Wireless Sensor Network for Monitoring Water Factory

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***Abstract*— Wireless sensor network (WSN) is widely applied in industrial field for monitoring conditions of machines or number of products. This paper presents the WSN system for monitoring product line of water factory. We designed and demonstrated the sensor nodes with photo sensor, and other instrumentation device with a serial interface. Sensor nodes and gateway are communicated with wireless signal in 2.4 GHz ISM band according to the schedule of sending time. As the results show that, maximum packet error rate is measured approximately 5 %. To reduce the risk of data loss due to electromagnetic interferences from machines, sensor node periodically sent the packet data in 200 msec intervals, also sending data implies the accumulation value of measurements.**

Keywords-Wireless sensor network;Sensor node;Monitoring system.

I. INTRODUCTION

Accurate information of factory operation state has been one of the main issues in industrial field. Due to machine deterioration or unknown environmental changes in factory, defective products are produced at several points of production line. Therefore, number of end products are different even if same amount of materials are injected. To monitor and manage the amount of materials and products, manufacturing standards, such as Industry 4.0 has been developed [1]. However, those standards define design principles of machine, it is not able to upgrade machines that have been worked in the factory. Additional installation of monitoring system is one of the methods for measuring real-time state of product line in factory. This system consists of several sensors and a main computer to collect sensor data. Real-time monitoring information of several points of product line is able to improve factory management and quality of products.

In this paper, we designed and demonstrated WSN for monitoring products manufactured each process of water factory. WSN has advantages of cost and installation due to the reduction of wiring construction [2][3]. Our proposed system performed real-time monitoring and data management. Fig. 1 shows the process of water factory. Product line is composed of three steps: bottle manufacture, water filling and release. Bottle manufacture is the process that manufactures the polyethylene terephthalate (PET) bottle from PET resin. Next, bottle is filled with water and labeled. Finally, bottles are shrink-wrapping and they are released by the form of pallet. The role of wireless sensor node is that measures the weight of PET resin, PET preforms, bottles and pallet of bottles.

This paper is organized as follows: In Section 2, we describes the components of WSN system. In Section 3, we presents actual system installed in factory and results of demonstration. Finally, we conclude the proposed system in Section 4.

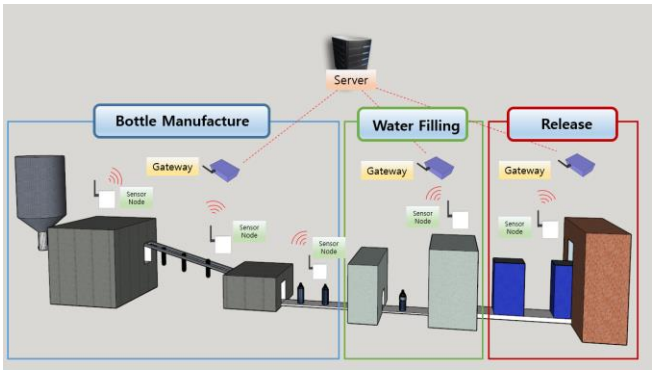

Figure 1. Schematics of manufacturing process in water factory.

II. SYSTEM ARCHITECTURE

WSN system includes sensor nodes, gateways and server. Fig. 2 shows the designed sensor node and gateway of the system. Sensor node consists of two microcontroller (MCU) MSP430F5438 manufactured by Texas Instruments (TI) for stable operation. One MCU manages sent and received packets and controls a wireless transceiver module. In this system, 2.4 GHz ISM band is used for wireless communication. Wireless transceiver module is selected CC2520 and CC2590 range extender manufactured by TI to improve the link quality. Another MCU manages sensors or external components, which include serial interfaces, such as RS-232 or universal asynchronous receiver/transmitter (UART). Sensor node periodically generates packet data, then sensor node send the data to gateway. Gateway controls the operation of sensor nodes and gather measurement data from sensor nodes. Gateway consists of wireless communication module and Ethernet port for communicate with sensor nodes and server, respectively. Measurement data sent from sensor node finally reaches to server passing through the gateway.

Sensor nodes and gateway are wireless communicate based on time division multiple access (TDMA) method. TDMA has an advantage of periodically data transmission without carrier sensing. Sensor node operates according to the time schedule of superframe and send packet to gateway in assigned time slot. To prevent the risk of packet loss due

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to wireless environment of factory, sensor node tries to resend the packet at its time slot when no acknowledgment packet sent from gateway is received within a certain period of time. Also, packet included the accumulated values of measurement data and send every cycle while measurement data is not changed.

