MISSING TAGS DETECTION ALGORITHM FOR RADIO FREQUENCY IDENTIFICATION (RFID) DATA STREAM

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A thesis submitted in
fulfillment of the requirement for the award of the
Degree of Master of Information Technology

Faculty of Computer Science and Information Technology
Universiti Tun Hussein Onn Malaysia

AUGUST 2019

In the name of Allah swt, Most Gracious, The Merciful

Peace and blessings to the beloved Prophet Muhammad S.A.W and his family.

Special dedication to my late father Zainudin Bin Atan, this is for you Abah. Also to my mother Rohani Binti Khalid, thank you for your support and encouragement. My siblings, Ili, Aqmaa, Atiaa, Aniq, Faiq, Afiq and Illyas, thank you for understand me. Thank you for keep supports me.

This thesis is dedicated to all of you.

ACKNOWLEDGEMENT

Alhamdulillah, thank you to Allah swt for this knowledge. Thank you for the strength and blessing in completing this study. I would like to express my sincere gratitude to my advisor Assoc. Prof. Dr. Hairulnizam Bin Mahdin for the continuous support of my master research, for his patience, motivation and knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my master study.

Also, sincerely acknowledge to Universiti Tun Hussein Onn Malaysia (UTHM) for providing financial assistance appointment as a research assistant under Multidisciplinary Grant (MDR).

I would also like to thank my ibu for her wise counsel, her prayers and supports. My family, you are always there for me. Finally, there are my friends. We were not only able to support each other by deliberating over our problems and findings, but also happily by talking about things other than just our papers. Thank you for all, I will not finish this master journey without the help from all of you. May Allah swt blessing our life. In shaa Allah.

ABSTRACT

RFID technology is a radio frequency identification services that provide a reader reading the information of items from the tags. Nowadays, RFID system is rapidly become more common in our live because it cheaper and smaller to be track, trace and identify the items. However, missing tag detection in RFID can occur due to RFID operating environment such as signal collisions and interferences. Missing tags also called as false negative reads is a tag that is present but it cannot be read by the nearby reader. The consequences of this problem can be enormous to business, as it will cause the system to report incorrect data due to an incorrect number of tags being detected. In fact, the performance of RFID missing tag detection is largely affected by uncertainty, which should be considered in the detecting process phase to minimize its negative impact. Thus in this research, an A^C complement algorithm with hashing algorithm and Detect False Negative Read algorithm (DFR) is used to developed the Missing Tags Detection Algorithm (MTDA). A^C complement algorithm was used to compare the different in each set of data. Meanwhile, DFR algorithm was used to identify the false negative read that present in the set of data. There are many approaches has been proposed to include Window Sub-range Transition Detection (WSTD), Efficient Missing-Tag Detection Protocol (EMD) and Multi-hashing based Missing Tag Identification (MMTI) protocol. This algorithm development has been guided by methodology in four stages. There stages including data preparation, simulation design, detecting false negative read strategy and performance measurement. MTDA can perform well in detecting false negative read with 100% detected in 3.25 second. This performance shows that the algorithm performs well in execution time in detecting false negative reads. In conclusion, it will give insight on the current challenges and open up to new solution to solve the problem of missing tag detection.

