International Journal of Multimedia and Ubiquitous Engineering
Vol.11, No.10 (2016), pp.159-166
http://dx.doi.org/10.14257/ijmue.2016.11.10.15

Internet-of-Things Based Approach for Warehouse Management System

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Abstract

From information revolution to ubiquitous revolution, IT (information technology) has prospered influencing the life of human and general industries. The transition from production management system in the early days to SCM today in logistics is mostly attributed to IT. In terms of WMS, from the initial production management system to the current system, massive amounts of IT have been applied to its use. Hence, this thesis presents a new type of logistics tracking and inventory management system that is able to track back the location of each commodity applying IoT (Internet of Things), known to be a current trend of IT, to utilize location-based information. The presented system also has capability to supervise the condition of commodity and real-time cargo shifting, applying environmental information gathered in inventory.

***Keywords**: Internet-of-Things, Warehouse Management System, Arduino*

1. Introduction

WMS (Warehouse Management System) is a process that includes inbounds of commodity, storage, loading and unloading, and finally outbound, not for simple storage and handling manufactures, but for a smoother progress in inventories or in-betweens. WMS has expanded its range to more than a simple storage/inventory management through SCM (Supply Chain Management), and it is considered as a representative technique. Despite this fact, various issues exist in WMS, such as the lack of basic information for first-in-first-out, inaccuracy of inventory information, difficulties in figuring out the balance location, inefficiency in terms of space in warehouse, miscarriage when releasing, difficulties in checking out-of-stock before the release, and the inability to have actual inspections on commodity [1].

Barcode or RFID system has been in use. The barcode system had weaknesses such as needing a scanner, being vulnerable to contamination, limitation of storing information leading to inability to provide various kinds of information, and being easily damaged, which makes it hard to scan the information. RFIP followed up by compensating some defects of the barcode system with the characteristics of inaccessibility, however, it has been frequently reported from the field that it occasionally is unable to read tags that are overlapped with manual records for inventory caused by intervention of metal [2]. Thus, this article forges an idealized inventory management system aiming for the construction and application of real-time storage management system that utilizes IoT through an analysis on changes of pro and post IoT technology application in SCM environment. The referred system has high-efficiency in storage management that occurs efficient inventory management, decrease of workload, stock reduction, and miscarriage prevention, based on data accumulated and analyzed in real-time. Not only able to bring the aforementioned, but also the system has a purpose to maximize the company’s profit

ISSN: 1975-0080 IJMUE

securing competitiveness in market caused by phasing in an increase in customer service to bring in a shorter work hour, cost cutting, and drops in errors about.

2. Related Work

2.1. Information Technology and WMS

The transformation in human life and industries since the emergence of IT in the 1950s is beyond the transition that needed multiple thousands of years to happen. WMS has also transformed itself whenever there is a new IT appearance. In the 1970s, MRP's main purpose was to eliminate inefficient application or waste of enterprise resource based on information such as material requirement planning, BOM (Bill of Material), request sheet, MPS (Master Production Schedule), and inventory record. MRPII (Manufacturing Resource Planning II), which appeared in the 1980s, is an expanded version of MRP, capable of not only managing the materials but also an efficient management of all the resources needed for the production. MRPII can be referred to as MRP that has added functions such as collecting data of automated process, order management, financial management, and sales management to suggest a feasible production plan as a manufacture activating system. However, MRP and MRPII are criticized to be unsatisfactory on account of insufficient communication and IT resource.

Yet, with the realization of PC communication and Internet/mobile Internet as of the 1990s, inventory management through ERP has been generalized and since the appearance of smart gadgets, SCM has been materialized. Barcode and RPID technology have provided speed in information gathering, putting storage management on a different level.

Today's WMS (Warehouse Management System) is the core element of SCM, and a system that facilitates superb inventory management and warehouse operation by thoroughly tracking and regulating stock trends in warehouse, and a system that has both network technology and automated information gathering technology have been combined and blended in.