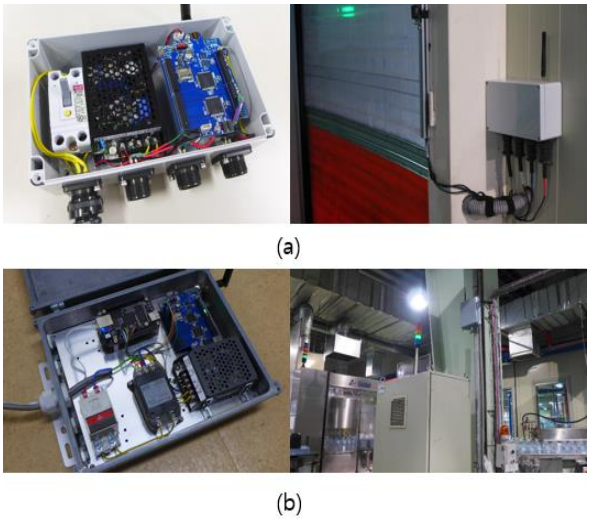

Figure 2. HW designs and installation locations of (a) sensor node and (b) gateway.

III. EVALUATION

The demonstration was implemented in a working water factory. In this demonstration, sensor node counted several number of targets that were produced in product line. Targets and methods of counting each target are described below.

- The amount of PET resin is measured using the crane scale tool supported the RS-232 interface
- Bottle Preforms are counted using photo sensor.
- Bottles filled with water are counted using photo sensor.
- Pallets of bottles are counted using photo sensor

Each sensor node continuously measured the targets and periodically sent measurement data to gateway. Sensor node and gateway were installed shown in Fig. 3. A total number of four gateways were installed in product line and distance between gateway and sensor node was under 50 m.

Packet sent from sensor nodes were displayed shown in Fig. 4. Packet contains measurement data and time tick. As the results of demonstration, maximum packet error rates between sensor nodes and gateway was approximately 5 %. However, sensor node sent packet every 200 msec, undelivered data possibly sent to gateway next period or within 1 sec.

IV. CONCLUSION

We designed wireless sensor nodes with several sensors and gateway and implemented in water factory for improving factory management. Sensor nodes operate the sensors to measure amount of PET resin, number of bottle preforms, bottles and pallets of bottles. Demonstration result shows that collected data sent from sensor nodes is successfully sent to server passing through the gateway.

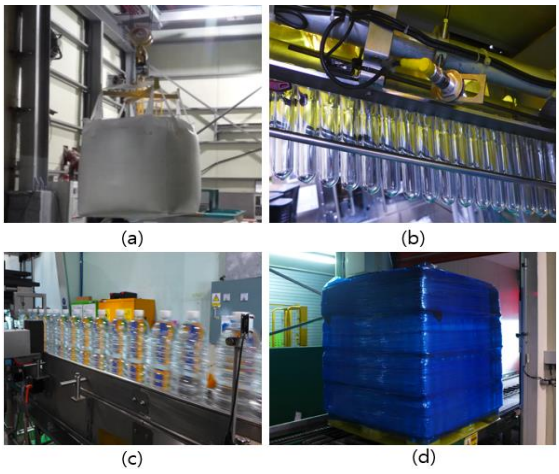

Figure 3. Targets for monitoring by sensor nodes; (a) PET resin, (b) bottle preforms, (c) bottles and (d) pallets of bottles.

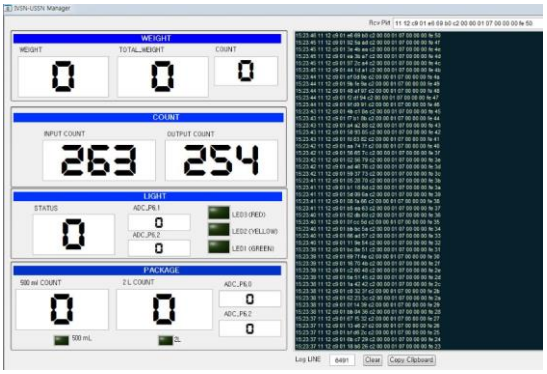

Figure 4. Log data sent from sensor nodes.

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