ABSTRAK

Teknologi RFID adalah perkhidmatan pengenalan frekuensi radio yang menyediakan pembaca membaca maklumat item dari tag. Pada masa kini, sistem RFID semakin menjadi biasa di dalam hidup kita kerana ia lebih murah dan lebih kecil untuk dijejaki, mengesan dan mengenal pasti item. Walau bagaimanapun, pengesanan tag yang hilang dalam RFID boleh berlaku kerana persekitaran operasi RFID seperti perlanggaran dan gangguan gangguan isyarat. Tag yang hilang juga dipanggil sebagai bacaan negatif adalah tag yang ada tetapi ia tidak dapat dibaca oleh pembaca yang berdekatan. Akibatnya boleh menjadi masalah sangat besar untuk perniagaan, kerana ia akan menyebabkan sistem melaporkan data yang salah kerana jumlah tag yang tidak dapat dikesan. Malah, prestasi RFID pengesanan tag yang hilang sebahagian besarnya terjejas oleh ketidakpastian, yang harus dipertimbangkan dalam fasa proses pengesan untuk meminimumkan kesan negatifnya. Oleh itu, dalam kajian ini, algoritma pelengkap A^C dengan algoritma *hashing* dan mengesan Algoritma Pengesanan Tag Hilang (MTDA). Algoritma pelengkap A^C digunakan untuk membandingkan dalam setiap set data. Sementara itu, algoritma DFR digunakan untuk mengenal pasti bacaan negatif dalam set data. Terdapat banyak pendekatan yang telah dicadangkan untuk merangkumi Pengesanan Peralihan *Sub-range Window* (WSTD), Protokol Pengesanan Hilang-Tag yang Cekap (EMD) dan protokol Pengenalan Tag Hilang yang berasaskan *Multi-hashing* (MMTI). Algoritma ini telah dipandu oleh metodologi dalam empat peringkat. Terdapat peringkat termasuk penyediaan data, reka bentuk simulasi, mengesan strategi bacaan negatif dan pengukuran prestasi. MTDA boleh melaksanakan dengan baik dalam mengesan membaca negatif palsu dengan 100% dikesan dalam 3.25 saat. Prestasi ini menunjukkan bahawa algoritma berjalan dengan baik dalam masa pelaksanaan. Sebagai kesimpulan, ia akan memberikan wawasan tentang cabaran semasa dan membuka penyelesaian baru untuk menyelesaikan masalah kehilangan pengesanan tag.

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LIST OF SYMBOLS AND ABBREVIATIONS

a	-	First Array
b	-	Second Array
B2B	-	Business to Business
CRM	-	Customer Relationship Management
EMD	-	Efficient Missing Tag Detection Protocol
EPC	-	Electronic Product Code
ERP	-	Enterprise Resource Planning
f	-	Time Frame Slot
GPS	-	Global Positioning System
i	-	Value Of Data
ID	-	Identification
IIP	-	Iterative ID Free Protocol
ioT	-	Internet of Things
j	-	Value Of Second Data
K	-	Subset Of Reader
m	-	Length Of Second Array
M	-	Missing Tag
MMTI	-	Multi-Hashing based Missing Tag Identification
N	-	List inventory
n	-	Length Of First Array
RFID	–	Radio-Frequency Identification
SCM	-	Supply Chain Management
SMURF	-	Statistical Smooth For Unreliable RFID Data

t	-	epoch/ time
TRP	-	Trusted Reader Protocol
WMS	-	Warehouse Management
WSTD	-	Window Sub-range Transition Detection

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LIST OF PUBLICATIONS

1. Nur'Aifaa Zainudin, Hairulnizam Mahdin, Rd Rohmat Saedudin, Mohd Sanusi Azmi, Mokhairi Makhtar, Norhailawati Misran. (2018). A Review on Missing Tags Detection Approaches in RFID System. *International Journal on Advanced Science, Engineering and Information Technology*, Vol. 8 (2018) No. 6, pp 2635-2640
2. Nur'Aifaa Zainudin, Hairulnizam Mahdin, Deden Witarsyah, Mokhairi Makhtar, Mohd Izuan Hafez Ninggal, Zirawani Baharum. (2018). An Efficient Approach to Detecting Missing Tags in RFID Data Stream. *Indonesian Journal of Electrical Engineering and Computer Science*. Vol 11 No 3 pp 1024-1213.

CHAPTER 1

INTRODUCTION

1.1 Introduction

RFID technology uses radio-frequency waves to automatically identify people or objects. It has been used in a wide variety of applications such as apparel, supply chain management and food industries (Bibi et al., 2015). However, there are still challenges to be solved in an RFID system, and one of them is missing tag detection problem. Missing tag detection can happen due to signal collision (Ma, Lin & Wang, 2012), electrical interference (Xiong et al., 2012) and unknown resources (Xie et al., 2014). When an RFID reader misses detecting a tag, it will affect the data integrity of the system. The system will send an incorrect tag count to the backend processing and will feed user with misleading reports.

