

A Construction of An Intelligent Industry Network through Wireless Sensor Network

Yeo-hong Yun, Kwang-il Hwang, Woo-young Han, Doo-seop Eom
Dept. of Electrical and Computer Eng., Korea University
yeo2020@final.korea.ac.kr

Abstract

In industry areas, a lot of factories and process plants need network for processing data acquired from field and for communicating between sensors or actuators or field controllers. Most of the industry networks are based on wired solutions. But, recently, a lot of factories and process plants are moving into wireless solutions since they have some advantages compared with wired one. In this paper we first review the characteristics of wired and wireless network technologies and introduce the new technique called wireless sensor network (WSN). And then we describe the wireless sensor node system designed by us for WSN which has the ability of small size, flexibility and low-power consumption and embedded into the Bar-code scanner to communicate each other. Finally, we conclude this paper by showing that wireless industry network can be constructed with wireless sensor network without large change of traditional wired topologies through experiment using wireless sensor nodes.

I. Introduction

In industry areas, network is absolutely needed to process the data gained from fields and monitor the status of the fields. But, the communication technique is originally developed not for multi-node communication but for point to point communication and a number of topologies and user-specific protocols existed diversely. To unify them, many techniques, such as Modbus [2], Field Bus [3], Profi-Bus [4], IEEE1394 [5], and etc, have been appeared and applied to industry areas.

However, the growth and cost down of wireless

technology accelerated a need of wireless solution to support mobility and flexibility of sensor nodes in industry network. In recent years, to reduce installation cost and decrease amount of cables, wireless techniques, such as wireless LAN, a Mobile Ad hoc Network (MANET) and BLUETOOTH [1], are partly being used for industry network.

But, we especially propose to apply not the above techniques but the new technique called Wireless Sensor Network for industry network, since industry fields consist of a lot of sensors and actuators and they are densely deployed and cooperatively operated.

Accordingly, in this paper we introduce wireless sensor network with which distributed and cooperative industry network can be achieved, and present how to apply to wireless sensor network into industry network and then our sensor node for the industry sensor network is introduced.

II. Traditional Industry Network Technologies.

2.1 Wired industry network

For early days, the factories and process plants were trying to create a Modbus, Field Bus, Profi-Bus, IEEE1394 and etc. The Factory and process plants needed the techniques to acquire data from fields and to communicate between the server and field controller. The techniques would use copper twisted pair as the physical medium; the need for cable screening would depend on the surrounding environment. The techniques are for unifying a number of topologies and user-specific protocols existed diversely. They also adapted Ethernet (IEEE802.2) as well as RS-232 and RS-485 for the physical

layer.

Modbus is communication protocol of Modicon controllers. This protocol defines a message structure that controllers will recognize and use, regardless of the type of networks over which they communicate. It describes the process a controller uses to request access to another device, how it will respond to requests from the other devices, and how errors will be detected and reported. It establishes a common format for the layout and contents of message fields [2].

Field Bus is a communication system which is expressly designed for process control and especially concerning the 'real-time' constraints of physically or chemically dynamic systems [3].

Profi-bus was recently considered as one of the Fieldbus solutions of the General-Purpose Fieldbus Communication System European Standard, EN 50170. The Profi-bus MAC mechanism is based on a token-passing procedure used by master stations to grant the bus access to each one of them, and a master-slave procedure used by master stations to communicate with slave stations [4].

The IEEE1394 architecture standard defines a high performance serial multimedia bus that allows several components in a network to communicate with each other at high speed. In the physical layer of the architecture, a leader election protocol is used to find a spanning tree with a unique root in the network topology. If there is a cycle in the network, the protocol treats this as an error situation [5].

In recent year, as a number of sensor devices, thermometer, manometer, seismic sensor, light detector, microphone, or chemical and biological sensors, are developed, deployment of a variety of sensors in an industry area became possible. Accordingly, for industry automation, data acquisition, and monitoring in field, a technique to communicate between sensors or actuators and server is needed and therefore sensor network to communicate between them appeared.

2.2 Wireless industry network

Also, the growth and cost down of wireless technology accelerated a need of wireless solution for industry network. There are some advantages of the wireless approaches to wired techniques for sensor network. The first is greatly reduced installation cost. The wired on-line system requires the

expensive installation of cables and in many of cases conduit to every sensors. The second is decrease of amount of cables. Cables are costly to maintain, are vulnerable to damages and need to removed and re-run whenever equipment needs moving, replacement or maintenance.

