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Original Research Article

Implementation of Energy Management System (EMS) Framework for Smart Manufacturing

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Abstract

In this paper, an energy management framework for smart factory is illustrated based on context-awareness. The smart factory is composed of the three layers, and IoT sensors are deployed in the smart industries and used to collect many kinds of data including personnel, equipment, and environment. The first layer, the data collection and control layer, collects and sends environmental and control data to the second layer. And, the second layer, energy management based on context- awareness layer, analyses the data and infers the context from them. Finally, the energy service layer provides energy management services to users through monitoring and controlling the status of energy consumption. By the use of proposed scheme, users can monitor their energy consumption, and control their machine and equipment to avoid energy leakage.

Keywords: Smart Industry, Energy Saving, Framework, IoT, Context-aware

INTRODUCTION

Recently, smart Industry technology is emerging as the main research issues to increase the productivity and efficiency, where the smart machines collaborate with each other and with users and customers. Smart Industry requires 4 Zero factors, including Zero Waiting-time / Inventory / Defect / Down-time. Information & Communication Technology (ICT) convergence for production resources affects 4M1E, containing Man, Machine, Material, Method and Energy, in real time and event processing in all types of manufacturing enterprises [1]. Therefore, there are many kinds of ICT technologies to provide automatic and intelligent services in smart factories. Among them, many kinds of IoT sensors, gateways, controllers, equipment and software are needed to collect the information during manufacturing process and control the equipment by adapting customers' requirement. In smart Industry, the real-time production information can be gathered and provided the chief executive officer (CEO) to quickly decide the business plan, factory managers to monitor the status of the factory, and customers to know when they can receive the product.

Due to the global warming, many researches for green technology are going on, such as solar energy, wind energy, smart grid, energy saving and management, and zero carbon green technologies [2]. Energy management technologies are spread almost all kinds of areas including factory, building, campus, hospital, and home, to make the sustainable planet by reducing the energy consumption [3]. Also, the energy management for smart factories is required to reduce carbon dioxide and manufacturing cost by managing energy consumption.

In this paper, the energy management framework based on context-awareness is proposed for smart factories. To manage energy consumption in smart factory, some functions are needed including data collection, transformation data into information, inferring situations, provision users with intelligent services.

This paper is organized as follows. In sections 2, we describe the technologies for smart factory and energy management as related work. And we illustrate the proposed architecture of energy management framework for smart Industry in section 3. Finally, section 4 summarizes the paper and talks about the future work.

RELATED WORK

A. Smart Industry

These days, manufacturing is changing rapidly in all kinds of regions, and that is called a fourth industrial revolution [4]. While the introductions of steam power, the assembly line and early automation drove the first three industrial revolutions, machine intelligence will be the main technology for the fourth one. Advances in electronic intelligence make it possible for equipment to measure and change processes, and for factories to communicate over a wide area. For this kind of intelligence, IoT (Internet of Things) plays the important role in smart Industry to detect and control the situation.

A number of benefits can be provided through the transition, including greater efficiency, flexibility, quality and safety, as well as improved maintenance, energy savings and lower production costs [4]. Traditionally, industry automation has been optimized to produce identical or similar products efficiently and rapidly to achieve cost reductions from volume production. Product variation and design changes often require some degree of flexibility be built into the process. This flexibility usually requires down time for resetting equipment and retooling, which can decrease volumes and increase costs. To the extent necessary, quality, reliability and safety are also built into the process, though these positive factors often represent short-term costs, even if they provide long-term value.

Energy Management Technology

The performance of machine and equipment in factories and buildings becomes reduced, and the energy consumption gets higher because of the ageing and malfunction [2] [3].Facilities of the most of factories and buildings are not managed systematically or professionally, since the existing energy management are performed based on the facility managers' experience and habits. To solve these problems, many kinds of automatic and intelligent energy management technologies are developed and used these days.

As per these trends, Factory Energy Management System (FEMS) is studied and deployed and energy policy is changed from the supply management to the demand management. Reflecting this trend, main functions of FEMS are shown in Figure 1[5]. Using the five main functions of FEMS, including energy monitoring, context analysis, demand prediction, simulation and optimization, energy can be efficiently managed in existing factories.

