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An Efficient Smart Factory Management Based on IoT Optimized for Cloud Environments

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Abstract

With the advent of the fourth industry, small and medium-sized enterprises are increasingly dealing with manufacturing processes through automation. Especially, starting with Industries 4.0, small and medium-sized companies are turning their manufacturing sites into smart factories. However, most SMBs do not have enough manpower and assets (including investment) to build smart factories. This paper proposes a management technique that can optimize smart factory that can improve manufacturing process that is operating on the manufacturing site (building IoT device in part of the process). The proposed model supports automatic processing of production information through IoT equipment that is built in smart factory environment to efficiently process product information that is generated at smart factory. The proposed model has features that automate the linkage between IoT equipment to each other because all the actions of IoT devices built on smart factory sites are handled by a hierarchical centralized management method. The proposed model used IoT equipment built at smart factory. Performance evaluation of efficiency resulted in 13.3 % improvement from previous models depending on the number of IoT devices. The accuracy of information analysis of IoT devices installed at smart factory was improved by 9.2%. The average processing time of information using IoT devices was reduced by 14.9 % from the previous model. The more expensive it is to reduce manpower by 23.9 % on average compared to previous models.

Keywords: *IoT, Smart Factory, Low cost, Information collection, SMBs.*

1. Introduction

With the recent development of information and communication technologies, an increasing number of small and medium-sized enterprises are trying to apply IoT equipment to manufacturing sites[1]. In particular, with the emergence of various technologies related to the fourth industry, many changes were also seen in the automation of factories by small and medium-sized enterprises. Smart Factory has transformed many existing manufacturing sites, and automation in terms of production process allows many kinds of mass production in terms of connectivity, flexibility, and intelligence between manufacturing products.

Although Smart Factory is supported at national level starting with Industry 4.0, Korea still lacks national level support[2]. Even under tough financial conditions, manufacturers are increasingly creating brand and product value by linking things and services both inside and outside smart factory. However, small and medium-sized businesses are making a lot of efforts to improve their existing process processes, but due to their unique characteristics and poor investment capacity, many smart factories are difficult to deploy at the manufacturing site.

In this paper, the best-suited smart factory management technique of IoT base is proposed to improve management of small and medium enterprises and reduce costs. The proposed model provides real-time decision-making by attaching IoT devices to manufacturing plants to actively link product information generated during production with each other. The proposed model partly linked the entire factory process currently operated by small businesses to improve productivity at a low cost.

The proposed model has the following objectives to efficiently build a smart factory environment: First, the proposed model allows all IoT devices built on smart factory sites to be approached in a hierarchical, multi-step structure so that they can be directly controlled from the center. The reason is to easily control the manufacturing process of smart factory from the center.

Second, IoT equipment built into Smart Factory uses different recognition codes, and recognition codes of IoT equipment are encoded in the overall probability element values. The reason for this use is to maintain improved load and processing rate of IoT equipment used during manufacturing process.

Third, IoT devices are required to generate information that is generated during manufacturing process with a code according to a certain rule and then place it in a cross-distributed manner. The reason for this is to access the smart factory manufacturing process and minimize the processing time of the server when processing the service.

The paper is made as follows: section 2 explores existing relevant studies. In section 3, we proposes an IoT-based smart factory management model. Section 4 evaluates the proposed model compared to the existing model. An end and future work are given in a section 5.

2. Preliminaries

2.1 Smart factory

Recently, many countries around the world have expanded their support policies to secure competitiveness in manufacturing[3-4] At the center of the manufacturing industry, companies are introducing smart factory systems to secure productivity and increase efficiency[5-6].

Since the global financial crisis, the global manufacturing industry has recognized the need to build smart factories due to a long-term slump as well as rising labor and raw material costs.

The smart factory market is a market where next-generation new technologies and manufacturing technologies are integrated beyond the existing factory automation (Factory Automation, FA) level, and solutions for upgrading smart manufacturing technologies such as IoT and CPS should be introduced. As shown in Table 1, smart factories differ greatly in terms of digital aspects of manufacturing process and human resources development compared to conventional factory automation.

