UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

Novel Architecture of Dual Band RFID Passive Tag With Malaysian Microchip (MMChip)

by
Dr. Widad Abdul Halim
Dr. Zaini Abdul Halim
Ms. Wan Nur Hafsha Wan Kairuddin
Mr. Tan Chek Ling

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BORANG FRGS – P3(R)

Kod Projek :	FRGS/FASA1-2010/(BIDANG)/(NAMA IPT)/(NO.RUJ. KPT)

2010

FINAL REPORT
FUNDAMENTAL RESEARCH GRANT SCHEME (FRGS)

Laporan Akhir Skim Geran Penyelidikan Asas (FRGS) IPT
Pindaan 1/2010

A

RESEARCH TITLE : **NOVEL ARCHITECTURE OF DUAL BAND RFID PASSIVE TAG WITH MALAYSIAN MICROCHIP (MMChip)**
Tajuk Penyelidikan

PROJECT LEADER : **DR.WIDAD BT ISMAIL**
Ketua Projek

PROJECT MEMBERS : 1 Dr.Zaini Bt Abdul Halim
(including GRA)
2. Wan Nur Hafsha Bt Wan Kairuddin
3. Tan Chek Ling

PROJECT ACHIEVEMENT *(Preslasi Projek)*

B

ACHIEVEMENT PERCENTAGE			
Project progress according to milestones achieved up to this period	**0 - 50%**	**51 - 75%**	**76 - 100%**
Percentage			X

RESEARCH FINDINGS		
	Indexed Journal	***Non-Indexed Journal***
Number of articles/ manuscripts/ books	1. Khadijah Kamarulazizi, Widad Ismail, "" Electronic Toll Collection System Using Passive RFID Technology " ID: 1500-JATIT-2K10, Journal of Theoretical and Applied Information Technology, Accepted for publications, November 2010, to be published in 2011 issue, SCOPUS listed 2. Bassam M.Al-Mahideen, Widad Ismail, Mokhled Altarawneh, "Wireless Image Sensors Network for Monitoring Dust on Roads in Arid Conditions", Electronics World Magazine, Volume 116, Issue 1892, August 2010, ISI listed 3. Mohamed Aboud Kadhim, Widad Ismail," Implementation of WiMAX IEEE802.16e Baseband Transceiver Based on Multi-Core Software Defined Radio Platform", International Journal of Computer Theory and Engineering (IJCTE), Vol. 2, No. 5, October, 2010, pp. 1793-8201, SCOPUS listed	4. Mohammed Aboud, Widad Ismail, "Performance Transmit and Receive Diversity Techniques for Different Modulation Signal", Journal of Telecommunications, Volume 4, Issue 2, September 2010 5. Mohammed Aboud, Widad Ismail, "Analysis of MISO WIMAX IEEE802.16d in SUI Multipath Fading Channels ", Journal of Telecommunications, Volume 3, Issue 2, July 2010
Paper presentations	**International**	***National***
	1. Saba Al-Rubaye, Anwer Al-Dulaimi, Laith Al-Saeed, H.S. Al-Raweshidy, Brunel Univ., Ekhlas Kadhum,	

	Widad Ismail, "Development of Heterogeneous Cognitive Radio and Wireless Access Network", 24th Meeting of Wireless World Research Forum, April 2010, Penang, Malaysia	
Others (Please specify)		

HUMAN CAPITAL DEVELOPMENT

Human Capital	Number		Others (Please specify):
	On-going	Graduated	
PhD Student	1		
Masters Student	2	1	
Undergraduate Students	4		
Temporary Research Officer	1		
Temporary Research Assistant	1		
Total			

EXPENDITURE *(Perbelanjaan)*

C

Budget Approved *(Peruntukan diluluskan)* : **RM 32,000**
Amount Spent *(Jumlah Perbelanjaan)* : **RM 37,218.69**

Balance *(Baki)* : **RM - 5,218.69**
Percentage of Amount Spent *(Peratusan Belanja)* : 116 %

ADDITIONAL RESEARCH ACTIVITIES THAT CONTRIBUTE TOWARDS DEVELOPING SOFT AND HARD SKILLS
(Aktiviti Penyelidikan Sampingan yang menyumbang kepada pembangunan kemahiran Insaniah)