In a supermarket, for example, a reader is installed on a rack to read all the tagged items (Chen et al., 2016). When a reader misses reading the tagged items, it will feed the system with an incorrect total, which is less than the actual. The decrease in number of items will trigger the system to instruct respective personnel to do item replenishment on the rack. A wrong instruction is issued in this case because of incorrect readings made by readers. Moreover, at a certain point, the system can also instruct the department to order new stock because of this error. Another example is a factory that implements RFID to automate their system. When RFID misses to read an item moving on the conveyor, the system will trigger incorrect action to the item at the next stop in the production process. In the case of a car assembly plant (Zhenxin & Zhuliang, 2014), incorrect paint color may be applied to the wrong parts because of the misreading problem.

Missing tag detection in RFID can occur due to RFID's operating environment such as signal collisions and interferences. The performance of RFID missing tag detection is largely affected by uncertainty, which should be considered in the detecting process phase to minimize its negative impact.

This research reviewed some of the prominent approaches to tackle the missing tag detection problem. There are many approaches that have been proposed including Window Sub-range Transition Detection (WSTD) (Tang, Du, Tan et al., 2012), Efficient Missing-Tag Detection Protocol (EMD) protocol (Luo, Chen, Li et al., 2011) and Multi-hashing based Missing Tag Identification (MMTI) protocol (Liu, Li, Min et al., 2014). The reviews done will give insight on the current challenges and suggest new solutions to solve the problem of missing tags.

RFID false negative read phenomenon occurs when the reader is unable to detect an RFID tag. The reasons for this issue are complex because if there are two or more RFID readers read the tags simultaneously, tag collision may happen preventing the tags from being read properly (Liang et al., 2017). RFID reader reading device is unable to read the tags while receiving signal from other tags at the same time and prevent tags from being read. The results indicate that for medium to high read rates, the impact of false negative RFID reading on the cost remains modest (Hu, Li & Lu, 2013). The case of detecting missing RFID tags can be classified into three categories. First is missing tag event detection protocol that detects any missing tag without pinpointing which tag is missing, second is probabilistic missing tag identification that will identify which tag is missing, and lastly is complete missing tag identification protocols that pinpoint which tags are missing and report the identity of the missing tags (Liu, Li, Min et al., 2013). However, this research will just focus on the second case of probabilistic missing tag identification. This type of case will identify which tags are actually missing in the vicinity and classify them as false negative reads.

1.2 Problem Statement

One of the challenges in existing RFID system is missing tag detection that is also known as false negative readings. Due to several factors, the status and current location of an object cannot be identified – it could be in the distribution center, in transit to the store, still in its packaging or even stolen. Furthermore, missed readings result to incomplete RFID data and in asset tracking, this issue leads to difficulty to locate the objects. Hence, it is important to develop effective asset tracking application for managing missed reads in raw RFID data.

1.3 Aim

The aim of this research is to develop novel solution for detecting false negative reads in passive RFID system.

1.4 Research Objectives

The objectives of the research are as follows:

i. To study the requirements of developing missing tags detection algorithm
ii. To propose false negative reading detection algorithm in RFID data stream.
iii. To evaluate algorithm with existing approaches in terms of execution time and rate of false negative detection

1.5 Scope of Research

The research will be focusing on false negative readings problem, which is a common issue in the RFID system. The developed approach will solve the problem and minimize effort required to get a complete data stream. The data will be prepared a few sample to test the algorithm. The sample data is generated by using Poisson distribution because the data that has been generated is meet the RFID data criteria (Sarac et al., 2015). The detecting strategy is based on compliment algorithm with hashing and combine with false negative detecting algorithm. Furthermore, the developed approach will be test and compared with existing approaches to ensure that it is reliable in detecting the false negative read.

1.6 Significance of Research

Presently, the existing approaches are able to solve the missing tag problem. However, some constraints need to be considered in reducing the number of missing tags being read. For an example, in a large warehouse, the manager has to check the existence of all items at stipulated times because RFID tags identify the items, and their identification is recorded in the database for later references (Lim, Shim & Lee, 2015). This action will require a lot of time and manpower. Another example in warehouse management is the administrator needs to check the specified inventories according to the list of goods that is attached to an RFID tag with the unique ID. In this situation, both execution time and energy efficiency will increase and it becomes a crucial problem to devise efficient for identifying the missing tags (Xie et al., 2014).

