A Design of Dynamic Database Middleware System for Plant Factory

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Abstract. General middleware for WSN/M2M/IoT service limited functions with pre-defined types of devices, sensors and controllers for indoor or outdoor environment monitoring and managing Plant Factory. And thus, it requires additional setup expense in the system and further configuration for defining new devices. So, it would be valuable to apply adaptive middleware in plant factory for managing newly created devices and sensors with dynamic database and adding sensing data from it. In this paper, we have designed middleware to accommodate such goal for registration of new types of sensor node and algorithm for creating new DB table and storing sensor data with dynamic database.

Keywords: Plant Factory, Dynamic Database, Wireless sensor network

1 Introduction

Recently, the change of global weather trend and alteration of dietary life leads to the interest in study and development of production of crops in high-tech production facilities such as greenhouse and plant factory [1]. Many of researches are also being done for controlling such environment and promoting the growth of crops by applying artificial light, precise water control, etc. for high quality and a stable crop production [2]. Plant factory, a notable and the most advanced crop production facility, is being considered as a typical high-tech production facility and requires manage of versatile functionalities for its successful operation such as production automation, sensing technologies, light control, hydroponic system, environment control and energy consumption for air-conditioning. It is also needed to adopt kinds of managing and measuring technologies for environment such as artificial intelligence, knowledge base, data communication and sensor technologies[3][4][5].
Recently, kinds of experimental systems have been created to build management systems with wireless sensor network for agriculture environment monitoring. One research of monitoring for the external environment is “agricultural environment monitoring server system using wireless sensor networks” [6]. This system is pre-

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configured to use the specific WSN, soil and images for the purpose of gathering information and delivering it to the system. And, one another research of monitoring for the greenhouse environment is “wireless sensor network-based paprika growth management system” [7]. This system is made to collect and monitor information related to the growth environment of crops outside and inside paprika greenhouses by installing WSN sensors and monitoring images captured by CCTV cameras. Another research of monitoring for the greenhouse environment is “greenhouse automatic control system based on wireless sensor network” [8]. This system is using greenhouse environment monitoring and automatic control for preventing the crop from diseases.

However, these previous researches have built in the form of static middleware that is only support pre-defined sensor nodes, sensors and controllers for indoor or outdoor environment monitoring in greenhouse. It is required to reconfigure the settings in the system when we would like to add variety types of newly produced sensors. Thus, previous research middleware has the following problems. Managers can’t immediately manage when they want to add new sensor nodes or install different sensor types of sensors. So, the existing service middleware need maintenance cost in order to improve the system when trying to apply new user requirements. For this problem, in this paper, we propose an adaptive middleware for plant factory management platform. The middleware is able to a reusable and can be modified by requirements from users.

In this paper consist of Section 2 in describes the overall system structure of plant factory, Adaptive middleware system for plant factory will be explained in section 3, and then section 4 summarizes conclusion.

2 System Configuration for Plant Factory

We propose system with existing equipment installed, monitors the environments of plant factory using a WSN for the monitoring and management of the environmental information from the sensors (electricity, light, temperature, humidity, etc.) that are additionally installed in plant factory. Fig 1 is overall system structure for monitoring and control of plant factory. The plant factory system consists of the EMC(Environment Monitoring & Controller), Middleware server, DB server, and application Server. EMC consists of two parts; WSN for environment monitoring of plant factory, PLC for environment control of plant factory. Local ID will be issued for equipment in order to manage sensor node and PLC in middleware. The plant factory middleware is operated as follows. Plant factory environment data collected from wireless sensor network, and then store data in a database inside the middleware server, and then middleware server transmits environment data to application server. The user of the plant factory is able to environment control in plant factory through the PLC from applications.