D

International

Activity	Date (Month, Year)	Organizer
24th Meeting of Wireless World Research Forum, April 2010, Penang, Malaysia	12-14th. April 2010	Wireless World Research Forum (WWRF)

National

Activity	Date (Month, Year)	Organizer
University Industry Commerciallisation Collaboration Forum Corporation (MDEC), USM, 21 September 2010	21 September 2010	by Multimedia Development at USM Penang
Centre of Engineering Excellence	9 Ogos 2010	USM

Strategic Planning Workshop 2010, Sunway Hotel, Seberang Perai, Penang		
Participant for "Awareness Program on Wireless Sensor Network (WSN), North Zone", Penang, Hotel Gurney, Penang	1-3 June 2010	NEST, UPM
Plenary Speaker of 4th. National Seminar on Hajj Best Practices through Advance in Science & Technology, Eastin Hotel, Penang	27th July 2010	Hajj Research Cluster, USM
NICHE 2: COMMERCIAL-SAVVY ACADEMIC CAMP, 9-10 Feb 2010, conducted by Australian Institute for Commercilization (AIC) at Pan Pacific KLIA	9-10 February 2010	Higher Education Leadership Academy (AKEPT), Ministry of Higher Education Malaysia.

PROBLEMS / CONSTRAINTS IF ANY *(Masalah/ Kekangan sekiranya ada)*

E The funding given is not enough to continue with the fabrication of the antenna and IC assembly to be tested as a RFID tag as we applied for RM100k but the amount approved is only RM32k. The project was completed until simulation process of the dual band antenna. Eventhough with limited funding, the research outcomes has shown comparable achievements.

RECOMMENDATION *(Cadangan Penambahbaikan)*

F The project can be extended for full fabrications, implementations and testings for complete proven novel architecture which viable to be patented and commerciallized.

RESEARCH ABSTRACT – Not More Than 200 Words *(Abstrak Penyelidikan – Tidak Melebihi 200 patah perkataan)*

G

Dual-band antenna operated at frequency 919-923MHz and 13.56MHz has been simulated. Both antenna are designed to be on the same side of substrate.Substrate used are FR4 and PEC using finite and infinite ground.The enhancement for combination of antennas for both substrate used still need to be done to improve the gain and return loss to ensure maximum signal transfer.

Date : 10/2/2011
Tarikh

Project Leader's Signature:
Tandatangan Ketua Projek

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COMMENTS, IF ANY/ ENDORSEMENT BY RESEARCH MANAGEMENT CENTER (RMC)
(Komen, sekiranya ada/ Pengesahan oleh Pusat Pengurusan Penyelidikan)

H

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....

....

Name:
Nama:

Signature:
Tandatangan:

Date:
Tarikh:

UNIVERSITI SAINS MALAYSIA

JABATAN BENDAHARI
KAMPUS KEJURUTERAAN

PENYATA KUMPULAN WANG
BERAKHIR : 31/12/2010

Kod Akaun :203.PELECT.6071187	Tajuk Projek :	NOVEL ARCHITECTURE OF DUAL BAND RFIDPROF. MADYA WIDAD BT ISMAIL	
Penyelidik : WIDAD BT ISMAIL	Panel:	FRGS	
P. Pengajian: PUSAT PENGAJIAN KEJ ELEKTRIK & ELEKTRONIK	Penaja:		
Tempoh : 2010/4 hingga 2013/3	Jumlah peruntukan/geran :	0.00	

		Jumlah Peruntukan (a)	Perbelanjaan Sehingga 31/12/2009 (b)	Peruntukan Semasa 2010 (c)	Tanggungan Semasa 2010 (d)	Perbelanjaan Semasa 2010 (e)	Jumlah Perbelanjaan (f)=(d+e)	Baki Peruntukan Semasa (c)-(f)
111	Gaji Kakitangan Awam	10,000.00	0.00	10,000.00	0.00	7,218.69	7,218.69	2,781.31
221	Perbelanjaan Perjalanan & Sara Hidup	7,000.00	0.00	7,000.00	0.00	0.00	0.00	7,000.00
227	Bekalan & Alat Pakai Habis	7,000.00	0.00	7,000.00	0.00	0.00	0.00	7,000.00
229	Perkhidmatan Iktisas & Hospitaliti	8,000.00	0.00	8,000.00	0.00	30,000.00	30,000.00	-22,000.00
	JUMLAH	32,000.00	0.00	32,000.00	0.00	37,218.69	37,218.69	-5,218.69

