Jurnal Teknologi

Full Paper

IMPLEMENTATION OF WIRELESS MOBILE RFID READER IN REAL WORLD INDUSTRY ENVIRONMENT

Siti Norainah Semunab, Che Zalina Zulkifli*, Abu Bakar Ibrahim, Nursyahida Mohd Noor

Computing Department, Faculty of Art, Computer And Industry Creative, Universiti Pendidikan Sultan Idris, 35900, Tanjung Malim, Perak, Malaysia

Article history
Received
01 December 2015
Received in revised form
30 March 2016
Accepted
14 April 2016

*Corresponding author
chezalina@fskik.upsi.edu.my

Abstract

WIBRED is a new embedded system of Wireless Mobile Radio Frequency Identification (RFID) Reader is provide an approach of solving the complex tracking system of material flow in manufacturing industry. This new architecture is embedded with active RFID and passive RFID through wireless mesh network (WMN) platform and smart data processing adopted through web based tracking. RFID smart label solutions for cost effective to monitor and control the material flow in real time manner. The proposed architecture will be attached to smart phone with Android operating system using IOIO-OTG for monitoring and controlling warehouse management. WIBRED will scan the multiple of tags on WMN through 2.4GHz Zigbee technology with beyond 200m range on wireless mesh network platform for receive/transmit data indoor from reader to PC wirelessly. In relation to this traceability and accuracy system will become the solutions of a company to considerably decreased picking errors, reduced rework, reduced business risk and control assets and also lower correction costs. It will make the enterprise warehouse management becomes transparent and efficient work.

Keywords: Embedded system, zigbee, production monitoring, real-time, android, ioio-otg board, wireless mesh network, RFID

Abstrak

Wireless Mobile Radio Frequency Identification (RFID) Reader yang dikenali sebagai WIBRED, adalah satu bentuk sistem tertanam yang baru, sebagai satu pendekatan untuk menyelesaikan permasalahan sistem pengesanan aliran bahan yang semakin kompleks bagi industri pembuatan. WIBRED dibina daripada hasil gabungan aktif dan pasif *RFID* yang berfungsi di atas rangkaian mesh tanpa wayar(*WMN*), manakala pemprosesan data pintar yang diterima pakai berasaskan sistem pengesanan web. *RFID* adalah satu penyelesaian yang baru untuk kos yang lebih efektif bagi memantau dan mengawal aliran bahan pada masa nyata. Pembaca *RFID* akan mengimbas banyak tag pada satu masa di atas rangkaian mesh tanpa wayar melalui 2.4GHz teknologi *ZigBee* dengan jarak yang melebihi 200m di atas rangkaian mesh tanpa wayar untuk menerima/menghantar maklumat dari pembaca ke komputer. Dengan adanya sistem ini, masalah yang wujud semasa keluar masuk stok bahan dapat dikurangkan, pengulangan kerja, risiko perniagaan dapat dikurangkan dan kawalan terhadap aset dan juga kos selengaraan yang lebih rendah. Ia akan menjadikan pengurusan perusahaan gudang menjadi kerja yang telus dan cekap.

Kata kunci: Sistem tertanam, zigBee, pemantauan pengeluaran, masa nyata, android, papan ioio-otg, rangkaian mesh pengesan tanpa wayar

1.0 INTRODUCTION

Modern manufacturing is constantly facing new challenges arising from the evolving production environment, increasing product variety and complexity, miniaturization of components and product, new environmental regulations, as well as increasing time- based competition [1]. Mika [2] had mention, which is moreover manufacturing companies face information gaps between individual manufacturing units and poor visualization of production stages, WIP, and the state of warehouse. In line with this reason, they require an

accuracy system of material traceability, and real time feedback to maximize and improve productivity. This problem is highlighted from the industry themselves which require solution for the traceability and accuracy of materials flow in their company.

Millions of dollars has been wasted due to uncontrolled/manual and monitoring/tracking of the material flows in manufacturing plant [3]. Traceability and accuracy system is very much related to communication and real time feedback. However, industrial manufacturing has a wider range of areas which require an enormous number of manpower to ensure the productivity would be affected by the inefficient mode of communication and accuracy of material flow traceability. As a significant of problems in existing methods of identifying and tracking parts and products, mislay of parts and products, delay in schedule, late deliveries and increase in costs occur[4]. On certain condition based on the limitation of fixed RFID, where container is too large or heavy to go through the RFID gate or the environment is not suitable for a fixed gate. This might be the case if the site in question belongs to a 3rd party who is unwilling to install a fixed gate. The problem with fixed RFID reader wiring installation is the data cable and other wiring is difficult and costly which is impractical at overall departmental process.

In In fact, the use of technology can enhance the monitoring and traceability efficiency rather than merely relying on human intervention and traditional method such as Barcode. RFID tags offer numerous advantages than barcodes. Moreover Y. Zare Mehrjerdi [5] has listed the benefits of RFID based on 10 case studies which has been reported in the literature of L. Mika [2]. Unlike barcode technology, RFID has several advantages such as multiple reading at a rate of 1000 tags per second that makes it not only a feasible and cost-effective candidate for object identification but also a significant tool to provide visibility along different stages of the supply chain [6]. In fact, RFID-enabled supply chains can generate 10 to 100 times more information than the traditional barcode technology. Every RFID tag has a unique identification number and, depending on the type, it can have a rewritable memory [7].