2.2. Internet-of-things (IOT)

2.2.1. Definition of IoT

IoT, a concept of connecting things wherever and whenever, is a technological revolution to take off for future computing and communication. IoT is on an evolved level from the Internet/mobile Internet build on wireless communication, having either a tangible or intangible platform that is able to trade data communications and information autonomously without relying on humans but things connected to the Internet interact and handle information by themselves. Also, each thing has its own identity and can distinguish each other that it transmits others through network and receives data to process by computing skills [3-4].

IoT is a computing paradigm that is changing business models, technology investment, consumer environment, and even daily life. It is also a network built on the Internet that consists of actual things such as nanotechnology, home appliances, all sorts of sensors, embedded systems, and personal mobile gadgets. To realize IoT, supporting with network technology and communication technology such as IPv6, web service, RFID and 4G network is also included in Internet of Things. According to the prediction of the industry, there will be some 50 billion of gadgets that are going to be connected by 2020, and the figure is 10 times bigger than the current one that includes the number of all the smartphones connected [5]. Humans are virtually using IoT solutions with their mobile gadgets already. In-house safety, lighting, A/C and heating conditions are monitored on the screens of smartphones, and there is also a refrigerator that monitors its functional condition and reports through smart gadgets.

2.2.2. IoT in Logistics

The estimated profit coming from IoT is 8 trillion dollars. Among this, supply chain and logistics field is expected to bring a ripple effect that corresponds to 1.9 trillion dollars [6]. If IoT applies to logistics business in the future, innovative distribution operation systems in 4 parts, which are efficiency and stability of logistics operation, security, clients' experience, a new business model, are going to be in prospect.

Warehouse is responsible of the flow of goods in supply chain. Providing customers with a faster, cost-efficient, more flexible and smoother inventory management process compared to competitors itself can be one's competitiveness. For this reason, a number of logistics companies are trying to occupy the market applying IoT, the new technology, on their inventory management operation.

CJ Daehan Logistics is applying 3D visibility system on their distribution center. This system allows customers to watch three-dimensional goods through screens. With help from RFIP chips that are in every cell of each rack in the warehouse, it also automatically messages signals with the central system then figures out the information of the goods in cells in real-time, and creates a three-dimensional figure on the touchscreen with the information given [7]

FedEx presented Senseaware, an informational platform that figures out the flow of delivery. This system has an electronic tag on a package to obtain environmental information and to forward the information in real-time. Not only can it deliver the location of the package, but also delivery environment such as the temperature, humidity, pressure, while it also checks whether what is contained is exposed to the sun or not [8].

DHL has also applied IoT as a skill in dominating the market by trying to apply IoT to various parts such as inventory management, air freight shipping, and Last-mile shipping options [6].

Hence, this article designs a new process analyzing the elementary process of inventory management and realizing the process that IoT is able to apply to.

3. Analysis of WMS Process

Figure 1 represents the general inventory management process. It studies the methods of business process of each stage and checks for drawbacks.