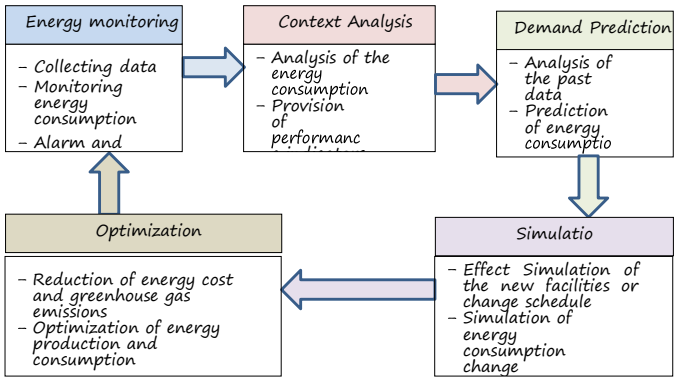

Figure_1: Main functions of FEMS

III. DESIGN OF ENERGY MANAGEMENT FRAMEWORK FOR SMART INDUSTRY

A. Components of the Energy Management for Smart Factory

In this paper, the energy management framework for smart factory is described for the purpose of maximizing energy efficiency and the comforts of energy managers and CEOs, who are provided energy management services as users.

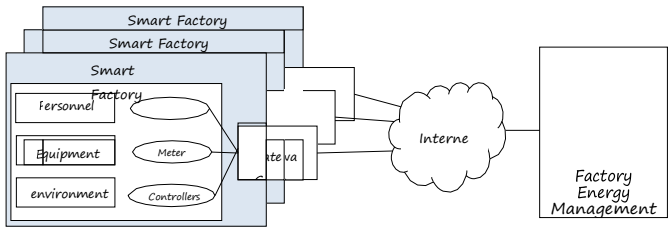

Figure_2: Components of the energy management

The component of the energy management is shown in Figure 2, including smart industry, gateway, and FEMS. In this paper, we call the energy management system for smart industry as FEMS, which has similar functions as the existing FEMS. In a smart industry, sensors, meters and controllers are added on to the existing personnel, equipment, and environment in the traditional factory. The data from the sensors and meters are sent to the FEMS through the gateway. Then, the data is transformed to the information and analysed to detect the energy leakage or abnormal state in the factory. In case of the unusual states of operation or the energy consumption, it is notified to the designated users to solve the state. The users can check the facilities or equipment and prevent the useless energy consumption.

B. Energy Management Framework for Smart Industry

The proposed energy management framework for smart industry based on context-awareness is shown in Figure 3. In this paper Context-awareness is accomplished considering the profiles and inferring rules for each smart industry.

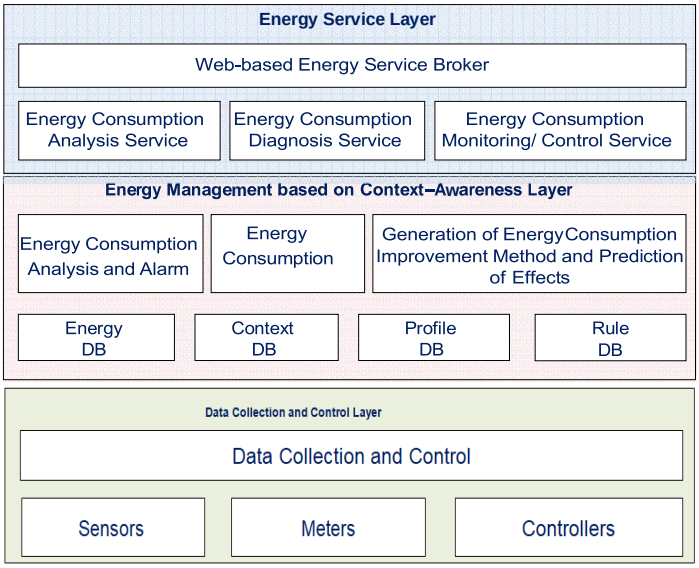

Figure_3: The proposed energy management framework

The framework consists of three layers and performs various functions including those of Figure 1. First, data collection and control layer consists of many kinds of sensors, meters, and controllers. The Sensors collect the environment data, including existence, illuminance, temperature and humidity, and the energy consumption data of facilities and equipment in the factory. And, the energy management based on context-awareness layer administrates databases (DBs), analyses the past and present energy consumption and predicts future energy consumption. Also, the layer generates the improved methods of energy management and forecasts the effects and performance indicators. In the layer, future energy consumption is presupposed for the demand control service. The layer has four kinds of DBs to manage the information related to the energy consumption. Energy DB has the tables for the raw data and converted data from the sensors and meters. The Context DB contains the inferred context information from the converted data in energy DB. The profile DB has the profiles tables for the factory itself, sensors, meters, controllers, personnel and equipment. The rule DB includes the rules for controlling the abnormal state. Using these DBs, more precise and delicate energy management services can be provided based on the context-awareness. Finally, the energy service layer has the functions for reporting the energy consumption, analysis and diagnosis, and monitoring and control through web-based energy service broker.