FINAL REPORT FUNDAMENTAL RESEARCH GRANT SCHEME (FRGS/PHASE 1-2010)

Project Title: **NOVEL ARCHITECTURE OF DUAL BAND RFID PASSIVE TAG WITH MALAYSIAN MICROCHIP (MMChip)**

Project Leader: Dr. Widad Ismail

Account No.: **203.PELECT.6071187**

PROJECT SUMMARY

FRGS PROJECT REPORT

Abstract—**A planar meander line tag antenna for the radio frequency identification application at the ultra-high frequency (UHF) band covering the Malaysia band (919–923 MHz) is designed by using Computer Simulation Technology Microwave. The proposed antenna consists of a rectangular feed ring, a meander line antenna, and shorting pins. The overall dimension of the antenna is 53 X 31 X 0.883 mm, and it is constructed on the material of a Roger 4003C substrate with a thickness of 0.813 mm and a relative permittivity of 3.38. The -3 dB impedance bandwidth of the proposed antenna is 916–927 MHz, and the directivity for the proposed antenna at 919.5 MHz is 1.832 dBi.**

Keywords: Radio frequency identification (RFID); UHF band; meander line antenna; CST MW(CST Microwave Studio)

I. INTRODUCTION

Radio frequency identification (RFID) is a wireless communication technology that enables users to uniquely identify tagged objects or people, which includes virtually everything on earth. Thus, RFID is an example of automatic ID (auto-ID) technology, in which physical objects can be identified automatically [1]. RFID systems recently had tremendous growth due to their wide application in many fields, such as retail, transportation, manufacturing, and supply chain. RFID systems transmit the data between the tag and the reader in a contactless manner through radio waves, unlike the barcode system, which requires line of sight. RFID systems also have longer reading distances.

RFID systems are generally distinguished through four common bands; low-frequency (LF) (125–134 kHz), high-frequency (HF) (13.56 MHz), ultra-high frequency (UHF) (860–960 MHz), and microwave (MW) (2.45 GHz or 5.8 GHz) [2]. However, there are different operating frequencies for UHF band used in the different regions for RFID systems such as 840.5–844.5 MHz and 920.5–924.5 MHz in China, 866–869 MHz in Europe, 902–928 MHz in the US, 866–869 MHz and 920–925 MHz in Singapore, 920–928 MHz in Hong Kong, and 952–955 MHz in Japan [3]. For Malaysia, based on the Malaysia Communications and Multimedia Commission, the UHF band used is 919–923 MHz [4]. Each operating frequency has its own characteristics. LF bands have low data-transfer rates but are good for operating environments with metals and liquids, while HF bands have more reasonable data-transfer rates compared with LF bands and penetrates water but not metal. However, compared with other RFID frequency bands, UHF bands are more popular in many application areas because it provides a broad readable range, fast reading speed, and large information storage capability [5–6].

In this paper, a UHF tag antenna with the operating frequency used in Malaysia is designed and simulated by using computer simulation technology MW studio (CST MWS). CST MWS is a three-dimensional (3D) electromagnetic (EM) field simulator useful in designing the antenna. It provides features such as optimization, sweeping, and some calculations that are helpful during the simulation. Some features of this simulation tool will be shown in this paper.

II. STRUCTURE AND DESIGN

The geometry of a compact meander line antenna at the UHF band is shown in Figure 1. The antenna consists of a small rectangular feed ring, a meander line antenna, and the shorting pin. Shorting pins are used to enhance impedance matching for the proposed antenna design, while the feed ring is used to improve the gain of the proposed antenna. Table I presents the parameters used to define the value of the meander line antenna for further optimization and sweeping. The radiating patch is constructed on a Roger 4003C substrate with thickness of 0.813 mm and a relative of permittivity 3.38. The radiating patch is constructed by the copper, with a thickness of 0.035 mm. By using CST MW, even in the simulation, the proposed antenna can be modeled like an actual antenna by constructing the SubMiniature version A (SMA) connector to the waveguide port of the proposed antenna, as shown in Figure 2. This can help provide good agreement between the simulation and the measurement result. The inner and outer diameters of the SMA connector can also be calculated by using the impedance calculation tool of the CST MW to match the antenna to the impedance required. In this paper, the proposed antenna is matched to 50 Ω.

