الجامعة الإسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيرسيتي إسلام انتارابغسا ملايسيا

DEVELOPMENT OF ALGORITHM FOR TRAFFIC MANAGEMENT USING RFID

BY

JAIZ ANUAR BIN YEOP JOHARI

A dissertation submitted in partial fulfilement of the requirements for the degree of Master of Sciences (Computer and Information Engineering)

Department of Electrical and Computer Engineering
Kulliyyah of Engineering
International Islamic University Malaysia

APRIL 2008

ABSTRACT

A new application of radio frequency identification (RFID) in road and transport management is presented. The system avoids problems that usually arise with other traffic control systems such as image processing and beam interruption techniques. A state of the art of ubiquitous real time traffic management is proposed. It provides a solution for multi-vehicles, multilane, multi road junction areas, where high probability of traffic congestion exists. The proposed Intelligent Dynamic Time Scheduling" algorithm emulates the judgment of a team of traffic policeman on duty. The real time operation can compliment other expert system such as self-learning swarm intelligent concept. Hence the system aims at saving a large amount of man-hours caused by traffic problems and accidents, where prevention can save lives and property. It is also able to manage priority emergency tag vehicles. It offers a valuable detailed database records and preference to planner and investigators. A system model assumes that vehicles are tagged with RFID to provide easy online access to the system that identifies type, size and route of a specific vehicle. The information is stored in a centralized server. The data is then used to organize traffic into cluster of appropriate numbers, commensurate with online statistical analysis. Intelligent algorithm sets real time Green wave speeds for Max junction efficiency, and multiple controllers follow an intelligent mark to space ratio of R-G according to batch size of the traffic cluster. Real time determination of lane and routing priority decisions are taken and changed with the dynamic situation. One of the main features of the system is that the network architecture can readily incorporate the existing centrally controlled system which integrates CCTV cameras, wireless link and remotely controlled traffic light switches. Another major feature is that the operations can be communicated from any head-quarters to any location in the system securely via internet.

الخلاصة

يقدم البحث تطبيقا جديدا لمبتكرات التعرف والتمييز بواسطة الترددات الراديوية، حيث يمكن استخدام دوائر الكترونية صغيرة جدا لا تحتاج الى مجهزات قدرة عالية في أنظمة ادارة الطرق والمرور بشكل كفؤ. ويتميز هذا النظام عن غيره بأنه يتفادى المشاكل التى تنطوي عليها تقنيات الأنظمة الأخرى مثل معالجة الصور وقطع الأشعة.المقترح في هذا البحث يقدم نظاما شاملا لتقنية حديثة يمكن بواسطتها ايجاد الحلول الديناميكية للسيطرة على وسائط نقل من أنواع مختلفة في طرق متعددة المسارات وعند مناطق تقاطع متعددة الشوارع حيث ترتفع احتمالية الاختناقات المرورية. يقوم النظام على ايجاد انسيابية زمنية كفوءة ذات برمجية ذكية لها القدرة على التكيف الديناميكي حسب الموقع المروري. إن التشغيل المتكيف للنظام في الزمن الحقيقي يتكامل مع النظم الخبيرة مستفيدا من فكرة انسياب السرب. ولذلك فانه يهدف الى توفيرقدر أكبر من ساعات العمل التي تضيع في زحمة الانتظار وما قد تسببه الحوادث من هدر للارواح والأموال. كما أن للنظام القدرة على منح أولويات لسيارات الطوارئ كالاسعاف والحريق والشرطة وما الى ذلك من خلال تزويدها بشارات خاصة تقوم المنظومة بتمييزها تلقائيا.إن المنظومة قادرة علىتوفير قاعدة بيانات تفصيلية عالية الأهمية ترتبط بنظام معلومات في حاسوب خدمي مركزي مما يساعد الباحثين والمخططين على وضع التدابير والإجراءات المناسبة.يفترض النموذج المقترح أن كل واسطة نقل لها شارة خاصة بها توفر مدخلا مباشرا الى منظومة التعرف التي تحدد النوع والصنف والحجم والمسار لتلك الواسطة. ثم تخزن المعلومات في الحاسوب الخدمي المركزي حيث تعالج المعطيات فتقوم بتنظيم المرور على شكل مجموعات لكل منها عدد مناسب تقرره الحالة القائمة المبنية على تحليل إحصائي آني. ثم تقوم خوارزمية ذكية بتحديد الزمن االلازم لمجموعة اشارات مرورية متسلسلة تحدد من خلالها أقصي سرعة لموجة خضراء، تحقق أعلى كفاءة ممكنة لكل تقاطع طرق وذلك بتحديد زمن الانطلاق وزمن الوقوف عند كل إشارة من اشارات المرور الواقعة تحت سيطرة المنظومة. وهذا الزمن يمكن أن يتغير تلقائيا حسبما يتطلبه الموقف وتقتضيه الأولويات.ولعل المزية المهمة للنظام المقدم تكمن في امكانية تطبيقه فورا وتكامله الآني مع منظومات قد تكون قائمة فعلا تشتمل على دوائر مراقبة تلفزيونية مغلقة ومفاتيح إشارات مسيطر عليها لاسلكيا من بعد. والمزية الأخرى هي إمكانية التراسل ما بين مراكز التشغيل أو من مراكز السيطرة المختلفة بشكل آمن عن طريق شبكة الانترنت.