In this proposed invention, we focus on industrial warehouse management process of material control, which have different networks requirement. To meet the needs to deploy a fully automated and accuracy traceability system of material flow in manufacturing plant, we will implement combinations of active and passive RFID solutions embedded to microcontroller. It is has its own Android application to communicate with smart phone provided with Internet of Thing (IoT) for material traceability and accuracy system. Wireless Mobile RFID Reader (WIBRED) has multi-purpose function in manufacturing plant.

This paper has been organized into a few sections, firstly we have explained the problems which persist propose solution for it. Some related work or previous research on developing RFID system has been explained as well as the overview of technologies used. Next, we will look at the architecture design and implementation of proposed architecture in real manufacturing environment. The comparison overview of proposed architecture with existing technology is also presented. Finally, the experiment setup, and then the result of experiment and sample of data stored in database are discussed.

2.0 RELATED WORK

RFID technology has been used in many organization and agencies such as Malaysia National Muzium. It will be the first in region to use RFID system, which is Solmate™ RFID Artifact Management and tracking system to manage and track their artifacts, Wal-Mart firm and U.S. Department of Defense(DoD). There are many existing research and development for RFID system in so many applications. For example in food industry such as Halal food tracking [8], Automatic Identification on supply chain operations [9], academic institution such as Context aware notification system [10], and library management and so on. All of these can proof the reliability and ability of RFID system for tracking, monitoring and locating purpose to replace the lack of manual system and less human intervention.

While in manufacturing industry application, [11] have been implement the wireless RFID and does a test run in real industry production line environment using RFID-based system, namely (1) passive reader (PR) and (2) passive and active reader (PAR) systems. Thus, the result showed the differentiation based on the efficiency percent in production line compared to barcode-based system, which is PR had 94.7 % efficiency while PAR had 90 % efficiency. This study find that the combination of passive and active RFID-based system effectively.

In addition, [3] have been proposed Managerial Control and Data Acquisition System namely MCDAS technology. It uses active RFID tool that adopts through wireless mesh network, the Zigbee technology to render the automation system more reliable. Besides, using MCDAS the real time information on production output achievement for individual production line can be monitored by the management group from the LAN (local area network) or where ever there is internet coverage. Automated monitoring system is able to update the production line activities, and able to detect the error occurrence during manufacturing.

In learning application, [12] have reviewed the issues and problems faced by student in learning wireless communication network. It is said to be complex and difficult, [12] proposed Wireless Kit (Wkits) as interactive learning tool based on RFID system to help overcome this learning problem. Finally, research and development of mobile RFID for internal location was accomplished by [13]. It uses a

java application with a RFID reader attached to a mobile device to locate the user's position in a building with fixed passive RFID tags attached. This research presents an indoor positioning systems architecture based on a combination positioning systems. This refers more to GPS for external positioning system. While WLAN (wireless local area networks), Bluetooth and RFID that are being used for internal positioning system of wireless, RFID and J2ME (Java 2 Micro Edition) technology.

RFID is in demand today and there still less enhancement in research and development for mobile RFID in manufacturing sector. However, mobile RFID is able to prosper new market and encourage other research and development to make new innovation from existing RFID technology. This will provide benefits to us in the daily routine in the deemed manner. This prototype research is expected to give some enhancement for RFID system and as references for other researcher and developer in their future research.

3.0 TECHNOLOGIES USED

3.1 RFID Technology

RFID has been around for over 60 years in so many applications. It is a wireless technology system that uses transmitted radio signals to automatically tag, identify, track, and trace the movement of an object [11]. It functions in different frequency ranges for different type of tag used. RFID is classified as a wireless Automatic Identification and Data Capture (AIDC) technology. Users of RFID technology can send and receive data with no contacts occurring between interrogators and tags. It can hold more information than data carrier system such as bar-Code system [5].

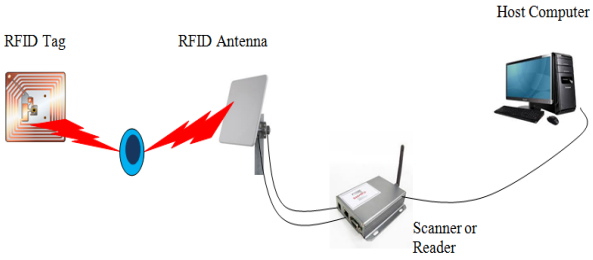

Figure 1 Component of RFID system

3.1.1 Component of RFID System

Figure 1 shows the component of RFID system. An RFID system is composed of three main elements:
Tag or Transponder -the tag comprise of a simple silicon microchip(typically less than half a millimeter in size) attached to a small flat aerial and mounted on a substrate, which usually holds an identification number and can be attached to an object, typically item, bin, or pallet to be identified. There are two types of tags known as (1) passive tag and (2) active tags. Passive tag: does not have a battery, it obtains the energy from a remote RFID reader.