Table 1: Factory automation vs. Smart Factory

Division	Factory automation	Smart Factory
Definition	the mechanism of a production system that controls the operation of a machine without relying on humans	automation platform that automates environmental safety/marketing/design/ process/shipment at the factory and optimizes quality and performance
Advantage	Create available software components using scripted languages as well as compiler languages such as C++	Integrate with Internet of Things (IoT), AI (Artificial Intelligence), Big Data, etc. for automation and digitalization
Weakness	Difficulty in connecting, collecting and analyzing data generated during production	Make a lot of initial investment capital

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Object	equipment such as computers and robots	Procurement, Logistics, and Consumer Related to Manufacturing
Function	Connect, collect, and analyze data autonomously by giving each object intelligence and connecting it to the Internet of Things (IoT)	Automate factory-wide unmanned and production processes using equipment such as computers and robots
Range	Vertical Integration - 'Factory' and 'Manualizing'	Horizontal Integration - 'Smart'
Characteristics	Integrate business activities with a focus on production management	Increase efficiency and increase productivity across management by combining the latest technologies, from factory operations to management.

2.2 Trends of smart factory

The Ministry of Science, ICT and Future Planning classified IoT as an Internet new industry in order to improve employment, productivity and efficiency of small businesses, and presented detailed tasks to nurture small businesses through various policy announcements[7].

POSCO is one of the companies that applied smart factory to the steel industry. POSCO sought to overcome the limitations of existing technology development by reducing the number of highly skilled persons and replacing the old facilities with the aim of reducing manpower costs. In addition, POSCO has applied the latest technologies to the steel industry to analyze and learn all data produced by the steel industry with artificial intelligence[8].

Smart Factory, which is currently built in South Korea, is applying IT technology to many process systems. However, the existing manufacturing site cannot reduce the failure rate of the process system without additional measures due to the cost problem[9-11].

2.3 Previous research

Blockchain technology has been used to rapidly process and analyze data collected from IoT devices, focusing on large companies[12]. As blockchain technology is applied to industrial sites, security breaches that have often occurred are being addressed in part[13]. Miller et al. uses the IIT and blockchain together to describe how efficiency has improved in various industries[14]. Liang et al. proposed a communication-related architecture using blockchain-based technologies used in smart factory environments[15]. This architecture is a communication architecture for IIT applications and is flexible for IIT applications. Aitzhan et al. proposed a technique to use coding technology in smart factory environments to ensure data[16]. Tesla et al. proposed a platform using IoT equipment that enables resource control technology in smart factory environments[17]. However, this platform does not have a clear description of the blockchain, so it cannot verify the details of the platform.

3. IoT-based manufacturing management model

3.1 Overview

The proposed model gradually deployed IoT devices in the manufacturing process in order to improve the smart factory environment. The proposed model was designed to support collection, storage, management, and processing of product information by recognizing product information generated during the manufacturing process by IoT devices. In addition, the proposed model automates linkage between IoT regardless of the number of IoT devices built in the factory by central servers operating product information to each other centrally.

Figure 1 indicates the operating process of a factory manufacturing site using IoT devices in a smart factory environment. As Figure 1, the proposed model has three characteristics.

First, the proposed model will be established so that all IoT devices built on smart factory sites can be accessed in a hierarchical, multi-level structure so that they can be directly controlled from the center. The reason is to control the manufacturing process easily from the center.

Second, IoT equipment that is built at smart factory manufacturing sites uses different recognition codes, and recognition codes of IoT equipment are encoded in overall probability element values. The reason for this use is to maintain improved load and processing rate of IoT equipment used during manufacturing process.

