Wireless Mesh Network in Integrated Web Base Monitoring Systems for Production Line Automation

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Abstract. Industrial automation plays an important role in the manufacturing plant. In this paper a system is being proposed that integrate real time Managerial Control and Data Acquisition System (MCDAS) with 2.45GHz active RFID (radio frequency identification) adopts through wireless mesh network, the ZigBee technology to render the automation system more reliable. MCDAS aims to improve managerial skills by enhancing awareness of emerging technology and related concepts to improve the industrial manager's aspects for more effective monitoring, better communications and corporate integration. In this paper general structure of the technology used and process framework, the web-based monitoring system for industrial automation in selected company are presented in detail.

Keywords: RFID, Mesh Network, Web base monitoring system.

1 Introduction

Internet base monitoring and control system has been introduced in recent years in numerous applications. This technology contributes a lot of beneficial for many areas, not only in the industry, but also in the field of military, education and hospitality. Now a day's famous research work on the Internet based process control has resulted in small-scale demonstrations like Sun Microsystems and Cyberonix, Foxboro, and Valmet. Most of them were developed in Java. Additionally, the OPC (Open Process Control) Foundation is working on supporting XML within Visual Studio so that the Internet based process control using XML is widely used. Intuitive Technology Corporation has provided web@aGlance for feeding real-time data to a Java graphics console [1]. The International Federation of Control (IFAC) has held the first workshop on Internet Based Control Education in Spain in 2002 [1]. The SCADA system funded by the European Council targets Internet based protocols enabling the monitoring and optimization of the process via the web [1]. The objectives of establishing Internet-based process control systems is to enhance rather than replace computer based process control systems by adding an extra Internet-level in the hierarchy [2]. Even though SCADA system is the solution of controlling and managing in wide range of industries, the proposed project holds the promise of replacing the existing controlling system. In fact, the proposed system has the advantages where RFID module is embedded in it and

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it is designed specifically for manufacturing sector. Using technology is not enough without developing managerial, communication and technical abilities. In MCDAS we designed the system that works best to help industrial sector to meet responsibilities.

Implementation of Wireless Mesh Network for monitoring of production output achievement can revolutionize industrial processing and help industries meet the demands of increasing competitiveness. Intelligent ZigBee technology with 2.4GHz Active RFID as wireless network and web-base monitoring in industrial environments enables real-time data sharing throughout a facility and this will increases industrial safety, efficiency, and productivity. This automated monitoring technology offers reliable, autonomous, and improved process control enhancing safety, ameliorating product quality, increasing yield, and reducing costs [3]. In industrial automation, users have realized the benefits of adopting wireless technologies in eliminating the need for cables in hard to reach areas within the plant, increasing data availability and quality and monitoring and controlling that otherwise were inaccessible [4]. Direct interfacing of sensors to the industrial communications network improves the system performance, because process data and diagnostics can be simultaneously available to many systems and also shared on the Web [5]. ZigBee mesh networks consist of low-cost, battery-powered sensor modules and embedded networking intelligence. Furthermore, ZigBee is also a growing technology that will gain more advantage in industrial automation. Hence, in our proposed system ZigBee is integrated with MCDAS to achieve real time automation monitoring and control in industrial manufacturing environment. From our study, integrated Wireless Sensor Network (WSN) with MCDAS is a new level of data acquisition and communication in manufacturing plant that permits finely-tuned remote monitoring. This paper is structured as follows: Section 2 review the related work, section 3 describes characteristics of MCDAS and its application in automated production monitoring. Section 4 gives an overview of system components and highlights the system architecture of the proposed system. Section 5 discusses system design and process flow framework. Finally section 6 gives conclusion.