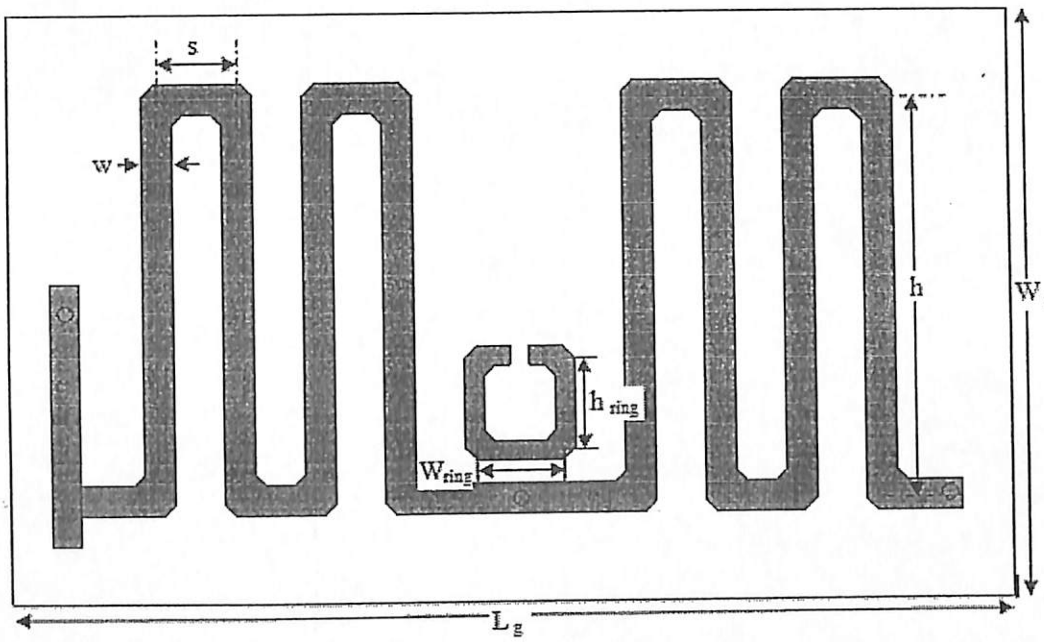


Figure 1. Geometry of the meander line antenna

TABLE I. PARAMETERS AND VALUES FOR THE MEANDER LINE ANTENNA

Parameters	Values (mm)
L_g (length of ground)	53.00
W_g (width of ground)	31.00
s (spacing between pitches)	4.25
w (width of meander line)	1.59
h (height of meander line)	21.20
W_{ring} (width of ring)	4.80
h_{ring} (height of ring)	5.00

