THE DEVELOPMENT OF A WIRELESS MOBILE RFID READER SYSTEM FOR REAL-TIME TRACKING BASED ON EMBEDDED ARCHITECTURE

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THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE (COMPUTER AIDED DESIGN TECGHNOLOGY)
(MASTER BY RESEARCH)

FACULTY OF ART, COMPUTING AND CREATIVE INDUSTRY
UNIVERSITI PENDIDIKAN SULTAN IDRIS

2018

ABSTRACT

The aims of the study is to develop a system that able to overcome the limitations of keeping track inventories on the manufacturing plant. The proposed system is named Wireless Mobile RFID Reader (WiBRED) in order to improve the accuracy and traceability of materials in the industrial warehouse management process. This novel system was developed based on the Waterfall model involving the integration of active and passive Radio Frequency Identification (RFID) and IOIO is a board specially designed to work with Android 1.5 and later device to support wireless communication over a smart phone running on Android operating system. This system was implemented in a Wireless Mesh Network (WMN) environment in which its performance was assessed in terms of maximum read range for indoor environment, multi tags communication efficiency, power consumption, and tag collection time. The findings of the assessment showed that maximum read range reach up to 3.5meter for passive wireless communication and 74meter for active wireless communication. Multi tags communication efficiency resulted more than 75% of data received. The duration of tags collection time for 25 tags is 192.5millisecond and the power consumption is 96.611milliampere. Conclusion, WiBRED is capable in improving the monitoring of warehouse management and control the material flow in the manufacturing industry when combining passive RFID and active RFID connected to Android smart phone and can perform in WMN platform. The implications of the findings suggest that this system can be used to improve existing practice of material flow monitoring of manufacturing processes through greater flexibility and mobility in eliminating errors and non-productive labor and delays caused by repetitive re-keying production data.

PEMBANGUNAN SENI BINA TERTANAM RFID AKTIF MUDAH ALIH TANPA WAYAR UNTUK SISTEM PENGESANAN MASA NYATA

ABSTRAK

Tujuan kajian ini adalah untuk membangunkan satu sistem yang dapat mengatasi batasan penyimpanan inventori di kilang pembuatan. Sistem yang dicadangkan ini dinamakan *Wireless RFID Reader (WiBRED)* adalah untuk meningkatkan ketepatan dan kebolehkesanan bahan dalam proses pengurusan gudang industri. Keaslian sistem ini dibangunkan berdasarkan model Air Terjun yang melibatkan gabungan *Radio Frequency Identification (RFID)* aktif dan *RFID* pasif yang tertanam dengan peranti *IOIO* di mana *IOIO* adalah papan yang direka khas untuk bekerja dengan peranti *Android 1.5* dan ke atas untuk menyokong komunikasi tanpa wayar dengan telefon pintar *Android*. Sistem ini dilaksanakan dalam persekitaran *Wireless Mesh Network (WMN)* iaitu prestasinya dinilai dari segi julat bacaan maksimum untuk persekitaran tertutup, kecekapan komunikasi multi tag, anggaran penggunaan kuasa litar sistem dan masa pengumpulan tag yang dicadangkan. Keputusan penilaian menunjukkan bahawa julat bacaan maksimum adalah mencapai 3.5meter untuk komunikasi tanpa wayar pasif, manakala 74meter untuk komunikasi tanpa wayar aktif. Kecekapan komunikasi pelbagai tag menghasilkan lebih daripada 75% data yang diterima. Tempoh masa pengumpulan tag untuk 25 tag adalah 192.5milisaat dan penggunaan kuasa adalah 96.611miliampere. Kesimpulannya, *WiBRED* mampu meningkatkan pemantauan pengurusan gudang dan mengawal aliran bahan dalam industri perkilangan apabila menggabungkan *RFID* pasif dan *RFID* aktif yang boleh disambungkan ke telefon pintar Android dan boleh dilakukan di platfom *WMN*. Implikasi dari penemuan ini menunjukkan bahawa sistem *WIBRED* ini boleh digunakan untuk menambahbaik pemantauan aliran bahan yang sedia ada di dalam proses pembuatan kerana sistem *WIBRED* yang lebih fleksibel dan mudah alih dalam menghapuskan kesilapan buruh dan kelewatan yang tidak produktif yang disebabkan oleh data pengeluaran yang berulang.