In such incident, there are ways to reduce the missing tags. The tags' ID can be collected and compared with the data set to detect the missing tags. If the items are present, RFID system can help to detect their actual location because every tag has a unique ID and a sensing feature to detect both vibration and tilting. However, a system cannot pinpoint which tags are missing and the process of detecting missing tags is slow because the missing tags need to be monitored instead of searching individually for missing tags (Chen et al., 2013).

Furthermore, a crucial factor that must be considered when designing a tag search protocol is timeliness. This is to ensure that its execution will not interfere with other normal inventory operations (Zhu et al., 2014). By reducing the execution time when identifying the missing tags, it will help the system in implementing a reliable detection system.

1.7 Thesis Organization

The research consists of five chapters. Chapter 1, Introduction, presents introduction to the research, research problem statement, research aim, research objective, scope of research, significance of research, research organization and summary. Chapter 2, Literature Review, will provide a brief overview of RFID, issues of missing tags and unreliable data. In addition, this chapter also presents relevant background information on previous RFID missing tag detection approaches. Chapter 3, Research Methodology, will discuss brief steps and strategy on how to detect missing tags and time required to perform this process. Meanwhile, Chapter 4, Results and Findings, will elaborate the result and analysis of the simulation done using the proposed algorithm. The proposed algorithm will be compared with other existing algorithms in terms of data reliability. Chapter 5, Conclusion and Recommendations, will provide the study's conclusion and recommendations for future works in order to improve system efficiency and data reliability in RFID systems.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The RFID technology is gaining attention within the Internet of Things (IoT) community due to its many advantages (Yao, Xiong & Luo, 2015). It has the facility for collecting data in many types of application (Yu et al., 2015). Based on a survey in 2014, the total market value for RFID is $9.2 billion and expected to reach $30.24 billion in 2024 (Das & Harrop, 2014). However, there are many issues regarding current usage of RFID.

Typically, an RFID system requires tags to be attached to the items as identifiers of the objects. Readers are the devices that will communicate with the tags using radio waves. The main advantage of RFID technology is it reduces the supply chain cost and provides automated identification. However, one of the limitations of the RFID system is missing tag detection or missed readings.

Missing tags detection is a serious issue because it can indicate that the corresponding object is actually missing from the monitored region. Missing tag detection in RFID occurs due to the sensitivity of RFID tag and reader performance. In terms of data, most of the data generated by RFID are unreliable because they may be insufficient or repetition (Huang, Mu & Zheng, 2015). This is because the RFID system has parallel transponders and receiver.

The transponders include RFID tag meanwhile the receiver include RFID reader. The RFID tag divides into active tag and passive tag. The problems that passive tag can occur are missing tags, tag collision or tag cloning. In this research, the focusing is on missing tags. Window Sub-range Transition Detection (WSTD) (Tang et al., 2012), Efficient Missing-Tag Detection Protocol (EMD) protocol (Luo et al., 2011) and Multi-hashing based Missing Tag Identification (MMTI) protocol (Liu et al., 2014) are examples of existing approaches to solve the problem. However, it is not enough to only detect the missing tags, we need to obtain detailed information about the missing items to assess the seriousness of the issue and make relevant improvements. The consequences of this problem will cause the system to provide incorrect information to the user due to incorrect number of tags detected. Figure 2.1 illustrates RFID missing tags taxonomy.