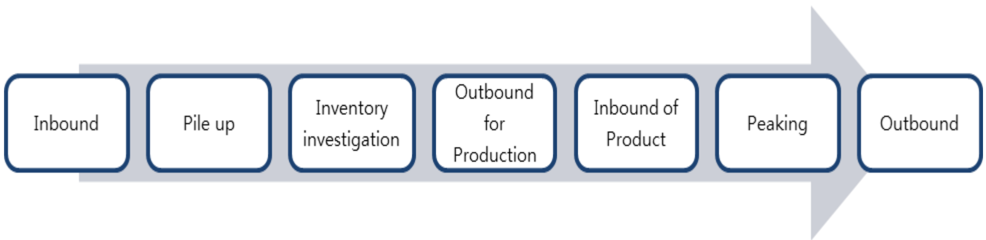


Figure 1. WMS Process

Inbound check is a process that inspects the incoming stock list when a lorry load of incoming stocks arrives at a warehouse. Pile-up is the step to pile up the inspected stocks to a designated location and to record confirmed contents on WMS. The progress of stocktaking takes quite a long time and takes many workers to check and compare every one of stocks to the stock list, and human errors are occasionally made during the progress. Production release is the stage wherein allocated stocks are inspected during allocation, as written on the release list. Production storage is the stage where production-completed stocks are inspected and are compared to the storage list when the stocks are put on. At Manufacture pickup, products are inspected during actually picking up the released stocks on the pickup list that is being released on schedule. Stocks that went through the manufacture pickup stage are again inspected before load, then are loaded, to be released.

Inventory management using barcodes not only takes up a long time, but is also inefficient because of scanning every barcode on each stage of incoming stock inspection, pile-up, stocktaking, production release, production storage, manufacture pickup, inspection on picked-up products and the final inspection before load.

In the case of using RFID, it can be time-efficient because it automatically gathers stock information, however, it can drop a few tags in terms of technological problems or operational problems that can cause trouble in the progress of inspections, material pile-up, or stocktaking. Thus, a new design of inventory management system is needed to solve the problems through a warehouse design that deeply considers the environment of the interior, monitoring the location and condition information in real-time to prevent dark asset and to be more efficient.

4. Implementation of WMS sing IoT

4.1. Systematic Architecture

Figure 2 shows the interior environment of warehouse that IoT is applied on. The interior IoT system uses Arduino platform. The system consists of two sub-systems. One is installed on palettes in a warehouse or on a forklift, while the other is installed on racks or cells that products are stored in. Figure 3 indicates the formation of the two sub-systems.

Products with RFID tags are generally delivered to companies that operate a combined SCM. With this assumption, the role of IoT node is defined as it is in Figure 4.

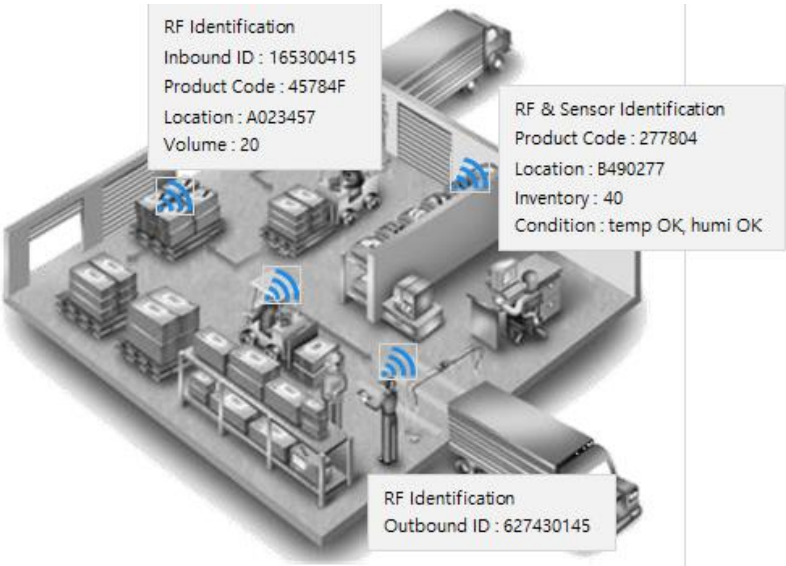
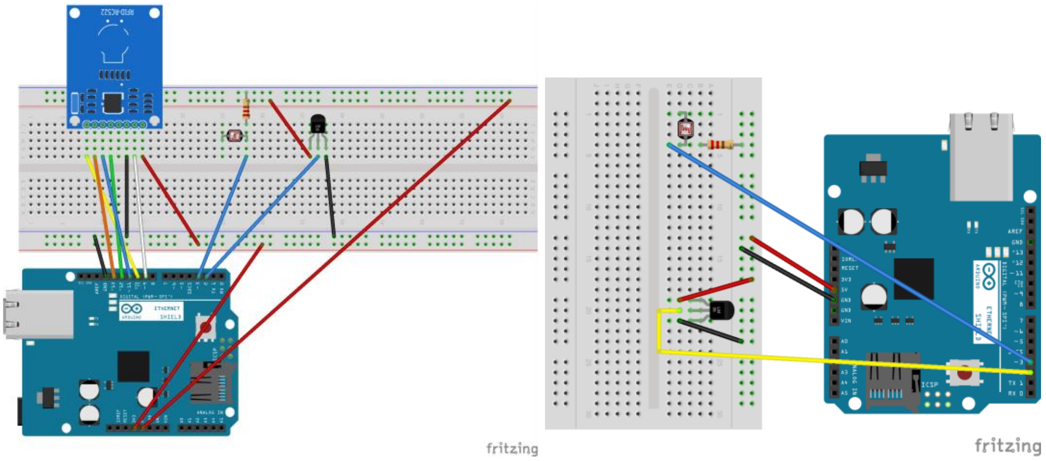