2 Related Work

Recently, the use of WSN in industrial automation has gained attention. In industrial environments, the coverage area of WSN as well as the reliability of the data may suffer from noise, co-channel interferences, and other interferers. For example, the signal strength may be severely affected by the reflections from the walls (multi-path propagation), interferences from other devices using ISM bands and by the noise generated from the equipments or heavy machinery. In these circumstances, data integrity and availability of operation-critical data on the fly is very crucial. Every part of these issues set a special prominence on automation design and the fact that WSN are technically challenging systems, requiring expertise from several different disciplines. Additionally, requirements for industrial applications are often stricter than in other domains, since the failure may lead to loss of production or even loss of lives [6]. Johan Potgieter et al., [7] proposed Computer Integrated manufacturing (CIM) and Modular Mechatronics for the development of an internet controlled manufacturing environment, which utilizes wireless network technology. The CIM control strategy was developed as a PC-based technology using the modular mechatronics design methodology. According to Hu et al., [8] Internet controlled machines require a high degree of autonomy and local intelligence to deal with the restricted bandwidth and arbitrary transmission delays of the internet, to be successful in real world applications. In order to allow the proposed system to be widely deployed to meet the maximum reliability and flexibility, we explore active RFID in integrated wireless mesh network and MCDAS for communication and monitoring in industrial application. The study shows that both of the hardware and software technology used to develop the complete MCDAS is a new competitive and valuable platform in industrial automation.

3 MCDAS Usability

In this part we explore the capabilities and benefits of MCDAS software system compared to traditional monitoring system in industrial environment applied for 9 line electronic goods production industry, in Seberang Perai Penang, Malaysia as shown in Figure 6. In ordinary monitoring system, it is difficult for the management group to monitor in real time the performance of output due to the information about the output status is just on the paper. In MCDAS the real time information on production output achievement for individual production line not only appear on display counter, moreover the management group can monitor from the LAN (local area network) or where ever have internet coverage. Automated monitoring system able to update the production line activities, not only the number of product has been produced but also can detect the error occurrence during manufacturing. In the same time, data collection is very important and is an expensive business; it should always be remembered that data collection and manipulation is a cost of quality. Therefore MCDAS here has been designed and developed the strategic data collection to increase online revenue by timely, complete and accurate. In this paper, we suggest that it is useful to consider four categories of data source; which is data input from the counter system to the RFID tag by USART communication, data renew from the active RFID tag to the reader, data generated by other users or other subsystem, as for example from planning system and maintenance system and data generated by local use of a remote data source, as for example data from email system, data import and export with the other format.

4 System Components and Architecture

Our proposed system is divided into three main portions. First stage of this system consists of integration of collecting data. In second stage, output from first stage will be transmitted by active RFID tag to RFID reader using Zigbee wireless technology. In this part, it is necessary for the RFID reader to communicate to the real time database server. The last stage is web based monitoring part, where the end user can access the system to view the outputs produced from each line through internet access. By integrating the sensor, counter system, and active RFID to support ZigBee mesh network, the web based monitoring system i.e., MCDAS will be developed, which would be enable to update the details of production line activities.

Figure 1 shows the block diagram for development of proposed system. The hardware elements consist of sensors, counters and active RFID tags. As the input to counter system, a photo sensor is integrated with the counter. At the end of each line, the photo sensor detects the products appear in front of it. The system will send the product count from the sensor to the counter. Each counter system needs to be paired with their individual RFID tags. Universal Asynchronous Receiver/Transmitter (USART) is used as Serial Communication Interface (SCI) to enable communication from counter system to RFID tag. In this development stage we explore the capabilities by embedded RFID tag to the counter system. The circuit is designed to enable RFID tag receive the power from MCU (microcontroller unit). One of the fundamentals obstacles in the RFID system is the power consumption. Clearly with the circuit enhanced capabilities the problem of power in the RFID tag can be eliminate. This RFID tag will update the data to the reader accordingly when the data from counter is renewed. The RFID reader will receive the data from the active RFID tag through Zigbee network. Whilst, the software elements consist of three subsystems: planning subsystem, maintenance subsystem and administrator subsystem.