Active tag- battery powered. It broadcast a signal to the reader and transmits over the greatest distance.

Reader or Interrogator- sends and receives RF data to and from the tag via antenna using radio waves.

Host computer- data captured by reader is then passed to a host computer, which is run on specialist RFID software or middleware to save the data or may route it to the correct application, or processed into useful information.

3.1.2 Working of RFID System

RFID tag is put on the objects/parts to be identified. The tag transmits their data response to the reader or interrogators. Then it decodes the tag signal and transfers the data to a computer through a cable or wireless connection. The tag and reader are assigned with a specific operating frequency for the purpose of this. Then the reader transfers the collected data from tags to another computer system. It usually runs on software that stands between reader and applications, which is called RFID middleware. RFID does not require a line-of-sight and can transmit through almost any material except metal.

3.2 Android Operating System

According to [14], Android is a mobile operating system running on the Linux kernel. It was initially developed by Android Inc., a firm later purchased by Google, and lately by the Open Handset Alliance. It is a software stack for mobile devices that includes an operating system, middleware and applications. Figure 2 shows the Android operating system architecture, consists of number of layer as application, applications frameworks, libraries, Android runtime and Linux kernel. Unlike the iPhone App Store, Android is open-sourced operating system, allows users to browse, buy and download. These privileges encourage Android developers to create their own application market.

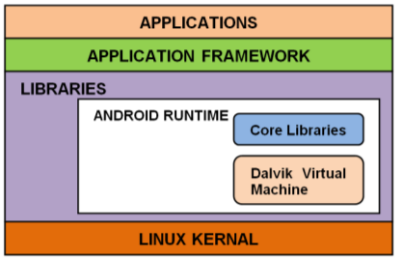

Figure 2 Android architecture [15]

3.3 Wireless sensor Network (WSN)

Wireless communication has become an important feature for commercial products and a popular research topic within the last fourteen years. According to [16], WSNs can be used in many applications such as habitat monitoring, security surveillance, target tracking, medical application etc. Wireless sensor network, as the name describes it, consist of a sensor to measure a physical parameter, circuitry to power and interface the sensor with microprocessor based electronics. There is also a radio transceiver, the software to interpret the data and organize it to the network. There are numerous technologies which exist currently to perform this functionality and many of which have been built on the top of the IEEE's 802.15.4. WSN node microcontrollers are reprogrammable, which enables easier modification to suit the application requirements [17]. WSNs are mainly used for sensing the environment and positioning and identifying objects/people [18]. WSN, similarly to RFID, is a very low-cost and low power technology employed in a number of possible techniques; each one of them considered by different transmission bandwidth and communication ranges [19]. Currently there is a huge need for WSN, especially a robust protocol enabling self-configurable devices that can form a self-healing network. Most of the traditional wireless systems, such as cellular telephone networks and wireless local area networks (WLAN), use either point-to-point or point-to-multipoint network topologies [20]. Figure 3 shows the communication line using a mesh network. A sensor network consists of a large number of sensor nodes that can deployed on the ground, in the air, in vehicles, inside buildings, or even on human bodies [21].

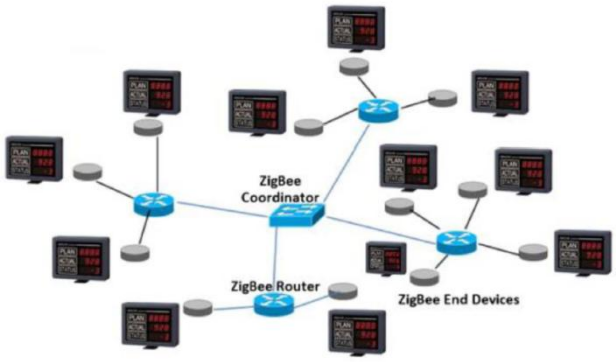

Figure 3 Communication line by using a mesh network [21]

3.4 Zigbee Technology

According to [22] Zigbee has many advantages compared to Bluetooth technology. The transmission range is 10 to 100 meter. Zigbee is a wireless networking technology built using the recent IEEE 802.15.4 communication standard [23], where the organization maintains, supports and develops more protocols for advanced applications in defining additional communication features [24]. Zigbee characterized by its low cost, low power consumption at low data rate [25]. Besides that, it is a cost-effective component that uses 2.4 GHz radio frequency (RF) with data throughput of up to 250 kbps for transferring data between Zigbee modules. Zigbee module has the ability to transmit Digital, PWM, Analog or serial RS232 signal wirelessly to communicate over UART or USART. This protocol implement media access control, addressing, error detection, and acknowledgements and retries to ensure data integrity and delivery. Zigbee wireless devices can operate for many years on simple battery power [25]. This is due to the implementation of the Zigbee protocol in which the sensors are mostly in deep sleep or idle mode to preserve power consumption [26].