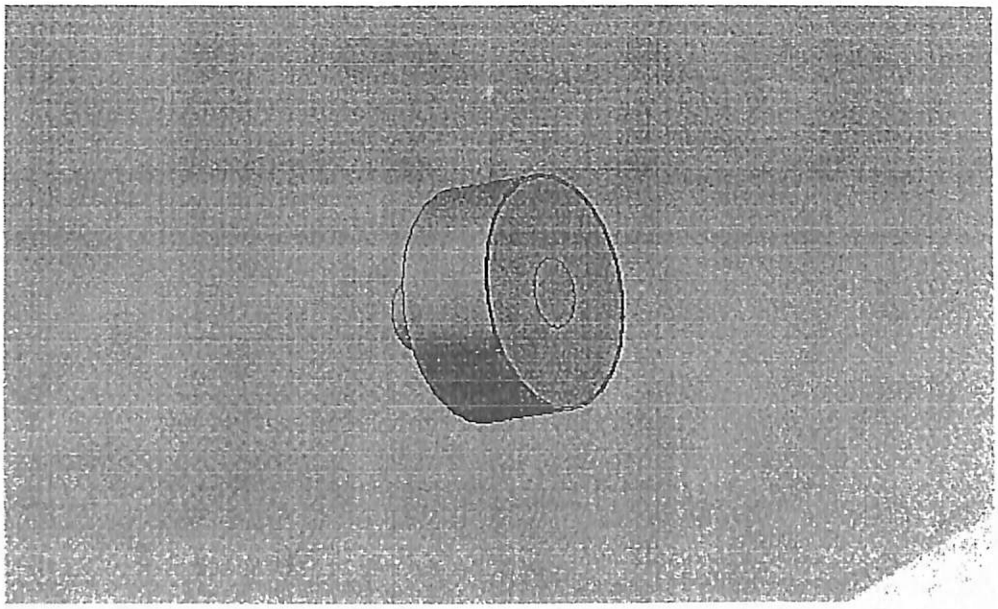


Figure 2. Model of the SMA connector using CST MW on the proposed antenna

III. RESULT AND MEASUREMENT

Figure 3 shows the return loss characteristic of the proposed antenna. The bandwidth at -3 dB is measured to be about 13 MHz (913–926 MHz), which includes the UHF band (919–923 MHz) used in Malaysia for the RFID system. The resonant frequency can be controlled by adjusting the spacing between the pitch of the meander line antenna. Figure 4 shows the effect of the different spacing between pitches to the resonant frequency by using the sweeping function of the CST MW. Figure 4 shows that the wider the pitch, the lower the resonant frequency becomes. Therefore, by controlling the spacing of the meander line, the operating frequency for different regions can be obtained. This sweeping function can easily show the effect of the parameter on the variation of the value.

Radiation patterns of the proposed tag antenna were also investigated. The radiation patterns in the H-plane and E-plane at 919.5 MHz were studied, and the corresponding polar forms are presented in Figures 5 and 6, respectively. The radiation pattern for the H-plane is omni-directional, while the radiation pattern for the E-plane is bi-directional. The directivity value for the proposed antenna at 919.5 MHz is 1.832 dBi.

