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Design of Warehouse Management System Using IPS under Bluetooth Environment

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Abstract

Convergence of manufacturing industry and ICT becomes a new competence and it is also regarded as revolution of production method. At the warehouse, monitoring information of the job order and completion is needed for the judgement of the process whether it has any problems or none. For this kind of action, database system that can interrelate material information and job order information should be adapted. Thus, the author suggest the warehouse management system using IPS(Indoor Positioning System) under Bluetooth environment. This system can make material management, job control management and location management using Tag information. It can also be utilized in existing warehouse.

Keywords*: Warehouse Management System, Indoor Positioning System, Logistics Tracking System, Bluetooth, Beacon*

1. Introduction

Recently, manufacturing industries are expected to be optimized as the equipment and manufacturing processes are connected thru network by converging with ICT. The trends of factories are going to change as smart factories that control manufacturing process and manage field repair and safety. Smart Factory can optimize the process and upgrade the flexibility and performance of full manufacturing process as new paradigmatic area. Smart Factory can make smart production by integration of manufacturing process, procurement, distribution and service by itself. Therefore, it can also make various kinds of production and mass amount of production. This Smart Factory is expected to lead new industrial paradigm by its direction guidance of factory automation, next generation IT technology.

Nowadays, logistics industry needs systematic management by and large, *i.e*., from the procurement of raw materials to manufacturing and sales, all of the processes should be changed efficiently. In other words, as the trends are going to multiple low-volume, ICT convergence have emerged, internal material management system become more important and especially, systematic material management system that can solve each of problem occurring during a job process is very important.

Warehouse management system monitors the job order information (stock time, stock route, stock completion time, stock status) and it shows status whether the job is completed or not and also shows the information that could go wrong.

For these kinds of work, the database system that can fetch product information is needed in addition to the warehouse management system that can find out the location and status of the product that should be constructed with proper communication system.

Thus, the authors suggested warehouse management system using IPS under Bluetooth environment.

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2. Design of Warehouse Management System

2.1. Structure of Warehouse Management System

Structure of the Warehouse Management System using IPS is as follows.

- WMS(Warehouse Management System) Tag: Bluetooth beacon device that transfers the product information with a Tag attached on that product
- WMS(Warehouse Management System) Receiver: Repeater that trace the position of moving path and stock location of warehouse rack
- WMS(Warehouse Management System) Gateway: Does the function as the power supply of warehouse rack repeater and Wi-Fi gateway
- Integrated software and database server: Information management and monitoring of Warehouse Management System

2.2. WMS Tag

Figure 1 shows WMS Tag that is attached on the product or box. Velcro B side should be attached on the product, and then construct Velcro A side that can be attached on the box or detached easily from box. After production Tag information is registered and attached. In case delivery is finished, Tag is initialized. Hall sensor is embedded inside the Tag, and it recognizes the magnet of Velcro B side. This means the sensor can recognize the status of the Tag whether it is attached or not. In case of attachment, it transmits the information of the product and initializes the information in case of detachment automatically. Through recognition of Tag movement, it can find out the movement of product.

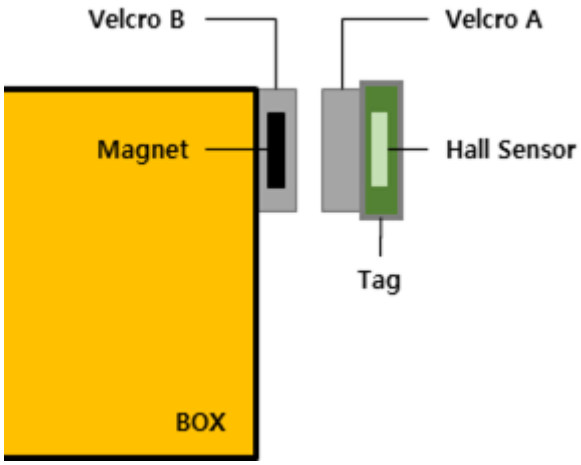

Figure 1. WMS Tag

Describing more detail, 3 axis acceleration sensors that are embedded inside the Tag recognize the status of Tag movement. If value of (x, y, z) axis have changed, then it recognizes the Tag is moving.