4.0 PROPOSED PROJECT DESIGN

This section presents the WIBRED hardware architecture and software architecture. The Framework of data transmission and reception in wireless mesh sensor network has been discussed.

4.1 Hardware Architecture

The proposed system is developed based on embedded system concept and along with RFID system, Zigbee technology and wireless mesh sensor network as network platform. Embedded system is designed to do some specific tasks, rather than be a general-purpose computer for multiple tasks. Figure 4 shows hardware architecture of WIBRED system. WIBRED system consists of three major parts that are interlinked in an appropriate relationship. These three major parts are (1) reader, (2) tag and (3) host computer or microcontroller for customized embedded system. Give 5V source to microcontroller (µc) and 3.3 V for Zigbee module through the proposed power management. Zigbee module and Microcontroller (µC) interfacing to controlling application via Universal Asynchronous Receiver/Transmitter (UART) module which supports serial communication. The data communication is done in mesh network using Zigbee module buffer RF. The data is received from the zigbee module antenna, while TX and RX pin is connected for communication purpose. The proposed WIBRED is a smart mobile reader, which can communicate with smart phone using Android Operating system. Thus it uses IOIO-OTG which is a board and allows for quicker and easy interface electronic circuits to an Android device. Secondly, the sizes of the entire component which are smalls make it possible to move from one department into another department in manufacturing industry or mobile.

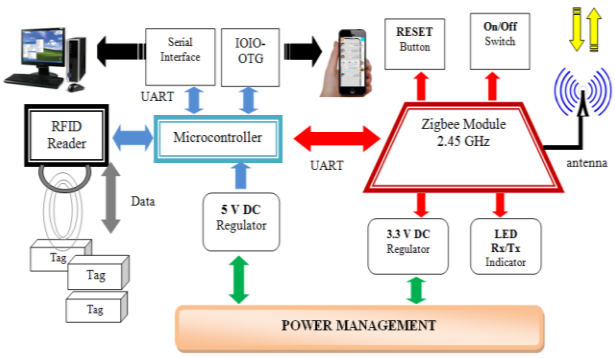

Figure 4 Block diagram of proposed hardware architecture

According to [27] there is two type of mobile RFID, which are (1) RFID reader equipped of mobile phone, and the other is (2) RFID tag attached to mobile phone. Proposed architecture can be categorized as RFID reader equipped with mobile phone. Comparing to another mobile RFID reader, WIBRED enhances the coverage range with a new designed embedded with passive and active RFID together. The new specialization of WIBRED design which can communicate with smart phone or other tablet with Android operating system, shown on figure 5, where user can plug in the reader on their smart phone using IOIO-OTG. The IOIO-OTG board is a board generally designed to work with android platform. This board is generally used for data acquisition of android device [28]. From [29], the IOIO board consist of ARM processor. The IOIO board can interact with peripheral devices like MCU. The IOIO device can use the digital input/output, pulse width modulation, I2C, Analog input and USB port. The IOIO board provides an I2C pins for transmitting outputs and inputs on the boards, as directed by a specialized Android application.

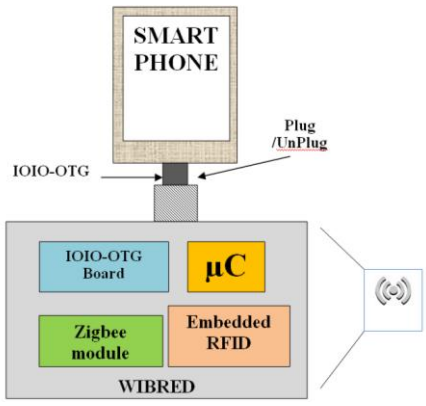

Figure 5 WIBRED serial communications with smart phone

User will use WIBRED to search mislay of part/objects either during production process or for searching part storing at warehouse. WIBRED has its own Android application developed in Java programming languages. Moreover, it's run on Android Runtime layer which includes the core libraries for Java. The connection between smart phone and devices is using IOIO-OTG, WIBRED designed with USB port. It is easy to carry and use, because of the small physical it have.

From [30], Android is based on an open-sourced Linux operating system. It is an open-sourced platform that anyone cans extend. Thus, an open, free system will normally win against a proprietary, closed one. The Android OS allows hardware manufacturers to build user friendly interfaces. In addition, based on these criteria WIBRED had been chosen Android for its mobile application software compared to other operating system.

4.2 Software Architecture

Figure 6 shows the difference between proposed software architecture and existing software architecture. The similarity of proposed and existing system is, it uses RFID system to tracking, monitoring and locating object. On the other hand, the proposed software architecture adopts embedded passive and active RFID to perform long range transmission network coverage inside building beyond 200m, compared to existing technology with short range coverage network. The Internet of Thing (IoT) technology are utilized for data centralization, collection of data received and exchange data. It also facilitates the information in real time to other department. The intelligent monitoring system is developed based on Android platform to communicate with smart phone using Wireless Mesh Sensor Network as their communication platform.