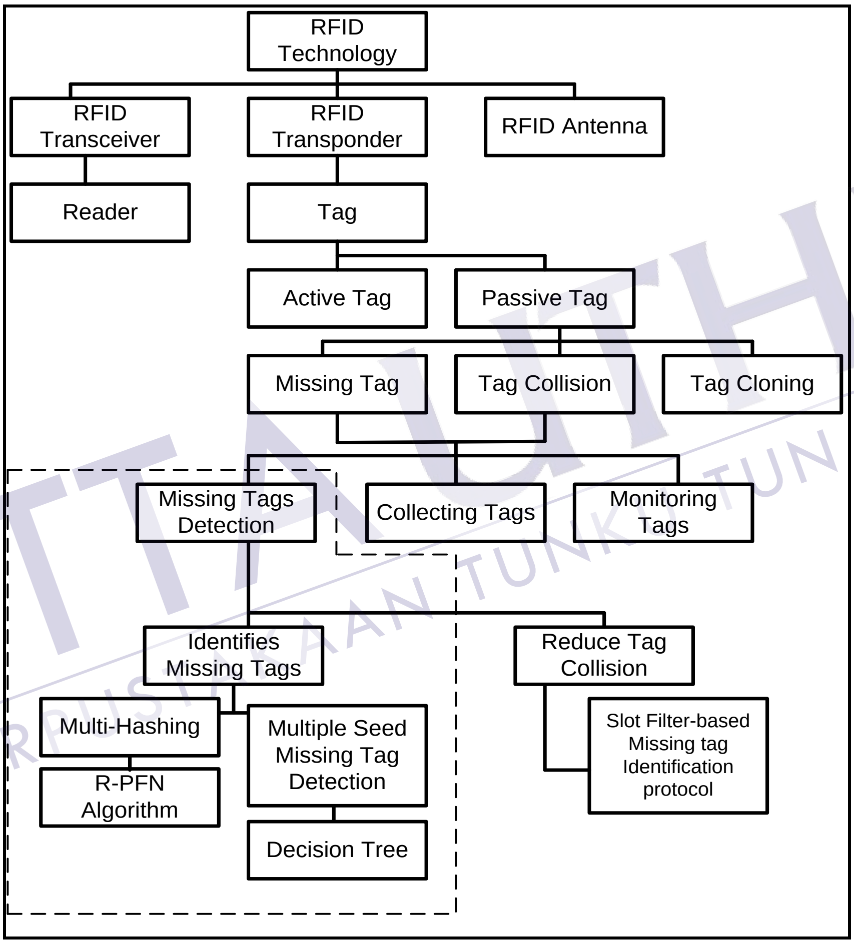

Figure 2.1 RFID Missing Tags Taxonomy

This chapter will review existing approaches that have been used to solve the problem of missing tag detection, namely Efficient Missing Tag Detection Protocol (EMD), Multi-Hashing based Missing tag Identification (MMTI) and Window Sub-range Transition Detection (WSTD). Analysis will be done on the advantages of each technique in dealing with false negative reads in RFID. This analysis will be use to come out with a better algorithm in tackling this problem. The next sections in this chapter will discuss on RFID components, RFID missing tag architecture and existing RFID approaches.

2.2 RFID Components

There are four fundamental components in a basic RFID system namely tags, readers, middleware and backend system. Interface layer compresses thousands of tag signals into a single identification system and acts as a conductor between the RFID hardware elements of the client's application software systems, such as inventory, accounts receivable, shipping and logistic. The architecture is illustrated in Figure 2.2.