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LIST OF ABBREVIATIONS

AES	Advanced Encryption Standard
AIDC	Automatic Identification and Data Capture
AP	Access Point
API	Application Program Interface
ATM	Automated Teller Machine
BS	Base Station
BSS	Basic Service Set
CE	Compact Edition
CPU	Central Processing Unit
DES	Data Encryption Standard
DS	Distribution System
ESS	Extended Service Set
HAL	Hardware Adaptation Layer
HNP	Host Negotiation Protocol
I2C	Inter-Integrated Circuit
IBM	International Business Machines
ID	Identification
IERC	Internet of Things European Research Cluster
IOIO-OTG	IOIO-On-The-Go
IoT	Internet of Things
IP	Internet Protocol
IT	Information Technology
JVM	Java Virtual Machine

LAN	Local Area Networks
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LOS	Line-Of-Sight
MAC	Medium Access Control Layer
MCU	Microcontroller Unit
MIDP	Mobile Information Device Profile
NLOS	Non-Line-Of-Sight
OS	Operating System
PC	Personal Computer
PDA	Personal Digital Assistant
PHY	Physical Layer
PWM	Pulse Width Modulation
RAM	Random-Access-Memory
RF	Radio Frequency
RFID	Radio Frequency Identification
RIM	Research in Motion
ROM	Read-Only-Memory
SCO	Synchronous Connections Oriented
SDK	Software Development Kits
SIG	Special Interest Group
SPI	Serial Peripheral Interface
TCL	Tool Command Language
UART	Universal Asynchronous Receiver/Transmitter
UI	User Interface

USB	Universal Serial Bus
USB-OTG	USB On-The-Go
WAP	Wireless Application Protocol
WiBRED	Wireless Mobile RFID Reader
Wi-Fi	Wireless Fidelity
WIP	Work-In-Progress
WLAN	wireless local area networks
WMN	Wireless Mesh Network
WPAN	Wireless Personal Area Network
WSN	Wireless Sensor Network
WUSB	Wireless Universal Serial Bus
ZC	Zigbee Coordinator
ZED	Zigbee End Device
ZR	Zigbee Router

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CHAPTER 1

INTRODUCTION

1.1 Background Research

Internet of Things (IoT) is a global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities (Jia, Feng, Fan, & Lei, 2012). It will offer specific object identification and connection capability as the basis for development of independent cooperative services and applications, which is characterized by high degree of autonomous data capture, event transfer, network connectivity and interoperability.

According to the IEEE Journal OF Internet of Things, an IoT system is a network of networks where, typically, a massive number of objects, sensors and devices are connected through communications and information infrastructure to provide value-added services via intelligent data processing and management for many different applications (Porkodi & Bhuvaneswari, 2014). For example, Radio Frequency Identification (RFID), Zigbee and Wireless Sensor Network (WSN) are used for wireless communication among diverse systems. In addition, The Internet of Things of European Research Cluster (IERC) provides a succinct definition of IoT, stating that it is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols, where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network (Gaikwad, Gabhane, & Professor, 2015).

In this regard, the characteristics of RFID serve as a prerequisite for the IoT. Admittedly, RFID is not new technology since it has been popularly used in the early twentieth century. The popularity of RFID lies in its practicality in a wide variety of applications. As such, it can virtually provide almost limitless potentials for future applications. Specifically, RFID technology can be efficiently used to monitor manufacturing products that constantly moving and have low visibility (Bachelor, 2014). Hence, it is not surprising that the use of RFID technology has been pervasive in many industries. More specifically, the technology has almost been fully utilized in the manufacturing industry, in view of the diversity and complexity of manufacturing products that need to managed efficiently.

For example Wal-Mart has been using RFID technology since 2003, the impact of which has made the company's operations become more efficient. This technology is poised to become more dominant in this decade as many industries across the globe will experience fast and high growth. For example, the Asia-Pacific region is expected to experience high economic growth in the next 10 years, with many expensive and massive projects being carried out by a strong legion of private companies and government enterprises(Bachelor, 2014). For example, Canon is one of the leading and largest camera producers in the world that is using the RFID technology in their manufacturing process. In lens production, considerable quantities of waste material resulted from the grinding process. Previously, based on its conventional system, about 1% of defective products could be recorded. Figure 1.1 shows a figure highlighting various costs along the process chain at Canon. For each machining process, the costs of raw materials, system, and the disposal were recorded and distributed between outputs. As shown, 32% of the costs were attributed to material loss. The figure shows that within six months the company managed to cover the cost of deployment of RFID system by only focusing on supervisory labour cost. Clearly, further innovarove use of RFID can lead to fewer downtimes, higher productivity, and reduced maintenance cost.