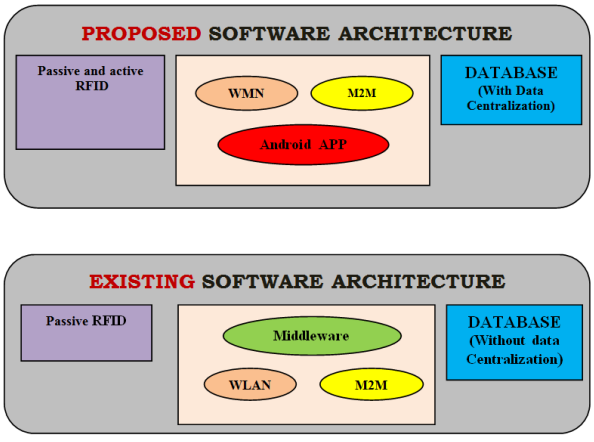

Figure 6 Block diagram of differentiation between proposed and existing software architecture

4.3 Data Operation Flow

Figure 7 shows the sequence during transmission and reception of data in basic Zigee network. It will become wireless mesh sensor network when there are many nodes (End-devices and Router) in

coverage network. Only one Coordinator is required in every network to in charge of setting up network. It can never sleep. Figure show three nodes. There are (1) Embedded passive and active RFID, we called it as End-device, and then there is (2) Router and (3) Coordinator. When there is no data received or transmitted, each node is in Idle Mode. This mode will change to other modes when node goes for certain condition. The modes are Transmit Mode, Receive mode, Sleep mode and Command mode. Each node will exit Idle Mode and attempt to do transmit/receive operation of data. Only End-device always in sleep mode, it only wakes-up when there is command received. This is a measure to reduce power consumption. Figure 7 shows command frame transfer from End-device to Router, Router to Coordinator and from Coordinator to PC/database. WIBRED act as End-devices to scan the ID tag. Each node will give respond status frame back to their sender, to inform they have received the command. If the packet cannot be delivered to the destination, the transmit status frame will indicate the cause of failure. That is why a 16-bit of address is required to route to the correct destination. All transmissions are sent using the source and destination of 16-bit addresses. The 16 bit address is also called the "network address" and the address is unique. 64-bit packetized used for command frame. Meanwhile, each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high).

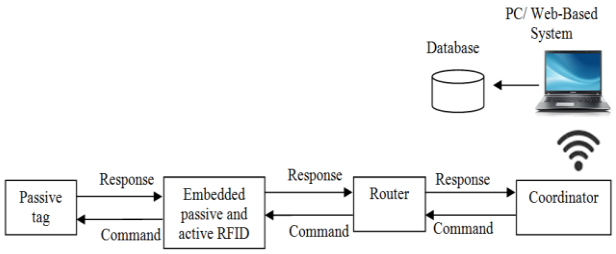

Figure 7 Transmission and reception sequence in zigbee network

5.0 PROTOTYPE IMPLEMENTATION FRAMEWORK

The aim of our conceptual framework (figure 8) is to provide visibility of material and information flows, which includes the processes from customer orders through manufacturing and product assembly to delivery of the product to the customer. It refers only to a part of the entire supply chain. Our aim is to facilitate the sharing of information with the integration of mobile RFID technology on WSN platform. Figure 8 show the material flow management uses in manufacturing industry, where the process as shown include from receiving until shipping the product which takes place in warehouse area. Warehouse management monitors vendor compliance, efficiently manages multi-channel distribution, and responds quickly to shifting demand to optimize performance. It also enhances inventory management by increasing accuracy, improving order fulfillment and reducing order cycle time.

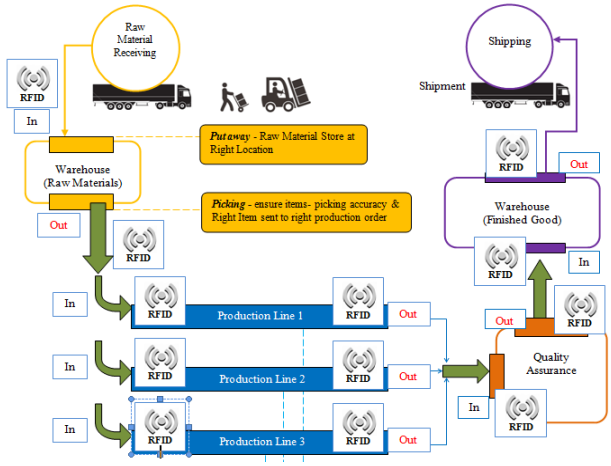

Figure 8 Implementation framework of proposed architecture in production line

There are few potential benefits of WIBRED to Warehouse management process:

- Transmit data immediately to smart phone rather than need to go to the base-station.
- Automatically and wirelessly transmit/receive data from/to database.
- reduced manual labor.
- Fast & accurate verification of items in various operations.
- reduce human error in warehouse.
- improve speed of handling process.
- improve data accuracy.