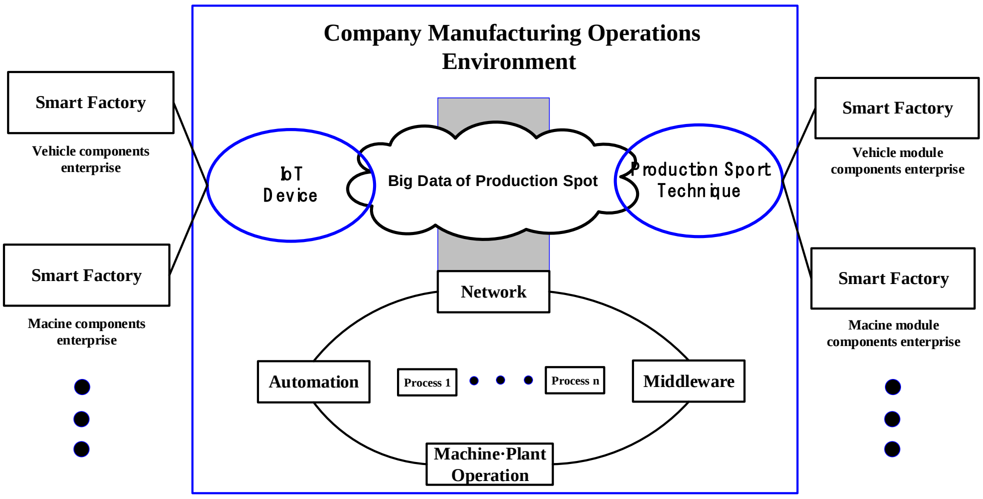

Figure 1. A Schematic Design for the Operating Process of Factory Manufacturing Sites Using IoT Devices

Third, IoT devices are required to generate information that is generated during manufacturing process with a code according to a certain rule and then place it in a cross-distributed manner. The reason for this is to access the smart factory manufacturing process and minimize the processing time of the server when processing the service.

However, in order for the proposed model like Figure 1 to be processed in the manufacturing process, existing manufacturing production sites in operation must be partially started and expanded to be replaced with automated facilities, but it can save a lot of money in terms of production by small and medium-sized enterprises.

3.2 Smart factory process

The proposed model will carry out a data collection process, such as Figure 2, for efficient data processing of smartfactories. As with Figure 2, the proposed model carries out the modelling process of the collection data for production products collected through various manufacturing equipment at the smart factory sites.

Figure 3 indicates the process of collecting information on products produced by adding IoT to manufacturing equipment operating at smart factory sites.