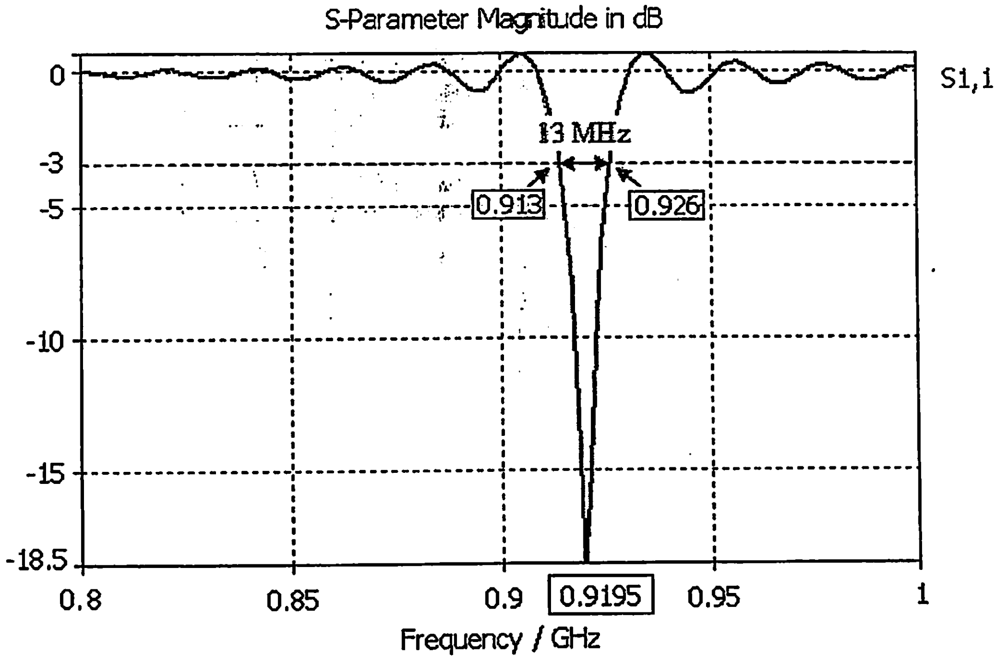


Figure 3. Return loss of the meander line antenna

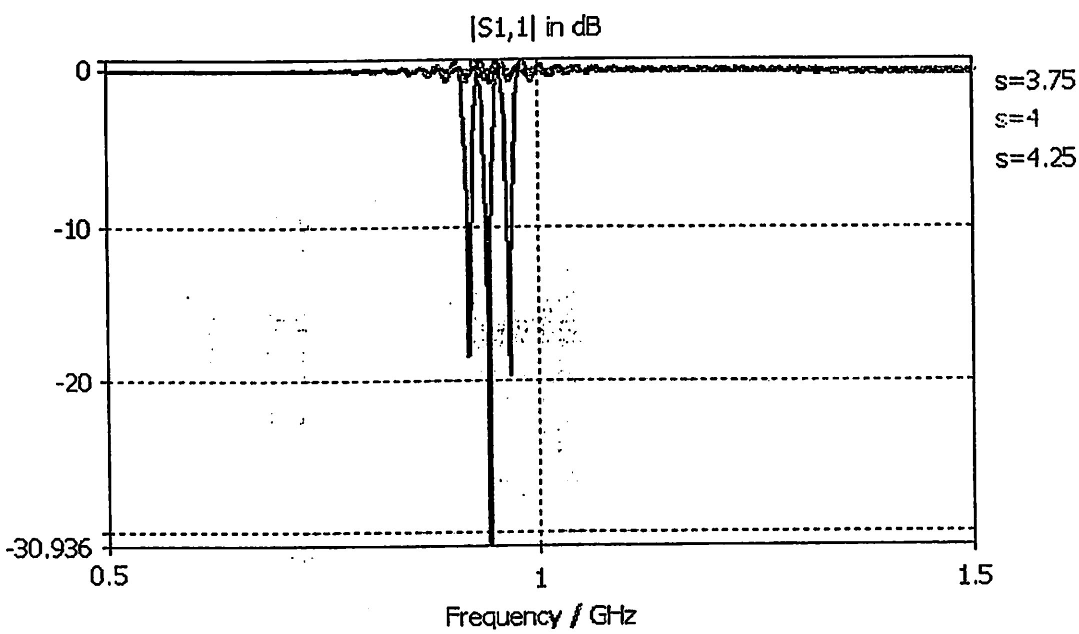
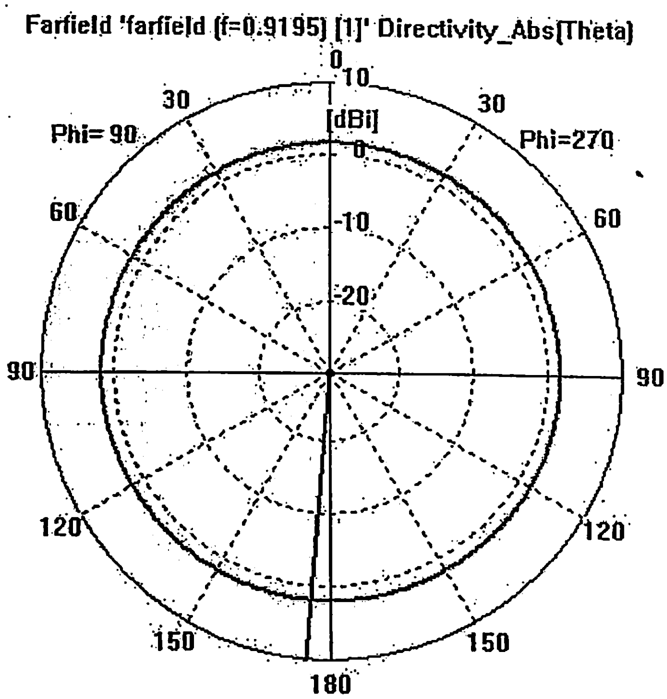
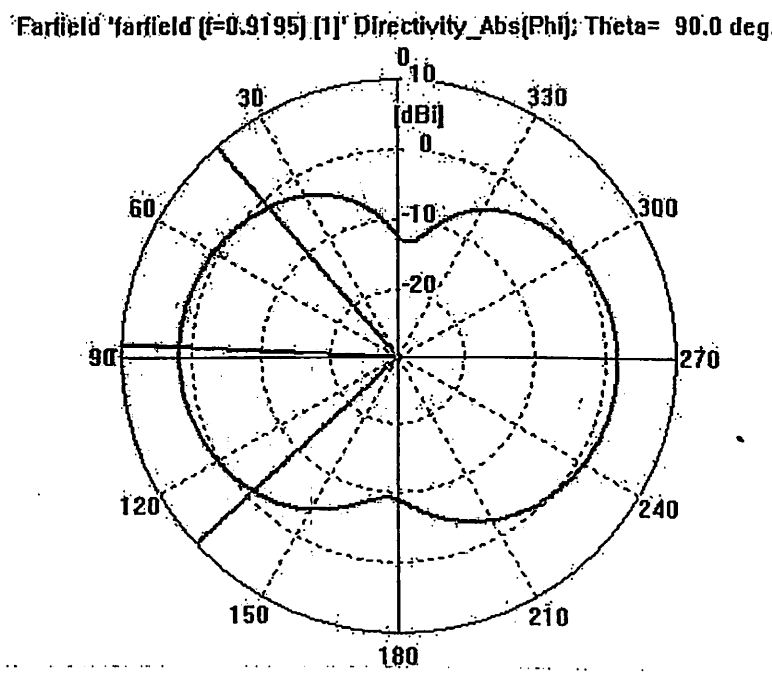