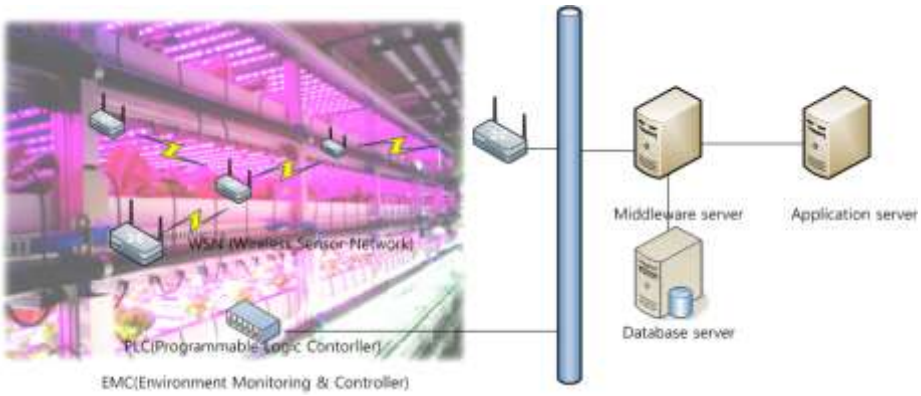

Fig.1. Overall System Structure of Plant Factory

3 Adaptive middleware system

The proposed middleware of plant factory has the characteristics as follow. First, it should collect data from heterogeneous sensor node and PLC. Also, it should provide registration, add, delete of function in middleware. Second, the dynamic database should provide data collection for the newly added sensor node and sensors. The middleware can recognize when addition of new type of devices in plant factory happens, and then the middleware should make a new table in dynamic database. Adaptive middleware structure is as shown in Fig 2.

1. Equip Interface(EI): Equip Interface can be connected between middleware and equipment in plant factory.
2. Application Framework core(AFC): AFC is coordinator role of receive request from upper layer and view resolver role for showing the results to the user in middleware.
3. API Controller(APIC): API controller is role of overall API control from request of upper layer and middleware
4. Plant Factory Service Logic(PFSL): PFSL has equip management service, grow management service and monitoring management service. This logic coordinates the Plant Factory application, processes of commands, generation of logical decisions for growth management and environment element evaluation, and performs calculations in plant factory.
5. Plant Factory Data Access Object(PFDAO): PFDAO is an object that provides an abstract interface to some type of database or other persistence mechanism. By mapping application calls to the persistence layer, PFDAO provide some specific data operations without exposing details of the database
6. Plant Factory Database Manager(PFDM) : The role of PFDM are transmit to upper layer at database value for request of upper layer and create of new table in database of upper layer by processing a request.

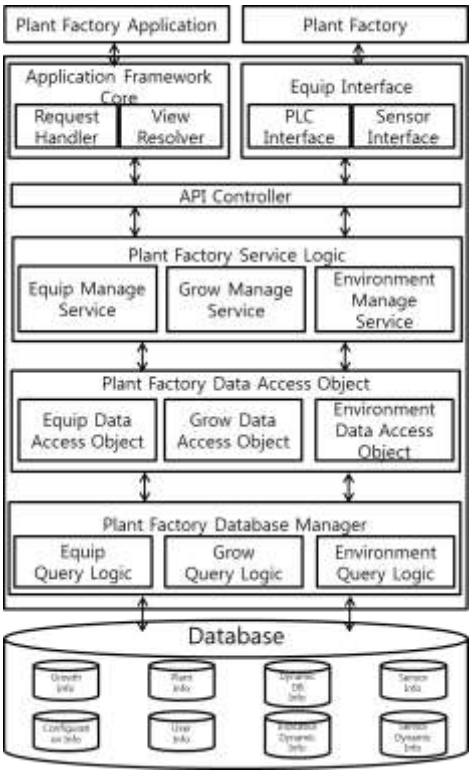

Fig. 2. Structure of Middleware

Device registration procedure is as follow for managing middleware to the newly sensor node, when recognize new type of sensor node in EI of middleware in plant factory. EI transmit Local ID and profile of sensor node data to API Controller. API controller transmits Sensor node data to Equip manage service of API Business Logic in order to save sensor node data in database, And EMS transmits command to create new DB table toward new sensor node and new sensor node data. DAO transmits command to SQL in order to create database toward new sensor node. Fig 3 is procedure for creation of dynamic database table at Equip Query Logic of PFDM