Figure 8 is shows how the prototype will be implemented in real environment of production line for tracing and controlling material flow. There are few stage illustrated for material flow process. There are (1)Warehouse of Raw Material, (2)production line, (3)Quality Assurance and (4) warehouse of finished goods, where each of these stage will be installed with WIBRED at the initial and final stage. Start from Receiving Raw Material up to the final stage of delivery to the customer. The operation is fully automated, thus human assistance is not needed in this process. Passive tags will put on every pallet and it will go through the portal reader. The RFID reader can read multiples tags at one time and sent the data to PC wirelessly through WSN platform for centralization of information received. Using WIBRED the material flow will be monitored and controlled effectively. It is a blessing in disguise for all those who have products moving around and where the visibility of the products is very less. WIBRED is easy

to implement in every department because it reduces the complexity wiring/cabling. It is mobile at anytime and anyplace needed.

6.0 EXPERIMENTAL SETUP

The purpose of this experiment is to show the working concept of the proposed architecture WIBRED. Figure 9 illustrates the real working process on how proposed systems function to trace material on moving conveyer and show the range coverage network. This experiment setup is to generate the efficient data result of read and transmit data through Wireless sensor network. Firstly, each node will be configured with the selected software application. This experiment consists of two nodes, which is (1) End node/Router and (2) Coordinator, and there is a PC as host computer to display the received data in real time. Passive tags are put on conveyer act as real material in real production process. During reading the passive tag, passive reader will read the ID tag with no line of sight required and then transfer it to the coordinator, then from coordinator to PC. All data received and transmitted work wirelessly using radio wave signal which is transmitted by RFID devices. The data captured will discuss in result section.

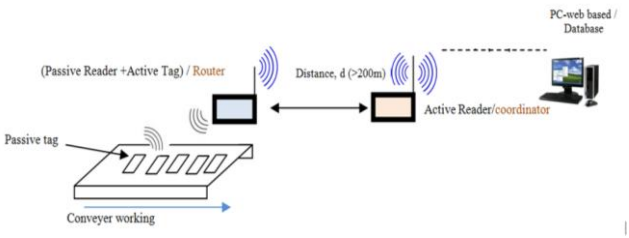

Figure 9 The experimental hardware setup

Figure 9 also illustrates the basic Zigbee network before embarking in deep Zigbee network. All node have to go through the following steps before distributed to any area. In Zigbee networks, the coordinator must select PAN ID (64-bit and 16-bit) and channel to start a network. After that, it behaves essentially like a router. The coordinator and routers can allow other devices to join the network and can route data. After an end device joins a router or coordinator, it must be able transmit or receive RF data through that router or coordinator. The router or coordinator that allowed an end device to join becomes the ''parents'' of the end devices. Since the end device can sleep, the parents must be able to buffer or retain incoming data packets destined for the end device until the end device is able to wake and receive the data.

7.0 RESULT

Figure 10 shows the real-time multi tag detection system screen snapshot for experimental setup on figure 9, to detect passive tags on running conveyer. Reader 1 refers to assembly department which indicates the material is on production line for assembly task. Through this way our experiment result shows that the proposed architecture is able to locate objects inside the building accurately in real time. This system is collected using unique ID tags, where it is put on objects/part. The collection of ID tags becomes important information to the industry. This is because it will be used for material management, product identification and work-in process tracking, where difficult to handle is compared to enter data manually or using bar-Code technology. The information share wirelessly between shop floor and ERP system, and also others departments.

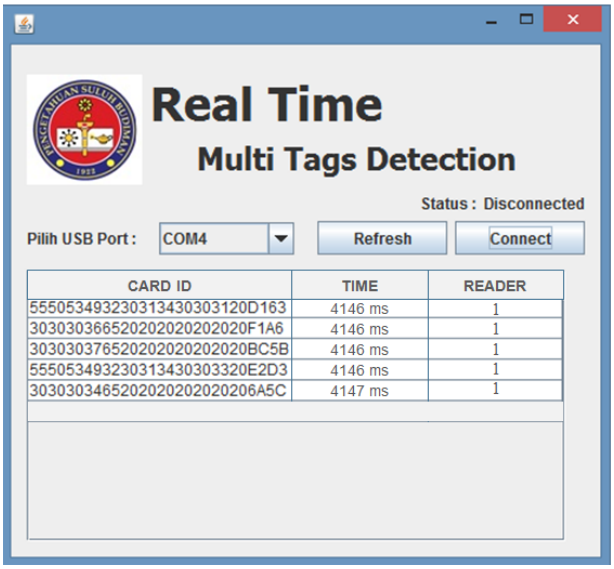

Figure 10 Monitoring system screen snapshot

Figure 11 shows the sample data collected based on result of experiment on figure 9. Figure 11 shows all hundred tags detected by reader simultaneously at in millisecond (ms) reading time to the host computer beyond 200m through WMN platfform. The database can be linked to the Web in a manner that allows user to access data through a web GUI. Information stored are a reader number, unique ID tags, time received, date received and process name. All these information can be used by other departments in manufacturing plant wirelessly. This saves the cost of saving the data on USB or external hardware for the purpose of transferring the data. This is because every department can use the data directly on their database system. The processes of materials traceability, data entry and report preparation are

very tedious and time-consuming and yet are very significant for the company's reference, observation. So, all the information is very crucial to be collected automatically with less human intervention.