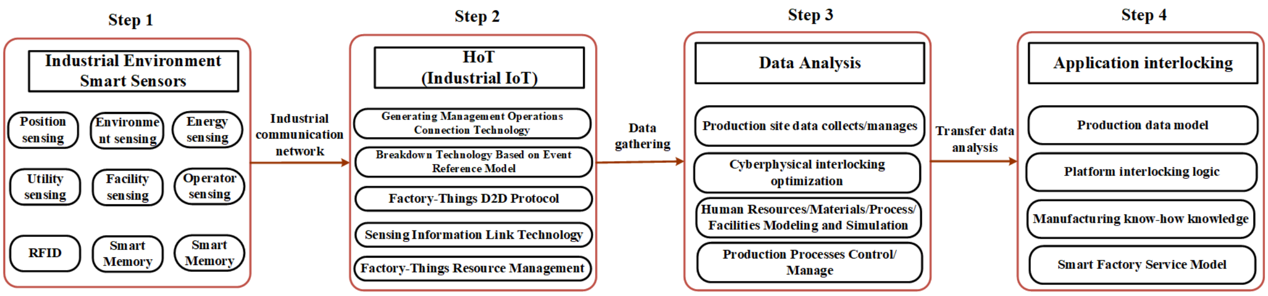

Figure 2. Data gathering modeling process of Smart Factory Model

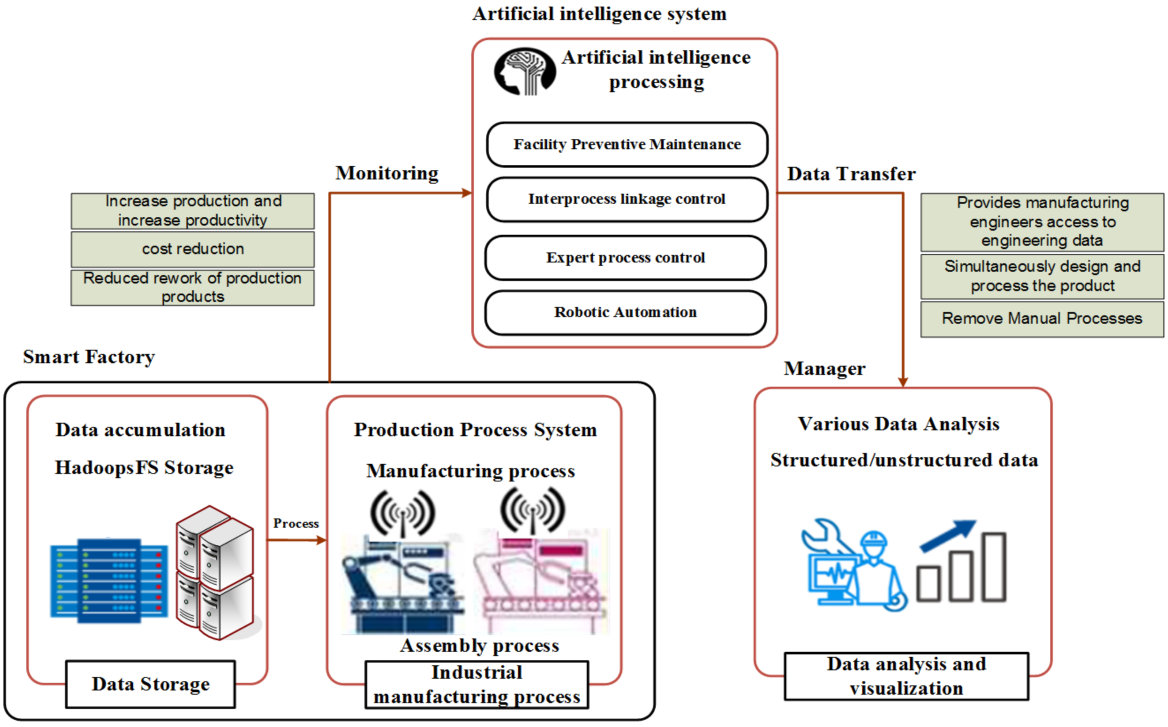

Figure 3. Process Model of Smart Factory

The proposed model should meet the following requirements to efficiently handle data analysis: First, existing facilities and equipment should be able to be replaced or upgraded for smart factory construction. Second, the manufacturing site shall have communication equipment capable of connecting heterogeneous devices. Third, equipment built on smart factory sites should be repositioned and utilized. Fourth, support links with R&D, education and human resources development consulting should be possible by analyzing data collected from manufacturing sites.

3.3 IoT information gathering and analysis

The proposed model provides direct access to manufacturing equipment to collect and analyze information about the equipment built into the smart factory. Information collected from IoT devices is reused for product development and management. The proposed model is used on the Big Data platform (Hive, Pig, Spark, etc.) by storing collected data in a variety of ways.

The proposed model carries out the process to collect information from the manufacturing site, such as Figure 4.

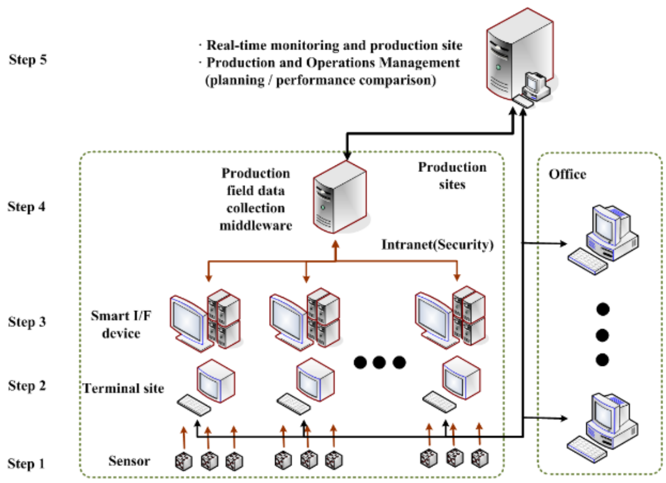

Figure 4. Smart Factory Process of Proposed Model

· Step 1: This step is the step to collect data from sensors installed at the production site of smart factories. At this stage, the sensor is attached to all the production facilities required for the manufacturing process.