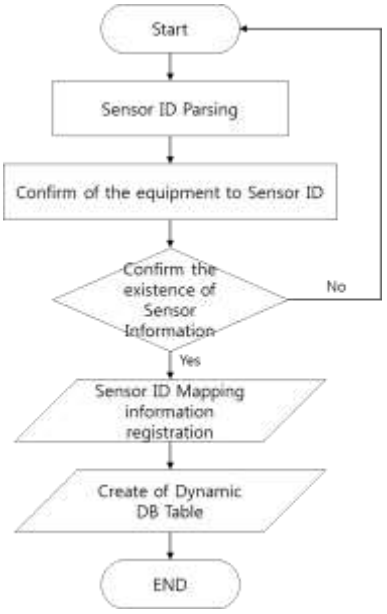

Fig. 3. Create of Dynamic DB Table

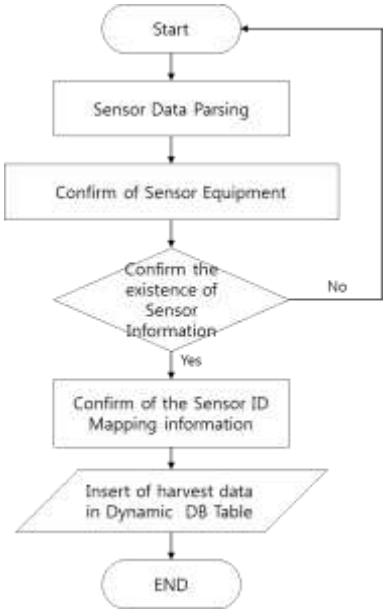

Fig. 4. Insert of harvest data in Dynamic DB

Euqip Query Logic parses the Sensor ID from Sensor data when transmission happens to the sensor data for Equip Query Logic from the Equip Data Access Object. Equip Query Logic verify to sensor node ID in database for confirming the existence of sensor node ID. If, confirmed the sensor node ID is new sensor node and not appeared in existing information, then register in database to mapping information of sensor node ID, and create of dynamic Database table.

Fig 4 is procedure for saving collected data from sensor nodes in dynamic database table. Environment Data Access Object parses the sensor data when transmission of sensor data from Environment Data Access Object happens. And then, Environment Query Logic verifies local ID of the sensor node from information of sensor node. When confirmed sensor data applicable in dynamic Database table, and then the environment query logic inserts the gathered data in dynamic DB table. Fig 5 is overview of UML class diagram in database of plant factory.

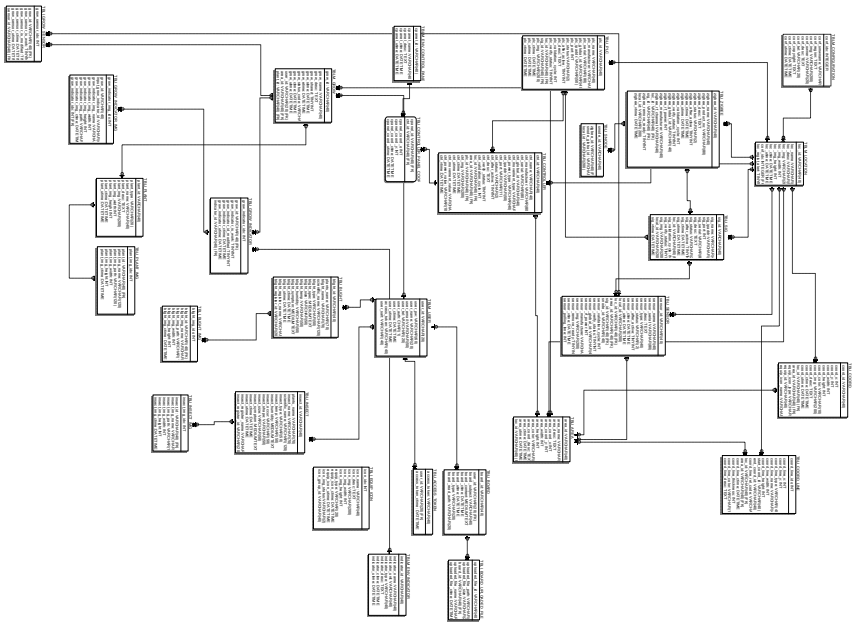

Fig. 5. Overview of UML Class Diagram

We are installed sensor node for power measurement in plant factory, and then we tested to recognize newly added sensor node from middleware. The middleware successfully created the dynamic database, and we have verified to provide the value of sensing data from created database for users. The middleware has recognized four power measurement sensors, and then showed view for users in the middleware in fig 6.

Fig. 6. View for user in middleware

4 Conclusions

We applied adaptive middleware in plant factory for creating automatic dynamic database based on the requirements from users and adding of sensing data to generated database. We have designed middleware for registration of newly created sensor nodes and collection and addition of sensing data to dynamic database. Based on the system, users can immediately manage when they have to add new sensor nodes or install different sensor types of sensors from pre-configured types in the system. So, the middleware is expected to reduce maintenance cost and re-setup labor/time.
For the future work, we are planning to develop a proto type system based on the proposed mechanism for adaptive middleware in plant factory.

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