Figure 2. IoT WMS



(a) Type 1 (b) Type 2

Figure 3. Two Kinds of Iot Node Hardware Components

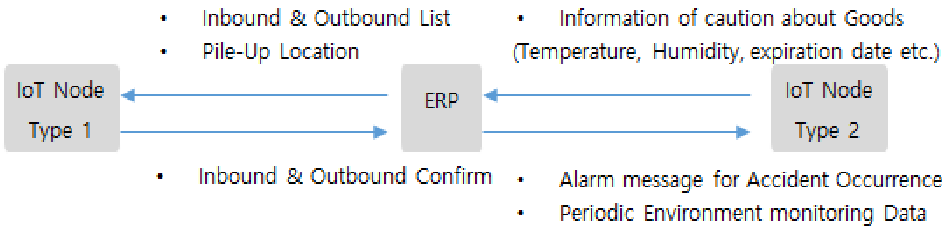


Figure 4. Data Exchange within Systems

4.2. System Implementation

Figure 5 is the screen embodiment of IoT WMS. The screen in the beginning is the inbound check process that is transmitted with the basic information that ERP, the host system of WMS, sends. When IoT node automatically recognizes the conditions of the inbound, designated information and the service date of inbound are transmitted to ERP, which completes the inbound work. Outbound process is similar to the inbound process.