ACKNOWLEDGEMENT

I wish to sincerely thank my supervisor Prof. Dr. Khalid Al-Khateeb, for his encouragement, professional guidance and personal advice. It was a pleasant and priceless experience to work under his supervision.

Thanks are extended to Kulliyyah of Engineering committee members, Prof. Dr. Ahmad Faris, Prof. Dr. Momoh Jimoh, Dr. Ir. Wajdi Al-Khateeb, Assoc. Prof. Dr. Ahmad Fadzil and Assoc. Prof. Dr. Othman Khalifa, who gave me support and encouragement.

My greatest thanks go to my beloved mother '*omak*', Aminah Daud and my late father '*apak*' Yeop Johari Yaakob, for their endless sacrifice in bringing me up and offering me an opportunity for education. Any undertaking such as endeavor would be impossible without their support.

Finally I would like to express deeply grateful to my beloved wife Nur Azlean Ramlan and my son Naqib Darwish Anuar, who has offered moral support, encouragement, patient companionship and share bitterness during my studies toward the thesis completion.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion; it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Computer and Information Engineering)

……..
Khalid Al-Khateeb
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Computer and Information Engineering)

……..
Ahmad Fadzil Ismail
Examiner

This dissertation was submitted to the Department of Electrical and Computer Engineering and is accepted as a partial fulfilment of the requirements for the degree of Master of Science (Computer and Information Engineering)

……..
Othman Khalifa
Head, Depart of Electrical and
Computer Engineering

This dissertation was submitted to the Kulliyyah of Engineering and is accepted as a partial fulfilment of the requirements for the degree of Master of Science (Computer and Information Engineering)

……..
Ahmad Faris Ismail
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Jaiz Anuar Yeop Johari

Signature …….. Date …….

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

DECLARATION OF COPYRIGHT AND AFFIRMATION OF FAIR USE OF UNPUBLISHED RESEARCH

RADIO FREQUENCY IDENTIFICATION APPLICATION IN TRANSPORT MANAGEMENT

Affirmed by Jaiz Anuar bin Yeop Johari

…… ……

Signature Date

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Traffic Management Systems (TMS) in transportation engineering has advanced dramatically over the last few decades. The new and more flexible application of traffic control devices, software systems, computer hardware, communications and surveillance technologies and method of analysis have become wide-ranging. (Helmer, 1993).

Figure 1: CCTV Control Panel Monitoring System

Most of the deployments consist of traffic management centers equipped with closed-circuit television (CCTV) cameras, traffic sensors, electronic message signs, traffic signals and traffic controllers to monitor in real time and manage the traffic

movement on the streets for intelligent transportation system. Any information monitored and recorded at the management center will be informed to the traffic user or traffic patrol via radio, television, Internet, and electronic signs along the roadways [1, 2]. (Ingle, Williams, Sobhi, 1994)

According to (Gardner, 2005) [3] the need to understand the number and type of vehicles using national highways is becoming more and more important. The government has struggled with ways to record vehicular movement. The government must have intelligent transportation system that requires real-time knowledge of traffic movement to be effective. Protection of our nation's aging infrastructure requires detailed understanding of the number, type, and minimum weight (without considering load) of the vehicles using roads and bridges.

1.2 OVERVIEW

The planning and development of RFID application in Malaysia has been discussed in the Ninth Malaysian Plan for expanding the communications network to ensure more equitable access to information and services. RFID technologies have been highlighted for implementation in order to create ubiquitous network. Under this environment, the RFID application through sensory tagging and tracking functionalities will be used to intensify information usage which can generate new value added activities and services within the ICT industry in Malaysia (Economic Planning Unit, 2006) [4].