C. Configuration and Message Flows for the Energy Management Framework for Smart Factory

The Configuration for the energy management for smart factory is shown in Figure 4. Smart factory includes many kinds of new items to detect the energy consumption context, provides data to the FEMS, and controls the facilities and equipment for energy management. FEMS collects data, analyses them, infers the context, and manages DBs. Users can be provided energy management services including monitoring, alarm, and control.

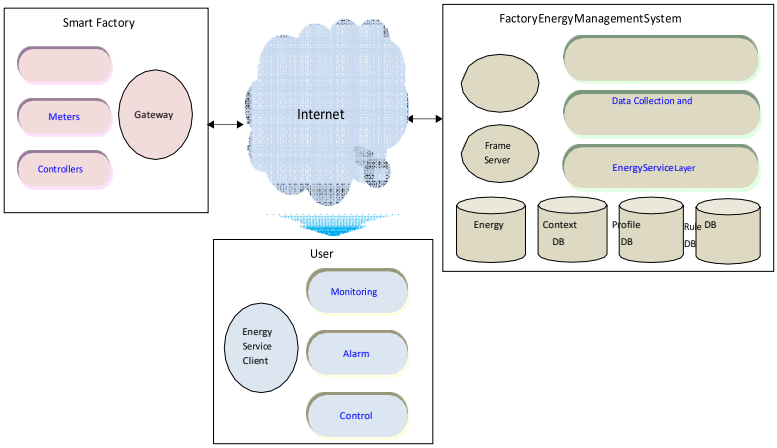

Figure_4: Configuration for the energy management for smart factory

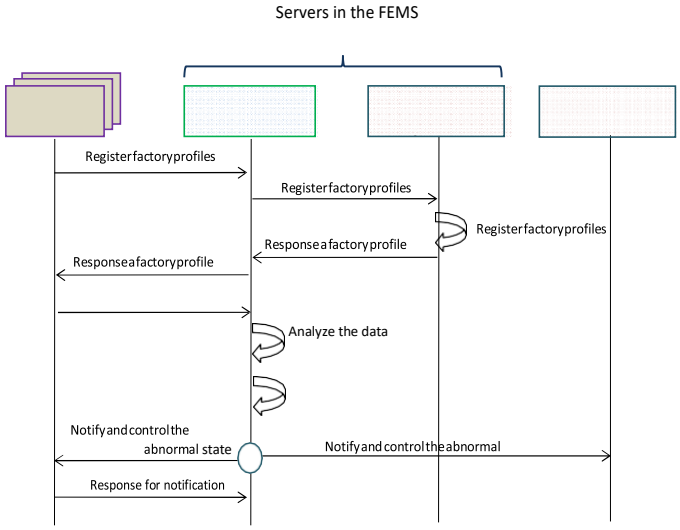

Figure_5: Message flows for the energy management for smart factory

The message flows among the components in Figure 4 is illustrated in Figure 5. First, the gateway in a smart industry registers the factory profile to the profiling server in the FEMS through the framework server. After registering is completed, the gateway periodically sends the energy consumption data in the factory to the framework server. Then, the server analyses the data and detects the abnormal state of the factory using the periodic data and factory profile. In case of an unusual state, then the framework server notifies to the designated user to resolve the state.

Using the proposed framework, energy managers and CEOs of the smart industry can monitor their energy consumption, and control their facilities and equipment to avoid energy leakage and efficiently manage energy consumption.

CONCLUSIONS

Due to the global warming and the increase of energy use, efficient energy consumption is the main research issues these days. Therefore, various kinds of energy management technologies for factories, buildings, and homes are studied and deployed to reduce carbon emission and energy cost.

The proposed energy management framework for smart factories provides energy managers and CEOs of the smart industry with monitoring services for energy consumption and controlling services for facilities and equipment. Using the framework, energy leakage can be reduced and energy consumption is efficiently managed in a smart industry. For the future study, we will consider the performance issues for energy management technology and the effect of them in the smart industry.

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