· Stage 2: In this stage, data is collected from sensors attached to various production equipment through terminals installed on the site.

· Step 3: In this step, data collected from the terminal is processed into data that will be passed to middleware collecting data from the production site by the smart I/F device.

· Step 4: At this stage, smart I/F devices deployed in an intranet environment are integrated and data collected from smart I/F devices is delivered to the smart factory's servers.

· Step 5: In this stage, the production site information processed by the server built in the smart factory is monitored in real time and the office is utilized for production operation management (plan/performance comparison).

The proposed model analyzes the information collected from smart factory sites in real time. The proposed model uses the collected information to easily control the processing of each process at the manufacturing site. Also, IoT information can be easily extracted because it is analyzed based on artificial intelligence.

4. Analysis

4.1 Environment Setting

The proposed model used IoT equipment built at smart factory such as Figure 5. Five IoT devices of Figure 5 were used at smart factory sites and IoT information was established so that it can be sent and received via Bluetooth or Wi-Fi [18]. Existing studies for comparative analysis of performance evaluations were conducted with proposed models.

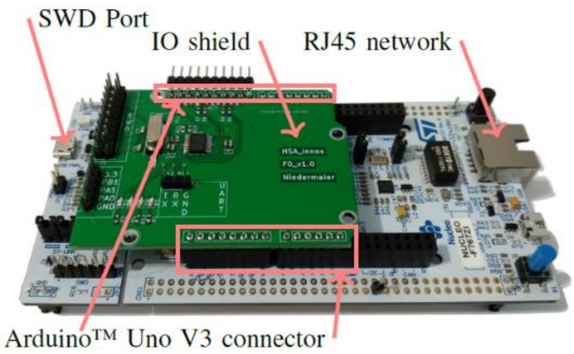

Figure 5. IoT Device for simulation

4.2 Performance Analysis

• Efficiency

Figure 6 assessed the efficiency of information collected from IoT devices built on smart factory sites. The efficiency assessment was investigated and analyzed in accordance with existing data collection analysis methods and the proposed model proposed. Performance evaluation of efficiency resulted in 13.3 percent improvement from previous models depending on the number of IoT devices. This result is due to easier access control of IoT devices that are deployed in Smart Factory.

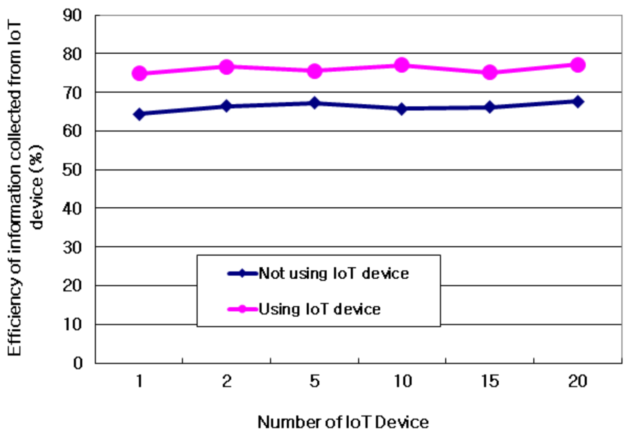

Figure 6. Efficiency of information collected from IoT device

• Accuracy

Figure 7 was evaluated for the accuracy of information collected from IoT devices at smart factory. The accuracy of information analysis of

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IoT devices installed at smart factory sites in Figure 7 was improved by 9.2%. The result was that information on IoT devices used in the proposed model had a low error rate using artificial intelligence algorithms.