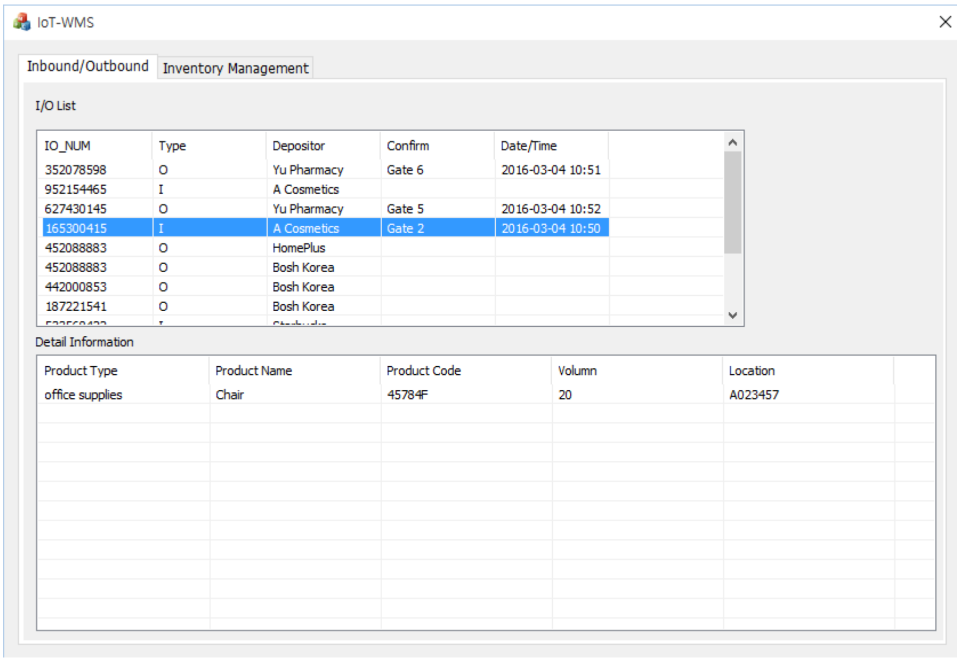


Figure 5. Inbound/Outbound Management

Figure 6 is the present stock condition screen of IoT WMS. Through information gathering in real-time, responsible workers are able to check the stock condition frequently, and if problems are spotted in the information of condition, stocks can keep the best condition through an alarm function.

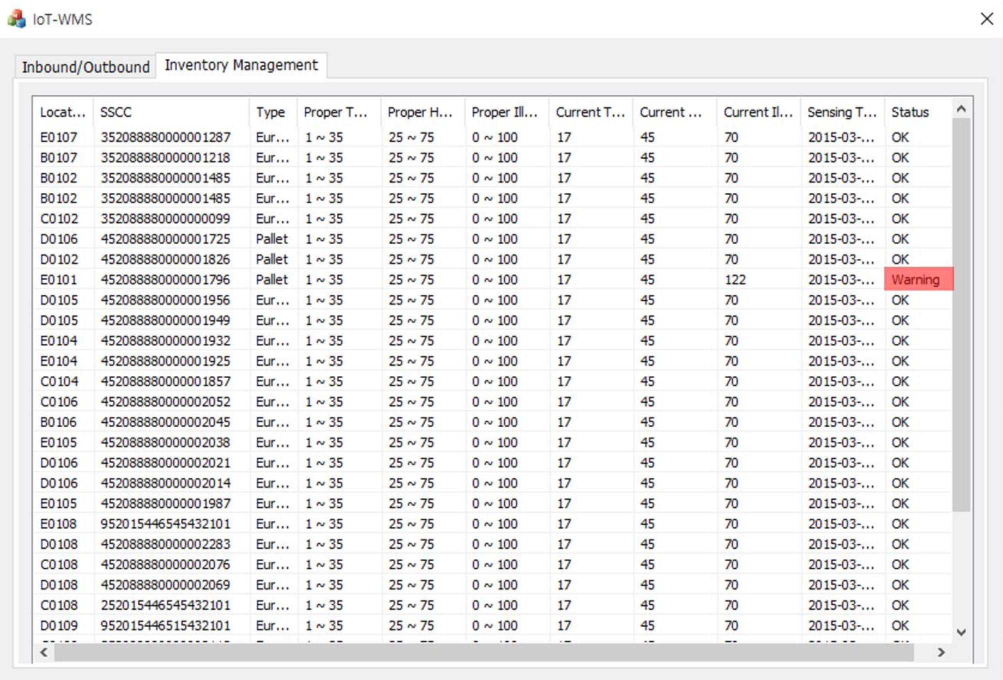


Figure 6. Environment Monitoring

5. Conclusion

IoT WMS is an inventory management system that stems from SCM operation and is built focusing on the flow of materials and products in warehouse. The constructed system is capable of more safely managing products by real-time monitoring of material warehousing, material release, from stocktaking to stock release, and by information gathering of the product's location, tracking, surrounding environment. Also by swiftly and accurately completing real-time management and inspection of stock, advantages of cost-efficiency, decrease of the cost of stock, time-efficiency on work, accuracy of stock, decrease of the rate of error, reduction of labor cost, and ultimately an improvement in customer service and trust will be brought in.

Acknowledgments

This Research was supported by the Tongmyong University Research Grants 2016(2016F036).

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