ADVERTISING_MODE is executed in case of moving status because it is the situation of product movement tracking. On the contrary, if there's no movement, then shutdown the ADVERTISING_MODE to reduce consumption of the battery power.

Figure 2 shows module diagram of WMS Tag. It is composed of NRF51-M0 Bluetooth BLE module, 3 axis Acceleration sensor linked with GPIO, 3.3V DC Converter module for the driving battery and charging circuit, LED to confirm charging status, and USB Connecter module to connect with USB of Client PC, Hall sensor to recognize the Tag attachment, LED and reset button to find out operation mode of WMS Tag.

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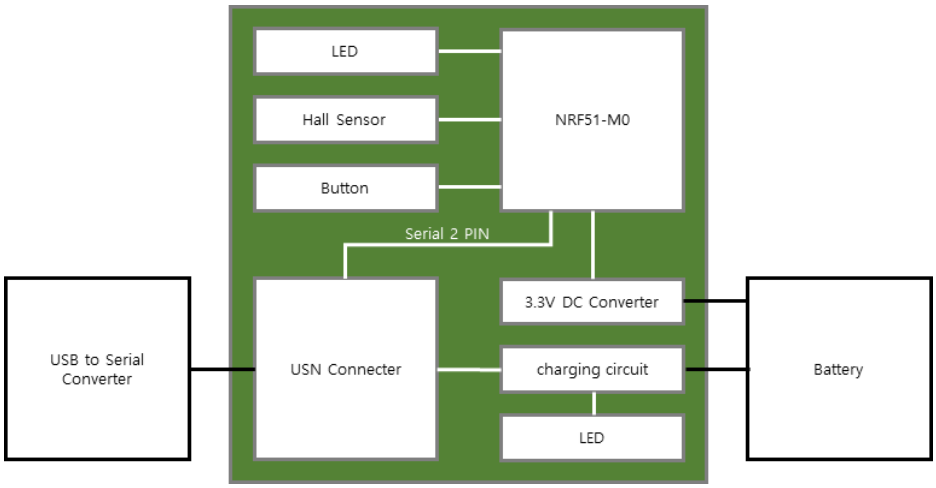

Figure 2. WMS Tag Module Structure

2.3. WMS Receiver

WMS Receiver uses Bluetooth and Wi-Fi for the communication with server and IOT and an LCD module to check the amount of stock is built in it. WMS Receiver inform the location of terminal that is installed on product rack by output and tracking the stock amount and delivery amount on the LCD.

For the tracking of moving path, RSSI (Received Signal Strength Indication) of beacon information is utilized. When Tag does not move, it recognizes the receiving signal halted and also recognizes the halted position or stocked position based on the last position of receiving terminal.

WMS Receiver is divided into two types WMS Receiver(C), WMS Receiver(R) depending on the usages and the module structures are shown in Figure 3, 4.

WMS Receiver(C) is a receiver for beacon signal relay of WMS Tag that is installed on the route for the tracking of moving path. This WMS Receiver transmits beacon signal of WMS Tag to server thru Wi-Fi.

WMS Receiver(C) is composed of LED to check operation status, USB Connecter to give device ID, Button to reset device, USB port, and LDO set for the power supply of 220V or 3.3V.