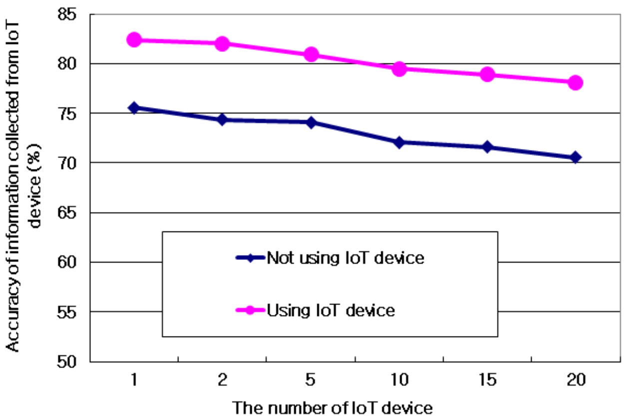

Figure 7. Accuracy of information collected from IoT Device

• Processing time

Figure 8 was evaluated for the processing time of information collected from IoT devices installed at smart factory sites with existing models. As a result of Figure 8, the average processing time of information using IoT devices was reduced by 14.9 % from the previous model. The result is that IoT devices installed at smart factory sites processed and stored data in real time.

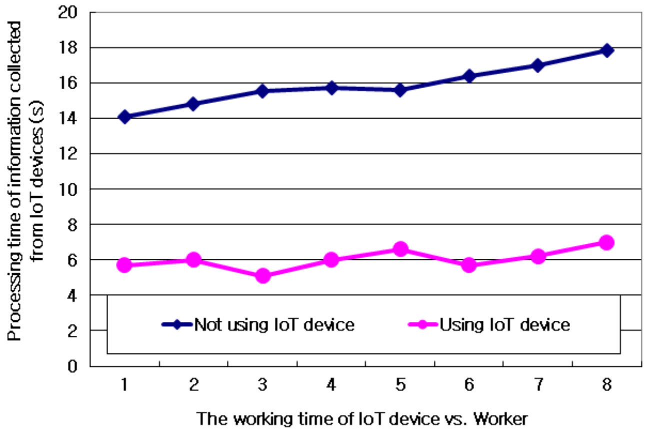

Figure 8. Processing time of information collected from IoT devices

• Cost

Figure 9 shows the cost of personnel change (10^7 won) for the entire smart factory site, compared to when IoT devices are deployed at smart factory sites.

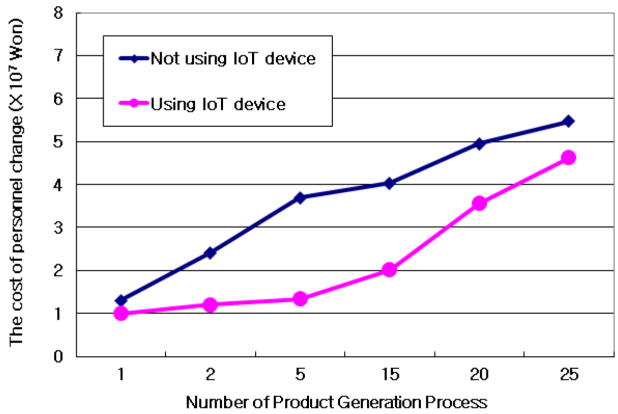

Figure 9. Cost change for the entire smart factory site (× 10^7 Won)

As with Figure 9, the more IoT devices are used at smart factory, the more expensive it is to reduce manpower by 23.9 % on average compared to previous models. This is because the proposed model not only handles information on IoT devices in real time, but also processed them immediately without delay in case of problems. However, it was found that minimum manpower is needed to restore IoT devices if IoT devices suddenly fail during the smart factory process.

5. Conclusion

Small and medium-sized enterprises that are preparing to automate their plants recently have an economic burden, but automate their manufacturing processes to maintain or improve their competitiveness. In this paper, we proposed a management technique that can optimize smart factory that can improve manufacturing process that is operating on the manufacturing site. The proposed model was to collect, store, manage, and process product information by recognizing product information so that IoT devices could be built and operated in stages by interworking with

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each other. In addition, the proposed model is linked to existing systems to achieve the production efficiency and cost savings of the existing manufacturing environment. Based on the results of this study, future research plans to compare production efficiency and cost of each product produced at the manufacturing site.

Acknowledgment

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