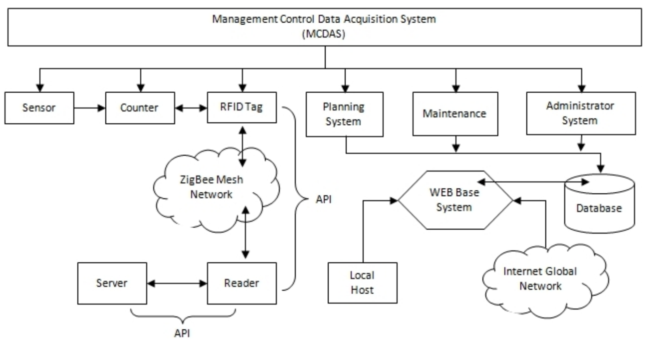

Fig. 1. Development of Hardware and Software System

RFID tags transmit production output data to the reader is through wireless mesh (ZigBee) network. The RFID readers, through wired infrastructure network are connected to the backend database server, which manages the user requirements. The end user can access MCDAS system to view the results produced from the production line accordingly. This accessibility is controlled by management group directly from the administrator subsystem. When designing the architecture for web base monitoring and control system, it is interesting to bring modularity into the design by using layers as entities that can perform different tasks. So each layer can perform its own jobs and communicate closely with others to make the whole system work seamlessly. Each layer acts independently. We divide MCDAS in different layers according to several stages of permitted users. As an example when the user is classified as an administrator, they can go in to the administration scopes such as, can manage the staff data, edit line production information etc. If the user is classified as normal user, they only can view the output achievement. For the production control (PC) group, they have permission to manage the output planning system. What makes this proposed automated monitoring system different is that it will track the accumulated quantity production output of good products versus faulty products by each model run by individual line instead of tracking individual product or location. Furthermore, this system is complete with a wireless mesh network and a web-based monitoring system.

5 System Design

Figure 2 shows the main flow chart of the whole system.

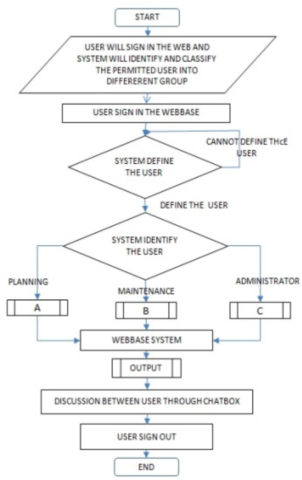

Fig. 2. Flow Chart Main System

The system begins with the user signing in to web base GUI (graphical user interface). The system will define the Permitted user. If the user is not in the user list database, message ‘failed’ will appear. Moreover, these systems can differentiate the groups by individual tasks. For example, if the user is from the administration group, then he can access the subsystems like user list system, planning system and maintenance system. While, if the user is from the line leader group, then he can only access the maintenance system that manage the production line’s information. As mentioned earlier, main system has three sub systems: planning subsystem, maintenance subsystem and administrator subsystem. The details about subsystems are described below:

5.1 Planning Sub System

Planning sub system is designed for Production Control (PC) to input the schedule and output target for all production lines according to management requirement.

In strategic plan, the planner needs to identify the target output for each model running through individual production line. Production scheduling addresses what model to produce, where to produce and how much to produce within the context of manufacturing plants. Thus through production scheduling, manufacturing are able to monitor the line production output achievement to meet the target. In the complete production planning software, system enables forecasting and planning of manufacturing resource requirements and machine capacity utilization. Nevertheless, in our system we designed for planning manufacturing and used to prioritize and schedule accordingly to feed the data to the database to update the real time production output monitoring system. This production scheduling sub system enables planer to update the tracking of manufacturing output across multiple areas of production line and model. Scheduling is based on order priority. Priorities for production are assigned for each line on each shift. Figure 3 shows the flow of the planning system. This subsystem has three main tasks: manage planning schedule, control working calendar and deal with model running.

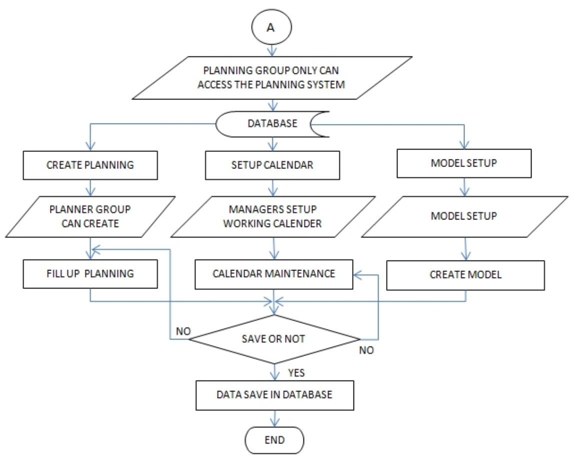

Fig. 3. Flow Chart Planning Sub System

5.2 Maintenance Sub System

Maintenance subsystem is designed for line leader or line supervisor to manage production line information, create new line, edit and delete details of line such as product models, line rename etc. and control production lines specifications – within the context of production plants. Thus through production maintenance subsystem user are able to manage the production lines information. Figure 4 shows the process flow for maintenance subsystem.