Wireless communications has evolved to the point where it is universally accepted as well as expected, wireless communications is not only for those who require mission critical communications but those who have a desire as well as a requirement to be reached at any time and any place that they choose [6].

We shortly review the following techniques for wireless industry network since wireless networking solutions to make wireless sensor network is needed.

A Mobile Ad hoc Network (MANET) is an autonomous system of nodes (MSs) connected by wireless links. A MANET does not necessarily need support from any existing network infrastructure like an Internet gateway or other fixed stations. The network's wireless topology may dynamically change in an unpredictable manner since nodes are free to move. Information is transmitted in a store-and forward manner using multi hop routing [1].

BLUETOOTH wireless technology enables links between mobile computers, mobile phones, portable handheld devices, and connectivity to the internet. Despite using a frequency hopping scheme, BLUETOOTH devices experience a drop in throughput due to interference because of WLAN and WPAN operations. A mathematical model has been derived for packet success probability due to interference. The interference in BLUETOOTH networks has been found to be intermittent in nature [1].

According to wireless techniques being developed, the factories and process plants are partly being used for industry network.

III. Wireless Sensor Network (WSN)

Wireless sensor networks have been attracting increasing research interest given the recent advances in miniaturization, low-cost and low-power design. Such networks will consist of a large collection of small wireless, low-power, unattended

sensors and/or actuators. Sensor networks can enable “ smart environments” which can monitor ambient conditions such as temperature, movement, sound, light, location and others. One important feature that distinguishes sensor networks from traditional distributed systems is their need for energy efficiency. Many nodes in the emerging sensor systems will be untethered, having only finite energy reserves from a battery. The requirement for energy-efficiency pervades all aspects of the system design. Another important feature is their unattended and ad hoc nature. Because of their compact form factor and potential low cost, nodes might be autonomously deployed in an unplanned fashion. The working environment for those sensor nodes might be unpredictable and thus affect the performance of the network dramatically [7].

The sensor is a major medium to connect real (physical) world to electronic world. As electrical device industry is developed, deployment of innumerable sensor in anywhere in the world became possible. Also, communication among the sensors or network to connect sensor to central device is needed. Moreover, it is important to have continuously updated information about network resources and application activities in a wireless sensor network after it is deployed in an unpredictable environment. Such information can help notify users of resource depletion or abnormal activities [7].

The main goal in conventional wireless network is providing high QoS and high bandwidth efficiency. But, for a sensor network, the main interest is conserving energy. Because of the above reasons, the traditional techniques of the conventional wireless networks are not fitted.

IV. Applying WSN into industry network

4.1 Industry network through WSN

Fig.1 shows the architecture of industry network including wireless sensor nodes. The sensor nodes can simply replace the traditional serial line physical interface as wireless network interface. And those are connected to the traditional Ethernet-based infrastructure through the sensor gateway nodes. As each node can be deployed in everywhere to be placed, status in the industry area can be monitored without the cables. Also, the sensor nodes can be easily embedded in devices that need to

have mobility, such as Bar-code scanners or Dynamic Display Device.

In addition to the fact that the sensor node has to satisfy the above conditions, they also have more severe energy, computation, storage, and bandwidth constraints than other wireless devices. Most of all, the major resource problem in sensor networks is energy, since these are static unattended networks and the nodes cannot be rechargeable by any user.

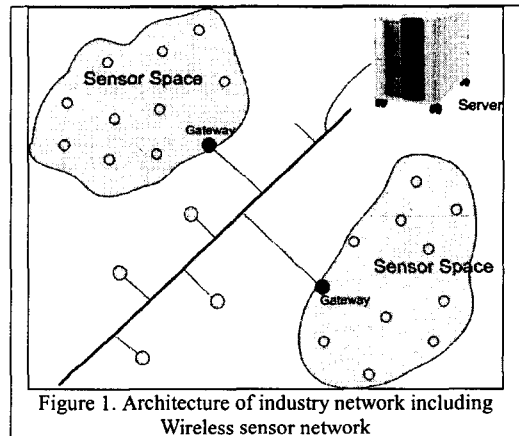


Figure 1. Architecture of industry network including Wireless sensor network

4.2 Experimental System

To design wireless sensor node, the important things are low power consumption, flexibility, and low cost. We have designed and implemented a low cost, low power consumption and flexible node to support those.