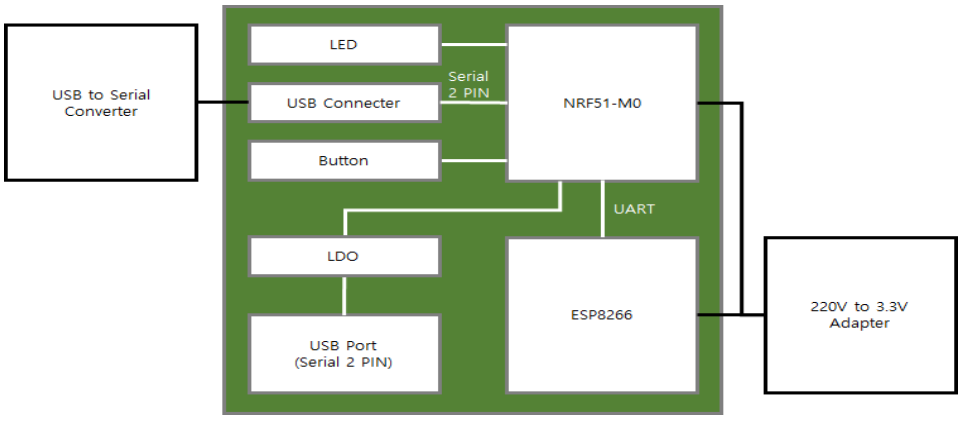

Figure 3. WMS Receiver(C) Modules

WMS Receiver(R) is used for tracking stock location of product as a rack receiver that is installed in each warehouse rack. The module structures are shown in Figure 4. It is connected with WMS Receiver(R) as N:1 thru I2C. It also transmits beacon signal of S-

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WMS Tag to S-WMS Gateway and then transmits to server thru Wi-Fi from the gateway. WMS Receiver(R) is composed of LED to check operation status, Button to reset device, and OLED to inform stock status and delivery status.

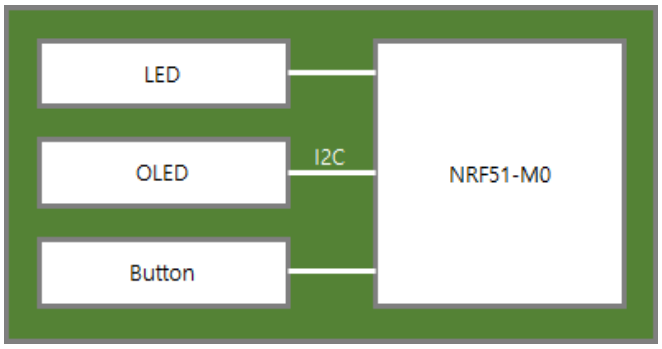

Figure 4. WMS Receiver(R) Modules

2.4. WMS Gateway

WMS Gateway is installed on each rack. It relays beacon signal from each WMS receiver to server. WMS Gateway is composed of ESP8266 Wi-Fi module to transmit Wi-Fi, 3.3V SMPS to allow the electric power of 220V, LED to check operation status, Button to reset device, and USB Connecter to give gateway ID.

