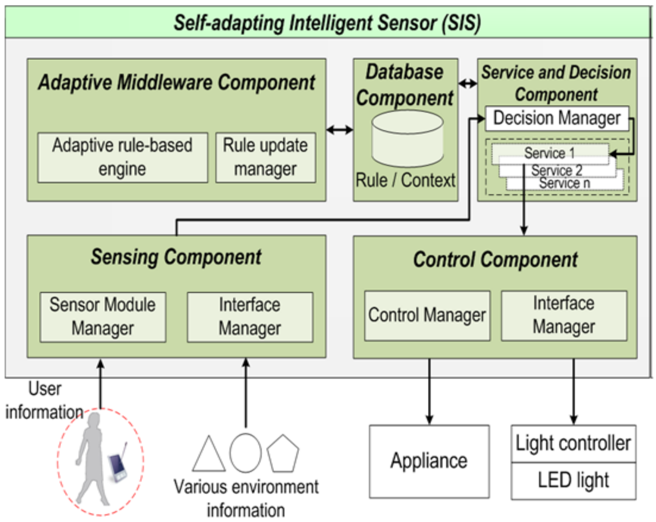


Figure 3. Self-adapting Intelligent Sensor (SIS)

The SIS is composed of five components: an adaptive middleware component (AMC), a service and decision component (SDC), the database component (DBC), a sensing component (SC), and a control component (CC) (see Fig.2). The SDC and the DBC in the SIS are more lightweight due to the removal of the trivial functions compared with those in the SIG. However, all the components except for the SDC and the DBC, because the functions of the SDC and the DBC are similar to those in the SIG.

- The AMC: [adaptive middleware component]
  The AMC manages the rule-update process. The user (administrator) modifies and updates the rules through the administrator mode of the SIG. For example, if the space has no people, so the user regards a reasoning task as a needless one, he (or she) is able to transmit the rule reconfiguration request data which makes this task quit. This process can also be done automatically by the SIG.
- The CC: [control component]
  Our system can command and control the consumer device, such as air-conditioner and TV by using IR signal. The CC manages this control process. The CC generates the IR signal based on the rules, so that the SIS controls the various consumer devices.
- The SC:[sensing component]
  The sensor module manager in the SC has the role of managing the various sensor modules. That is,if the control data of the sensor module is transmitted from the SIG, the SC makes the sensor module enable or disable. The various environmental and user information is collected through the interface manager in the SC.

3.2 Flow Chart of Dynamic Pattern Generation Algorithm

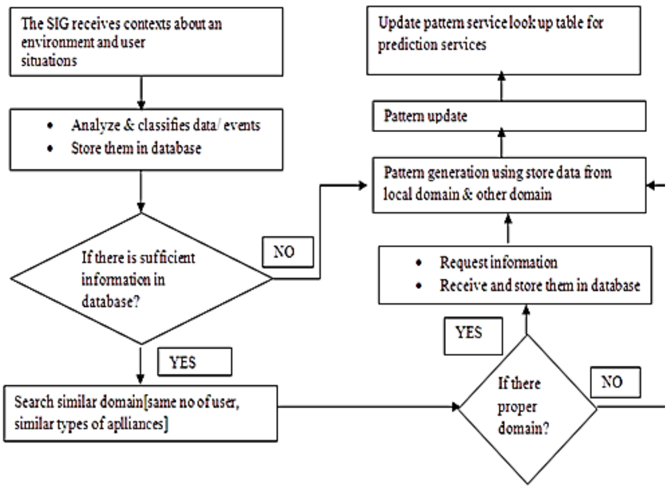


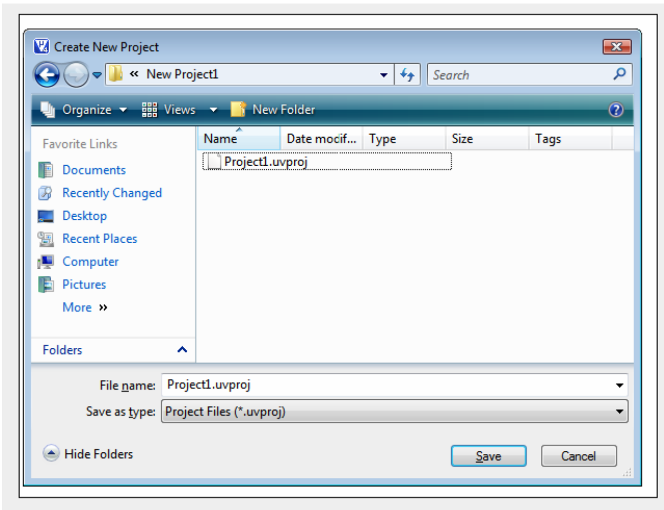
Figure 4. Flow Chart of Dynamic Pattern Generation Algorithm