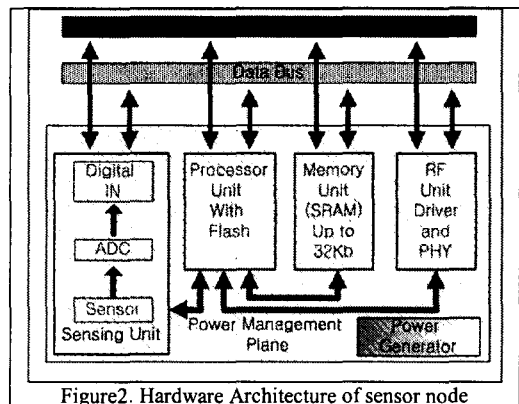
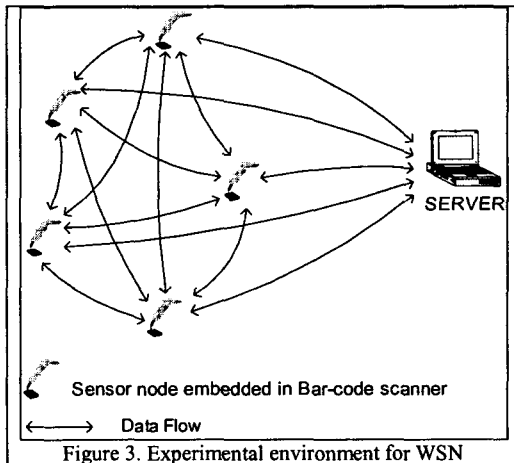


Figure2. Hardware Architecture of sensor node

A node consists of ATMEL 8bit CPU with embedded Flash Memory, 32KB RAM, and Low power short range RF transceiver (RFWAVES) using 2.4GHz ISM band, 1Mbps data

rate and 8Bit Digital input and output for attaching sensor or actuator. As shown in figure 2.

The system which developed by us is made with low-cost. Also, since data generating between CPU and RF module is processed as interrupt, the CPU should not be always run. POWER DOWN MODE and IDLE MODE, which is features of the ATMEL 8bit CPU on our sensor node, can help to control the power consumption efficiently.



We designed a wireless sensor node by embedding our hardware into the Bar-code scanner. And then we deployed wireless sensor nodes and experiment with them. As shown in figure 3. The data received from the wireless Bar-code scanner is transmitted to the other nodes or sever on demand. Moreover, the sensor node can constitute both of distributed and centralized networks. In this experiment, the wireless sensor node can communicate each other and transmit data to the server through multi hop. Server process the data received from nodes and monitors status of nodes. From above experiment, we conformed that wireless industry network can be constructed with wireless sensor network without large change of traditional wired topologies through experiment using wireless sensor nodes.

V. Conclusion

So far, we have described a need for wireless sensor node where sensor nodes deployed densely. We have focused on

power efficiency, not QoS. And then we have introduced sensor node which is developed by us and described how to apply wireless sensor network to the industry areas and how to be operated.

With our sensor node, construction of intelligent industry network through wireless sensor network will be achieved. Also, it will become the way to go to ubiquitous networks.

REFERENCES

- [1] Dharma Parkash Agrawal, Qing-An Zeng, "Intoroduction to wireless and mobile system", Thomson, 2003.
- [2] <http://www.modicon.com/techpubs/toc7.html>
- [3] Kirk, M., "Field bus", Industrial LANs for Management, Design and Manufacture, *IEE Colloquium on* , 30 Oct 1992, Page(s): 8/1 -8/3
- [4] Tovar, E., Vasques, F., "Real-Time Fieldbus Communications Using Profibus Networks", Industrial Electronics, *IEEE Transactions on* , Volume: 46 Issue: 6 , Dec 1999, Page(s): 1241 -1251
- [5] J. Romijn. A timed verification of the ieeec 1394 leader election protocol. *In Proceedings of FMICS'99*, pages 2--29, May.
- [6] Lakhanpal, N.K.; "Market requirements for seamless wireless services", Personal, Indoor and Mobile Radio Communications, 1996. PIMRC'96., *Seventh IEEE International Symposium on* , Volume: 3 , 15-18 Oct 1996, Page(s): 1257 -1261 vol.3
- [7] Yonggang Jerry Zhao, Ramesh Govindan, and Deborah Estrin. "Residual Energy Scan for Monitoring Sensor Networks." *IEEE Wireless Communications and Networking Conference (WCNC'02)*. March 2002.