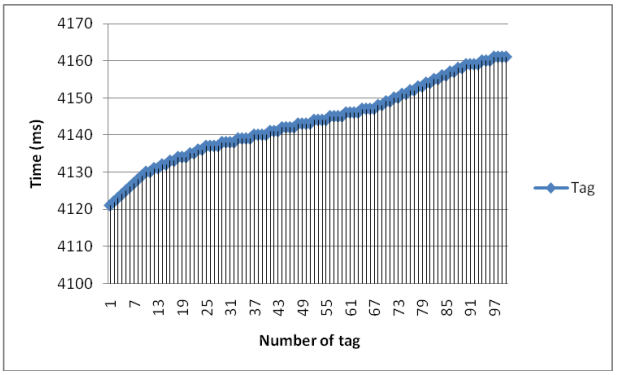

Figure 11 Result data

8.0 CONCLUSION

In this paper an overview of comparatively new technology and architecture for monitoring based system and active RFID integrated in wireless mesh network in manufacturing plant has been presented. The state of the art has been summarized by describing the framework of Wireless Mobile Radio Frequency Identification (RFID) Reader (WIBRED). Specifically, wireless mesh network can be exploited to gain improvement in monitoring warehouse management and for controlling material flow. It is developed on trusted network for effective real time data transfer to prevent the lost of data during transmission/reception of the information. Wider Scale Deployment of RFID can give benefit to socioeconomic such as improvement of the knowledge economy and Job Creation, an increase of productivity, platform for new markets and accelerated product and service innovation. RFID is a promising technology for wireless tracking of individual objects. RFID have been used in automotive and electronics industries for many years. As a result of this, the manufacturing industries seem to be aware that RFID can enhance their operations as well. As a call to this, observe at the multi-purpose potential of proposed smart architecture of embedded system in term of locating, monitoring and identifying object. It wills specifically benefit the manufacturing industry as it can be used in any applications in same manner needed. This will venture into new market of RFID innovation technology for new mobile RFID transformation.

Acknowledgement

This research is fully supported by FRGS grant, 2014/0129/109/02. The authors are acknowledged for the work throughout the study. The University of Sultan Idris Education is valued for the financial support through the grant provided.

References

[1] Liukkonen, M., Havia E., Hiltunen Y. 2012. Computational Intelligence In Mass Soldering Of Electronics- A Survey. Expert Systems with Applications. *Science Direct- Elsevier*. 39(10): 9928-9937.

[2] Liukkonen, M. 2015. RFID Technology In Manufacturing And Supply Chain. *International Journal of Computer Integrated Manufacturing*. 28(8): 861–880.

[3] Zulkifli, C. Z., Abdulla, R. M., Ismail, W. and Rahman, M. G. 2012. Wireless Mesh Network In Integrated Web Base Monitoring Systems For Production Line Automation. *First International Joint Conference, SPIT 2011 and IPC 2011*. Springer Berlin Heidelberg. Amsterdam, The Netherlands. 1-2 December 2011. 7–15.

[4] Mati, G., T. Lovri, T. and Mirjana, C. 2011. Using ERP System To Improve Internal Supply Chain Coordination. Univ. Osijek, Mech. Eng. Fac. *Slavonski Brod*. 4(3/4): 11-21.

[5] Zare Mehrjerdi, Y. 2011. RFID And Its Benefits: A Multiple Case Analysis. Assembly Automation. *Emerald.* 31(3): 251–262.

[6] Lee, D. and Park, J. 2010. RFID-Enabled Supply Chain Traceability: Existing Methods, Applications And Challenges. Department of Industrial Engineering, Seoul National University Republic of Korea. *INTECH Open Access Publisher*. 51–68.

[7] Gandino, F., Montrucchio, B., Rebaudengo, M. and Sanchez, E.R. 2007. Analysis OF AN RFID-Based Information System For Tracking And Tracing In An Agri-Food Chain. *2007 1st Annual RFID Eurasia. IEEE. Istanbul.* 5-6 September 2007.1–6.

[8] Anir, N. A., Nizam, M. N. M. H. and Masliyana, A. 2008. The Users Perceptions And Opportunities In Malaysia In Introducing RFID System For Halal Food Tracking. *WSEAS Transactions on information science and applications* .5(5): 843–852.

[9] McFarlane, D. and Sheffi, Y. 2003. The Impact Of Automatic Identification On Supply Chain Operations. *The International Journal of Logistics Management*. 14(1): 1–27.

[10] Haron, N. S., Saleem, N. S., Hasan, M. H., Ariffin, M. M. and Aziz, I. A. 2010. A RFID-Based Campus Context-Aware Notification System. *Journal Of Computing*. 2(3): 122–129.