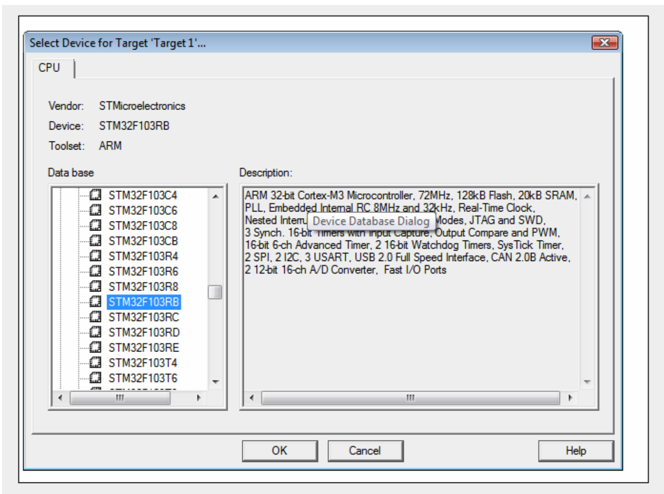
- The SIG receives contexts about an environment and user situations such as a temperature, humidity, intensity of illumination, a user's movement, a service execution event, etc. from the SISs and other appliances. The PA (in the PGC) then analyzes and classifies the gathered contexts and stores them in the database.
- Before generating the service pattern, the DM (in the SDC) determines whether the database has sufficient and proper information according to the predefined policies. The purpose of this process is to make the best use of the information from other domains in order to make adequate patterns. If the SIG only uses the local information without any information convergence, inadequate patterns will be generated frequently because of the lack of the information for pattern generation.
- If there is not sufficient and proper information for
- pattern generation in the database, the SIG searches other domains which have similarity to the local domain. These similarities include the user's characteristics, the characteristics of the space, the types of installed appliances, etc. The main role of the ICC is to search for similar domains and interconnect with them in order to carry out information convergence. In order to manage the domains efficiently, it also groups the domains according to the policies related to their similarity.
- After finding the proper domain, the ICC requests the information according to the user and environmental situation.
- The ICC receives the information, and then stores them in the database. The PG (in the PGC) performs a correlation analysis between user situations and services.
- Finally, the SIG generates patterns and update the Patterns in the database. That is, it generates the patterns based on the user's situations and the service history. Then it updates the look-up-table through matching the user's and environmental situation to generated patterns in order to effectively provide the service prediction to the local user.

III. RESULTS AND DISCUSSION

SIMULATION

The simulation of this project has done with the help of MATLAB simulation tool.





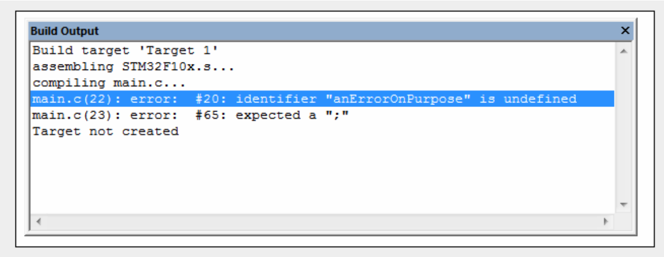


Figure 5.Simulation Window

RESULTS

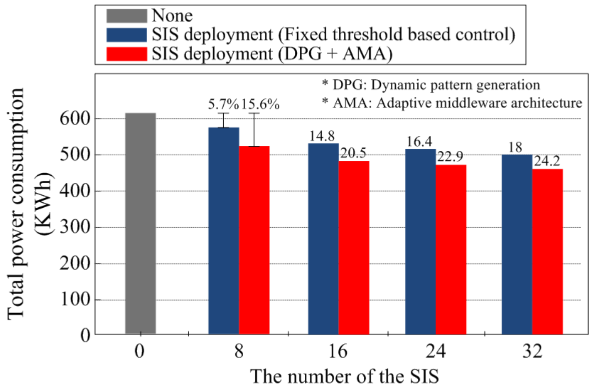


Figure 6. Comparison of total power consumption

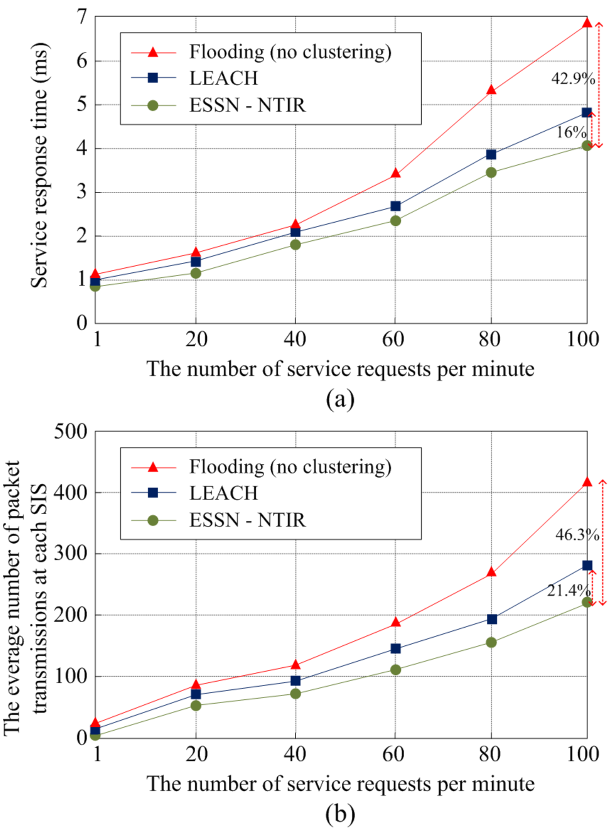


Figure 7. Comparison of (a) the service response time and (b) the average number of packet transmissions

IV. CONCLUSION

Self-adapting intelligent system which consists of the self-adapting intelligent gateway (SIG) and sensor (SIS) in order to make consumer devices more energy efficient and intelligent. The ESSN and NTIR to enhance service response time and network lifetime. The results show that the power saving using our system with DPG and AMA is approximately 16-24%, depending on the number of SIS. The SIS collects the information of the people's movement and illumination intensity and then the SIG dynamically generates pattern by using this information. Using this pattern max energy can save by controlling the lights using this pattern.

V. REFERENCES

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