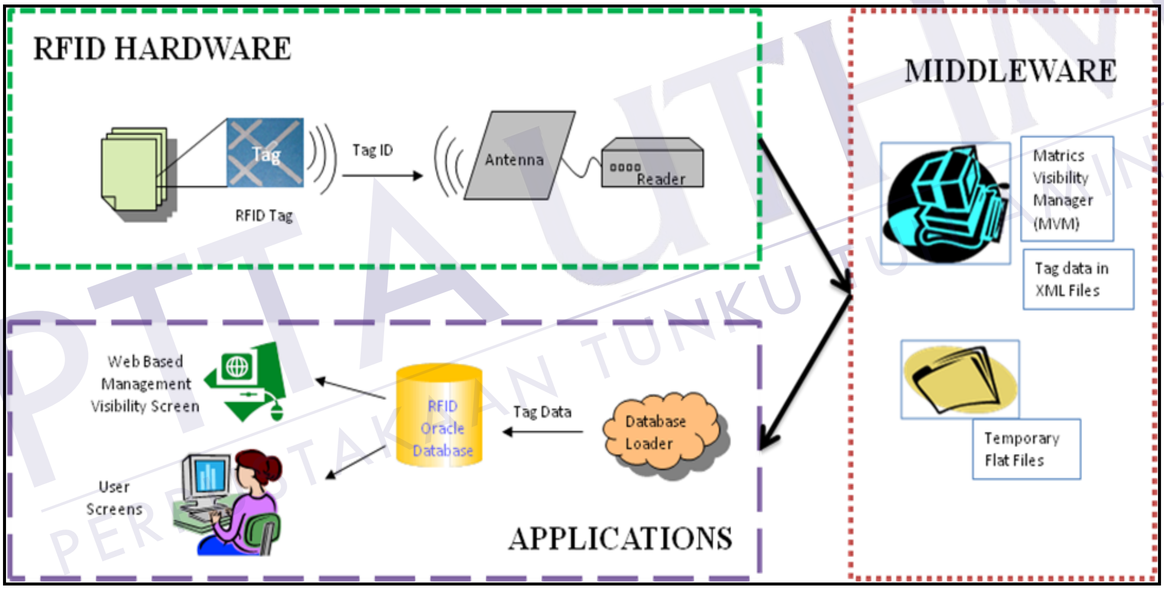

Figure 2.2 RFID Architecture

RFID hardware is a hardware used in RFID to detecting the tags. The antenna will use as middle hardware to transfer the RFID tag information to be reads by the RFID reader. The tag information will be process in the middleware layer before the information can be access by the users.

2.2.1 RFID Tags

Tags are the most fundamental components in RFID systems (Good & Benaissa, 2013). There are three kinds of RFID tag, which are active tags, passive tags, and semi-passive tags. These tags are categorized based on their power source. Generally, active tags are more dependable and accurate because the tags will broadcast the signal to the reader. Meanwhile, passive tags have no internal power source and depend on the RFID reader to transmit data. Semi-passive tags are similar to active tags, but it does not broadcast the signal until the RFID reader transmits a signal. In RFID tag, have some mixed numbers and letters. A header and EPC manager will be assign by EPC global, meanwhile object class and serial number will be assign by EPC manager owner. Figure 2.3 illustrate example of standard structure an RFID tag.

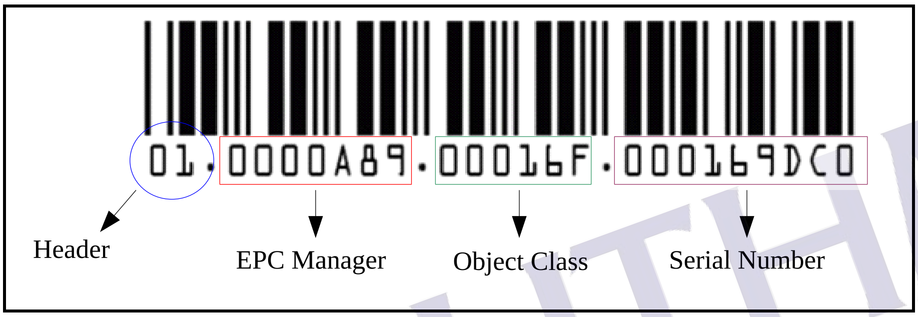

Figure 2.3 Example of an RFID Tag

Active tags are battery-powered tags that could cover range of up to one hundred meters. It can integrate temperature sensing technology or Global Positioning System (GPS). One of the problems with active tags is multiple active tags can be read at once, causing the report of multiple tags. Meanwhile, passive tags need to be programmed by the manufacturer or during the installation. These tags are powered by high power electromagnetic field generated by the antennas. Multiple passive tags in the same area can be recognized at once resulting to tags collision. Lastly, semi-passive tags are similar to active tags as it has its own internal power source. However, the reader did not broadcast the signal until it is woken by a signal from a reader.

In this research, we are using RFID data from passive tags. This type of tags is easier to manage due to their passive nature. In addition, the tags are usually powered by highly powered electromagnetic waves that are suitable for doorway detecting. These tags usually use ultra-high frequency that is unique to different tag types because of the simplicity of the tag. Due to interference from the collision of several radio frequencies, multiple tags can be detected concurrently, resulting the

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