Malaysia has planned to drive forward to deliver an advanced information, communications and multimedia service starting from 2006 until 2010. It has been stated in the strategic planning of Malaysian Ministry of Energy, Water and Communication. (MyICMS 886, 2006) [5]. They have identified 8 items of services, 8

items of infrastructure and 6 items of growth areas which aim to create a catalystic cycle by enhancing the existing investment in information, communication and multimedia services.

The planning of RFID development in Malaysia falls under the strategic growth area which focuses on the development of embedded components and devices. The multi range communication services offered by RFID technology will support the creation of multi range wireless connection type of applications which use low power. These types of communication have very large market potential in sensors-surveillances and intelligent system, and will encourage the local manufacturing of RFID tag that can be used in multi range communication of the different industries, allowing for computer peripheral connections and also between end user and electronic devices. (MyICMS 886, 2006)

The effort of designing RFID application locally will be intensified to mainstream ubiquitous access to other facilities and to promote wider adoption and usage in all aspect of everyday life. This approach will enhance Malaysia's position as a global ICT and multimedia hub.

In fact, RFID technology is the simplest form of read-only system. It has been introduced as a possible replacement for barcode technology. The advantages it offers include precise read accuracy, the ability to survive demanding environments, and less dependence on the line-of-sight requirements especially for the high end reader.

Studying its potential application in Malaysia, it is high-time to develop such fast, reliable, and do not require physical sight or contact systems in many areas. This research will focus on the implications and technological aspects of RFID

implementation in the TMS. The result from developing this system will enhance the capability of performing online statistical analysis and real time control of the TMS.

1.3 PROBLEM STATEMENT

Today, a part of transportation problem is congestion due to inefficient traffic management [6] (Kidokuro and Hanh, 1993). More often than not, the traffic congestion can be considered a routine problem for Malaysian drivers since it happens daily at a specific known area and known time. Three aspects have been identified as possible major factors that contribute to routine traffic congestion:

i. Inefficient traffic light management

ii. Improper management of tidal-flow traffic

iii. Outdated road planning procedure

1.3.1 Inefficient Traffic Light Management

A standard traffic light deployed in many junctions currently is based on timing mechanism which has been set up during the pre-installation. According to (Holtek, 2006), a normal traffic control setup is based on timing setup in order to control a normal traffic. Every junction necessarily required a different timing setup for its traffic light which is depend on the traffic congestion. The program example of traffic controller configuration has been viewed from the Holtek Semiconductor website [7] (Holtek, 2006). This inefficient scenario initiates ideas to the traffic management designers, to design intelligent traffic light systems in order to manage and reduce the time wasted experienced by drivers on the road.

1.3.2 Improper Management of Tidal-Flow Traffic

The traffic is typically congested at one side only, at certain particular of time, especially early morning when people are rushing to go to the office and after office hours.

Figure 2: One way traffic jam at Jalan Kuching 1

Figure 3: One way traffic jam at Jalan Kuching 2

Figure 4: Tidal-flow management at Jalan Sentul 1

Figure 5: Tidal-flow management at Jalan Sentul 2

Figure 2 and 3 show the reality of single sided or one way traffic jam along *Jalan Kuching* (Kuching Road) every morning which happens around 7:30 am – 9:00 am. The traffic jam flow then switches to the other side after office hour which is around 5:30 pm – 7:00 pm. It is a routine activity and has a unique daily pattern. Figure 4 and 5 show a manual tidal-flow management at *Jalan Sentul* (Sentul Road).

By the way, according to Gunay, advance electronic traffic control in the information technology era gained more predominance as the limitations of traditional traffic engineering became apparent. It shows that, manual tidal flow traffic management cannot be considered as a proper solution for modern traffic management [8] (Gunay, 1998).

1.3.3 Outdated Road Planning Procedure

Currently, there is no precise indicator being used for road planning in Malaysia. By referring to the web portal of Ministry of Work Malaysia, they have mentioned that their planning activities are based on the statistical analysis and documentation. The current system that they used for indicating the statistical analysis is through survey and research. This is the way they used to collect the data for future analysis. [9] (Ministry of Work, 2006)

The time taken to plan began from the data collection until complete analysis. By the time they completed the analysis; actual problem of the road traffic had changed. Road traffic analysis based on sampling method is not relevant and not practical to be imposed anymore. So far, there no mechanism to analyze the real time traffic problem and provide the solution straight away.

1.4 RESEARCH OBJECTIVES

In conjunction with the Ninth Malaysia Plan, the main objective of this research is to develop an algorithm for Traffic Management System by using RFID devices. The developed algorithm then will be used to simulate the intelligent traffic sequence for the proposed TMS concept. This simulation provides a possible solution for multi vehicles, multi lane, multi road junction areas, where high probability of traffic congestion exists. The advantages, capabilities and limitations of RFID technology will be examined in order to achieve an advance and intelligent TMS.