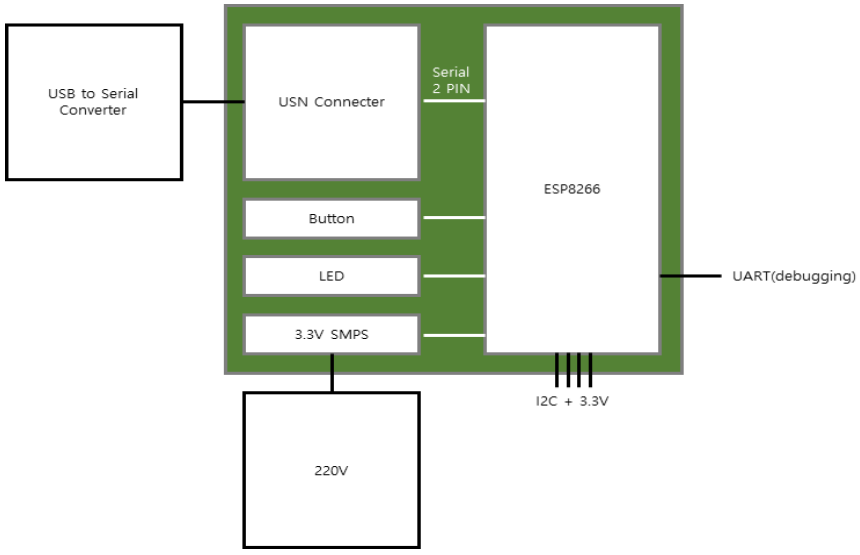

Figure 5. WMS Gateway

3. Design of Location Tracking Algorithm

Figure 6 shows the Tag tracking example of moving path. When one Tag is connected to 3 terminals, the signal strength of each receiving terminal has different value. The strongest signal is measured at nearest receiving terminal-1, but the weakest signal is measured at far most receiving terminal-3

If Tag is moving to receive terminal-3 then signal strength of receiving terminal-1 and receiving terminal-2 is decreased depending on the moving direction while signal strength of receiving terminal-3 is increased. Tracking of product moving path algorithm can be implemented based on these phenomenon.

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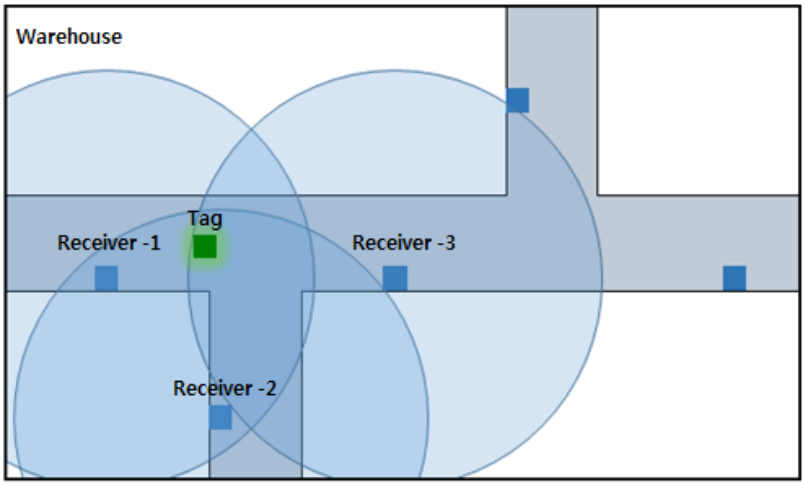

Figure 6. Example for the Tracking of Moving Path

Figure 7 shows the tracking example of Tag stock location. If the Tag is attached on the product, finish the movement and position it on the rack in stock place, it is positioned on the receiving terminal that receives the strongest signal at the last time and not receiving anymore. Beacon signal receiving strength is so sensitive depending on distance, and nearest beacon is received as highest the signal strength.

As shown in figure, if 'Tag-1'is stocked after movement, RSSI of Tag-1 that can receive signal from all near receiving terminals and located in nearest position can be measured as the highest value.

Thus, using this method, it registers the product after tracking the rack.

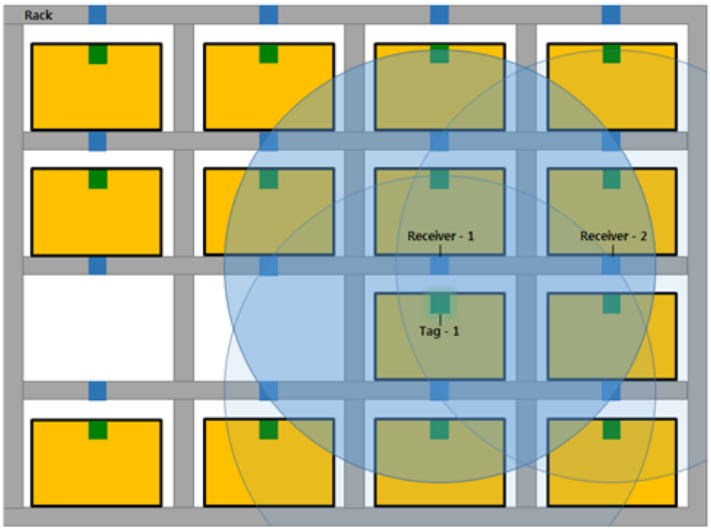

Figure 7. Tracking Example of Tag Stock Location

Based on moving path and location tracking scenario, the authors designed a location tracking algorithm under Bluetooth 4.0 environment as shown in Figure 8.