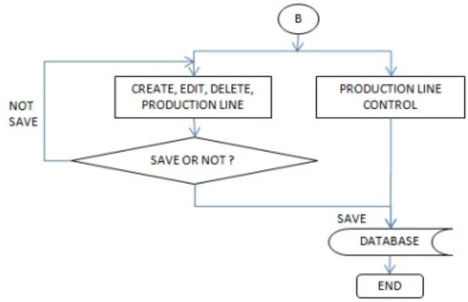

Fig. 4. Flow Chart Maintenance Sub System

5.3 End User GUI

Real time effective monitoring can lead to management efficiencies and reduce costs associated with public reporting on internal control because difficulties are identified and addressed in a proactive manner. By implementing, the management can perform the continuous monitoring, analysis, and appropriate follow-up on, line performance reports that might identify problem of a control failure. Figure 5 depicts the end-user GUI. Line or shift supervisor can review and control target achievement and line performance as a normal part of processing. Top management can perform individual line performance assessment regarding the line achievement they set in the factory.

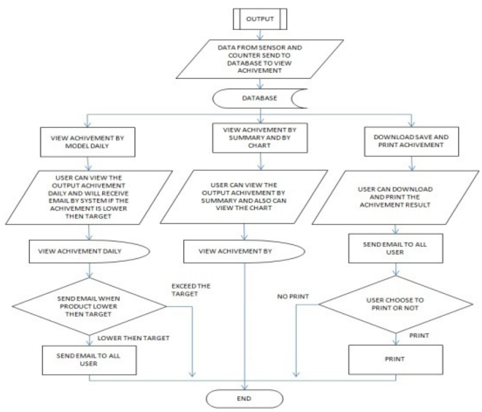

Fig. 5. Flow Chart WEB-GUI

5.4 Database Web Server

The database stores all the information about the production outputs and their interaction with the system. The databases designed can be linked to the Web in a manner that allows user to access data through a web GUI. These databases applying Web-to-database connecting technologies called JDBC (Java Database Connectivity) as a linking method between the Webs to access back-end databases [9]. The corporate databases can be linked to the Web in manner that allow users to access to corporate data through a web browser [10]. The capabilities of the database have been tested by integrating to the real hardware and real world industrial environment. The build mesh network link to the database have been experimented and the result obtain depict in table 1. In the experiment input data through counter system are continuous send to each RFID tag in the same quantity in one shift working hour (8 hours).

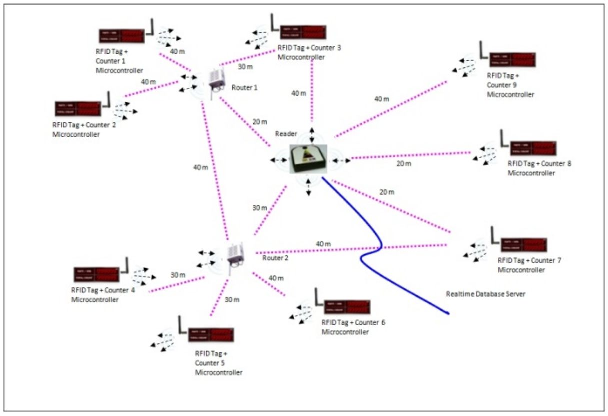

Fig. 6. Scenario of Experimental Set Up

Table 1. Result of Capabilities for Database Receive Data

Distance to reader	No of embedded hardware	Router selection	Reader	Mesh Network	Database Performance
5m ~ 100m	9	Router 1&2 is 'ON'	1	Yes	Real time from all counter
5m ~ 100m	9	Router 1 is 'ON'	1	Yes	Delay 0.002sec from counter 1 and 2
5m ~ 100m	9	Router 2 is 'ON'	1	Yes	Delay 0.002sec from counter 4, 5 and 6

The overall system to be tested and evaluated on performance of data transfer using the build network to be retrieved by users in company's various locations.

6 Conclusion

In this paper an overview of comparatively new technology and architecture for web-based system and active RFID integrated in wireless mesh network in industrial applications has been presented. The state of the art has been summarized by describing the framework of "real industrial environment" case study. It is likely that web-based architecture and wireless mesh network platform play an important role in the future of computer and communication technology specifically in industrial environment. The result shows that, the MCDAS architecture and capabilities is designed to best suite these applications. Specifically, wireless mesh network can be exploited to reduce cost and time constraints to gain optimum profit. The intent is to show ways on how industrial manufacturers can use wireless technologies to improve their monitoring systems.

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