Looking at the current practice for generating the statistical analysis for national vehicle information, as mentioned by (Gardner, 2005); it is impossible to continuously monitor traffic at every discreet point along the roadway. Therefore, there has always been a requirement to collect data samples from the traffic streams and apply those samples to represent the roadways in general. (Gardner, 2005) worries that numerous studies have been conducted to address each of these needs, but given the unpredictability of traffic movements, much improvements are still possible.

He proposed that advanced statistical methods for sampling and analysis may be applied, but a comprehensive, continuous data set is needed to develop sampling and analysis strategies. Despite that, by tagging all vehicles in Malaysia with RFID tags, a comprehensive statistical data analysis can be easily produced without the need for advanced sampling methods.

The advantages of introducing RFID in the existing TMS are also discussed in term of cost implications and how to utilize their merits to improve the current TMS in Malaysia. The focus of the work is multifold which include cost implications that include: installation compatibility for integration with the existing system, reliability,

maintenance, projection of future demands, the expected lifetime of this technology and the security aspects of the system.

The potential aspects and capabilities of RFID networks are identified in order to facilitate its implementation as part of input devices required by TMS in Malaysia. The issue will also discuss how to integrate the data with inputs from other important agencies in order to establish a general database provided by the ubiquitous RFID network. This approach should improve the currently implemented system application.

The collected information from RFID tag which accumulated in the centralized database can be used for advance traffic management application. The advance TMS aims at saving a large amount of man-hours caused by traffic congestion and accidents. It also can intelligently manage routine traffic routing, able to manage priority emergency vehicles and organize the traffic into cluster for green wave speed.

1.5 SCOPE OF WORK

The scope of work in this research is to study and understand the actual traffic congestion behavior. The study attempts to understand the relation of the vehicle movement and traffic problem. It tries to find an indication from the traffic movement to indicate real time traffic condition. The study will also incorporate traffic condition analysis that to be carried out by simulating the road condition based on actual data collection. The simulation will be using RFID devices in the experimental setup.

The research then will study and investigate RFID technologies. It studies all information about RFID. This research then proposes the suitable RFID specification.

It will propose technical specification that is based on the previous scope work which is able to be used for simulating the traffic behavior.

The research then examines the element of traffic management which is traffic light controller. Firstly, it will try to understand how the existing system works, then this research will propose a new algorithm to generate an intelligent traffic light dynamically switching sequence. The proposed algorithm will have added value where it can be scalable for future extension. The RFID devices will be used to test and evaluate the proposed algorithm. It will also investigate any other possible future work requirement which can enhance the developed algorithm acquired in this research.

1.6 RESEARCH METHODOLOGY

The research methodology used in this research is divided into three stages.

1.6.1 Stage 1

Stage one is the basic requirement of the research, which focuses on understanding the whole concept of RFID technology and the definition of the problem statement by performing literature review. The results of the literature review are listed in the bibliography.

Most of the work will be based on the study of capabilities and limitations of RFID technology for the implementation in the TMS. Studies were conducted to determine the appropriate approach and methodology of designing the RFID application system for TMS. It also discusses the latest technical specification available for RFID technology which can be suited for the research. The technical

specifications items that mainly require in this research are tag, reader and system design. These specifications will help to design the suitable algorithm for traffic management using RFID.

1.6.2 Stage 2

The scope of work in the second stage focuses on the design of implementation. This research will design an algorithm of an auto generated online vehicle database for easy access information of the vehicle statistical analysis.

This research will also focus on the design of the ubiquitous RFID network architecture and real-time traffic control system and conducted case study field visit for tidal-flow traffic management system. PLUS Highway has been chosen as a study field for the case study of the "Average speed vehicle movement". While *Jalan Sentul* and *Jalan Kuching* has been chosen as a study filed of tidal-flow management requirement. *Jalan Sentul* also has been chosen as a study field for intelligent traffic light, routine traffic routing and green wave traffic cluster.

The expected outcome from this research can be proposed to improve the current traffic light management scheme (based on predetermined timing scheme) and tidal-flow management along *Jalan Sentul*. The same approach proposed for *Jalan Sentul* can be adopted to solve the tidal-flow jam along *Jalan Kuching* in Kuala Lumpur in the future.

1.6.3 Stage 3

The scope of work in the third stage will discuss the impact and result of introducing this methodology in the existing TMS. The research will study the advantages and