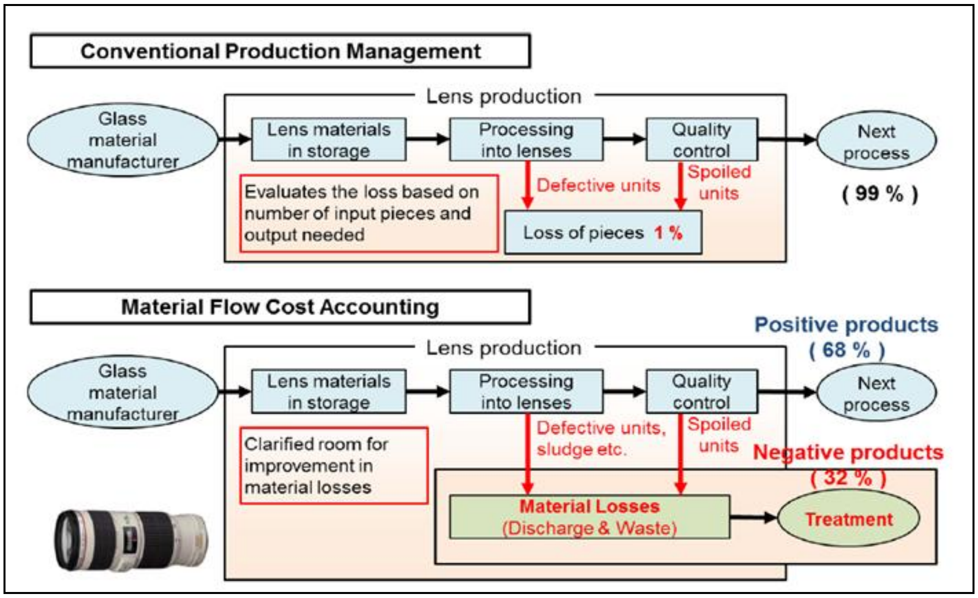

Figure 1.1. The Cost of Materials of Canon's Lens Production Based on Conventional System (Resources, 2013)

1.2 Problem Statement

Typically, a firm's stocks consist of a variety of inventories, including finished goods, work-in-progress (WIP) materials, and raw materials (Jou, Wee, & Chen, 2009). As such, keeping track of such materials is very critical to the company's operational efficiency. Nevertheless, this has become a major problem to many manufacturing companies, given their inability to gather and control accurate product and process data, causing massive loss of profits and competitiveness (North, 2013). Nowadays, the manufacturing industry is facing many challenges due to a host of problems, notably because of a lack of reliable tracking systems to control, monitor, and manage the flow materials and items (Ruankaew & Williams, 2013). In fact, material tracking and control systems are new to the manufacturing industry, as many companies strive to improve their manufacturing productivity and quality of products.

Without any anomalies in the expected physical material flows, the amount of good available in an inventory system would increase each time an expected replenishment is received and decrease each time a demand is satisfied. The existence of several unknown outputs and inputs, such as missing, misplaced, or inaccurate items (which are attributable to unreliable suppliers), the actual material flow would differ from the nominal one (Ruankaew & Williams, 2013). Thus, perfect synchronization between the physical flow and the associated data recorded in the information system is needed to verify if events happened as planned (without any loss or delay of products) and to identify the reasons for any deviations that took place.

In recent years, the use of mobile phones has been increasing rapidly, far surpassing the use of personal computers (PCs). Therefore, it is not only appropriate but also timely for manufacturing companies to capitalize on the accessibility and mobility of mobile devices to keep track and obtain product data quickly and accurately. With mobile information system, users are no longer required to physically go to the various process stations of a manufacturing shop floor to collect data or information of product parts, items, or components. In this study, the researcher propose a novel monitoring system, designed and developed using a multi-disciplinary approach with the use of an embedded system, RFID technology, Zigbee technology, wireless mesh network (WMN), android operating system, user interface, and Java Application. Specifically, the development of