[11] Abdullah, S., Ismail, W. and Halim, Z. A. 2015. Implementation of Wireless RFID for Production Line Management System in a Real Environment. *Springer Wireless Personal Commuicationn*. 83(4): 3119–3132.

[12] Zukifli, C. Z. and Suparmin, S. 2015. Wireless Communication Network Tools Kits With Visualization Techniques: Design Consideration For Proposed Architecture. *International Journal of Multimedia and Ubiquitous Engineering*. 10(7): 375–386.

[13] Potgantwar, A. D. and Wadhai, V.M. 2010. Internal Location Based System For Mobile Devices Using Passive RFID And Wireless Technology. *International Journal of Computer Science and Information Security.* 6(3): 153-159.

[14] Wang, C., Duan, W., Ma, J. and Wang, C. 2011. The Research Of Android System Architecture And Application Programming. *International Conference on Computer Science and Network Technology (IEEE), 2011 Harbin. 24-26 December 2011*. 785–790.

[15] Gandhewar, N. and Sheikh, R. 2010. Google Android: An Emerging Software Platform For Mobile Devices. International *Journal on Computer Science and Engineering.* 1(1):12-17.

[16] Yunus, F., Ismail, N. N., Ariffin, S. S., Shahidan, A. A., Yusof, S. S., Fisal, N., Saleem, K. and Ahmed, A. A. 2012. Proposed

Technique For Transport Protocol In Wireless Sensor Network (WSN) For Multimedia Application. *Jurnal Teknologi*. 58(1): 83–89.
[17] Estrin, D., Culler, D., Pister, K. and Sukhatme, G. 2012. Connecting The Physical World With Pervasive Networks. *IEEE Pervasive Computing*. 1(1): 59–69.
[18] Ho, L., Moh, M., Walker, Z., Hamada, T. and Su, C. F. 2005. *A Prototype On RFID And Sensor Networks For Elder Healthcare*. E-WIND '05 Proceedings of The 2005 ACM SIGCOMM Workshop On Experimental Approaches To Wireless Network Design And Analysis. New York, USA. 22 August 2005. 70-75.
[19] Salvatore, C., Bocchino, S., Petracca, M., Pelliccia, R., Ghibaudi, M. and Pagano, P. 2012. WSN And RFID Integrated Solution For Advanced Safety Systems In Industrial Plants. *Software, Telecommunications and Computer Networks (SoftCOM), International Conference. IEEE. Split.11-13 September 2012*. 1-5.
[20] Raed, M. T. A. 2012. *Design And Implementation Of Multi-Hop Active RFID System With Embedded Wireless Sensor Network USM, Penang, Malaysia*.
[21] Abdullah, S., Ismail, W., Halim, Z. A. and Zulkifli, C. Z. 2013. Integrating Zigbee-Based Mesh Network With Embedded Passive And Active RFID For Production Management Automation. In RFID-Technologies and Applications (RFID-TA), 2013 *IEEE International Conference. IEEE. Johor Bharu, Malaysia. 4-5 September 2013*. 1–6.
[22] Narayanan, L., Muthumanickam, T. and Nagappan, A. 2015. Animal Health Monitoring System Using Raspberry PI And Wireless Sensor. *International Journal of Scientific Research and Education*. 3(5): 3386–3392.
[23] Khalid, Z., Fisal, N., Ullah, R., Safdar, H., Maqbool, W., Zubair, S. and Khan, A.S. 2013. M2M Communication In Virtual Sensor Network For Shaal. *Jurnal Teknologi*. 65(1): 99–105.
[24] Zulkarnain, A. L., Abubakar, S. A., Azhar, A. A., Adibah, Y. 2015. Home Security System Using Zigbee. *Journal Teknologi*. 5: 64–67.
[25] Bal, M. 2014. An Industrial Wireless Sensor Networks Framework For Production Monitoring. *2014 IEEE 23rd International Symposium on Industrial Electronics (ISIE). IEEE. Istanbul. 1-4 June 2014*. 1442–1447.
[26] Zigbee, A. 2015. The ZigBee Alliance. 2015. [Online]. Available: http://www.zigbee.org/. [Accessed: 23-Aug-2015].
[27] Park, N., Kwak, J., Kim, S., Won, D. and Kim, H. 2006. WIPI Mobile Platform With Secure Service For Mobile RFID Network Environment. *Advanced Web and Network Technologies, and Applications*. 3842 LNCS. Korea: Springer-Verlag Berlin Heidelberg.
[28] Paul, I. E. and Ravela, V. D. 2012. Obstacle Detection Using Android Mobile. *International Journal of Innovations in Engineering and Technology* IJIET. 1(5): 70–73.
[29] Umare, M. K. B. and Padole, D. D. V. 2015. The Design And Implementation Of Handheld Multipurpose Scope Using Bluetooth Ioio Board. *International Journal of Advanced Research in Computer Engineering & Technology* (IJARCET).4(4): 1152-1155.
[30] Hall, S. P. and Anderson, E. 2009. Operating Systems For Mobile Computing. *Journal of Computing Sciences in Colleges*. 25(2): 64-71.