1) WMS Server manages all the WMS Tag information that is transmitted thru WMS Receiver.

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2) Set the location tracking counter when A-Data (Advertising-Data) of new WMS Tag is received.

3) Store in list until the received A-Data of WMS Tag becomes 10 or more, because the received beacon signal is sent to the server every 1 second, thus, current location of WMS Tag is updated every 10 seconds.

4) If 10 A-Data is stored, fetch WMS Receiver that transmits the highest RSSI signal strength among list.

5) Assort receiver type of extracted WMS Receiver.

5-1) If receiver type of WMS Receiver is C (Course), then assort receiver type that has former location of WMS Tag.

5-1-1) If receiver type of former location is C (Course) then update the moving path of WMS Tag from past receiver to current receiver and delete the list catalog.

5-1-2) If receiver type of former location is R(Rack), then compare with WMS Tag of delivery job order and transmit delivery start event in that case.

5-2) If receiver type of S-WMS Receiver is R (Rack), then store the corresponding receiver ID and wait for 1 minute.

5-2-1) Continue the location tracking if there is additional receiving within 1 minute.

5-2-2) Transmit the event that stocked in final receiver location if there is no additional receiving within 1 minute.

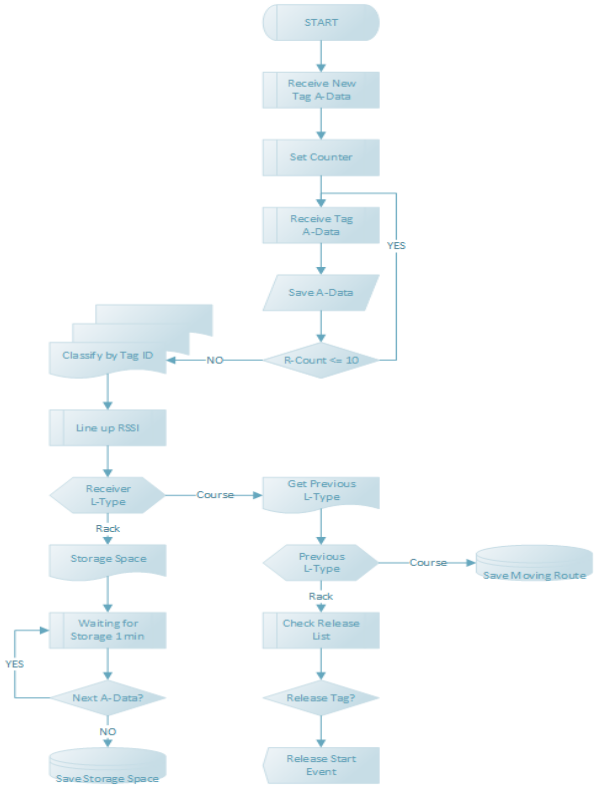

Figure 8. Location Tracking Algorithm under Bluetooth 4.0 Environment

4. Conclusion

For the efficient material warehouse, the authors suggested a warehouse management system that IPS is utilized under Bluetooth environment. The suggested system was designed and focused on the stock time, delivery time and tracking of moving path of product.

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This warehouse management system consists of several devices and software such as WMS Tag that transmits material information system, WMS Receiver that keeps track of the location, and WMS gateway that has the role of power supply and Wi-Fi.

Gateway and information management system so called Integrated Program and server is a system that can make stock control using Tag information, location tracking of product using Tag and Receiver. This system also has flexibility as it can be adapted by the installation of only a few devices such as Receiver, gateway, and Tag, thus, information about rack and product can be changed easily.

It is also expected to be highly utilized as it can be easily applied to the current logistics environment.

Acknowledgements

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