Figure 4. Resonant frequencies for the variation of the spacing between the pitch



Frequency = 0.9195
Main lobe magnitude = 1.8 dBi
Main lobe direction = 175.0 deg.

Figure 5. Radiation pattern for the H-plane



Frequency = 0.9195
Main lobe magnitude = 1.8 dBi
Main lobe direction = 87.0 deg.
Angular width (3 dB) = 92.2 deg.

Figure 6. Radiation pattern for the E-plane

CST MWS is a specialist tool for the 3D structure electromagnetic simulation, which is a kind of numberical calculation software based on Finite Integration Time Domain method. It provides a powerful solid modeling and adaptive mesh generation function. After completing the design, the software will automatically applied the meshing procedure before the simulation solver is started. Besides that, the CST MWS provided a built-in parametric optimizer that can help to appropriate dimensions in the design, this is the most efficient way to design and can help save a lot of time.

IV. Conclusion

A UHF band RFID tag antenna covering the Malaysia RFID band (919–923 MHz) was designed using CST MW. The proposed antenna is suitable for general use because of its simple structural design, small size, and the low cost of the materials used. The effects of the spacing between the pitch of the meander line antenna were also investigated in this paper.

References

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[3] J. Z. Huang, P. H. Yang, W. C. Chew, and T. Y. Terry, "A novel broadband patch antenna for universal UHF RFID tags," Microwave and Optical Technology Letters, vol. 52, no. 12, pp. 2653-2657, December 2010.

[4] N. A. S. Minan, "Industry Readiness and Policy Regarding RFID Implementation in Malaysia," EPCglobal Malaysia EPC/RFID Conference 2007.

[5] G. S. pope, M. Y. Loukine, D. M. Hall and P. C. Cole, "Innovative systems design for 13.56 MHz RFID," Wireless and Portable Design Conference, Burlington, Massachusetts, pp. 240-245, 1997.

[6] Y. M. Um, U. S. Kim, W. M. Seong and J. H. Choi, "A Novel Antenna Design for UHF RFID Tag on Metallic Objects," PIERS Proceedings, Prague, Czech Republic, 27-30 August

JOURNAL PUBLICATIONS

Electronic Toll Collection System Using Passive RFID Technology

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[1]eewidad@eng.usm.my

Abstract— **This paper focuses on an electronic toll collection (ETC) system using radio frequency identification (RFID) technology. Research on ETC have been around since 1992, during which RFID tags began to be widely used in vehicles to automate toll processes [1]. The proposed RFID system uses tags that are mounted on the windshields of vehicles, through which information embedded on the tags are read by RFID readers, The proposed system eliminates the need for motorists and toll authorities to manually perform ticket payments and toll fee collections, respectively. Data information are also easily exchanged between the motorists and and toll authorities, thereby enabling a more efficient toll collection by reducing traffic and eliminating possible human errors.**

Index Terms—**Electronic toll collection, RFID**

I. Introduction

Electronic toll collection (ETC) is a technology enabling the electronic collection of toll payments. It has been studied by researchers and applied in various highways, bridges, and tunnels requiring such a process. This system is capable of determining if the car is registered or not, and then informing the authorities of toll payment violations, debits, and participating accounts [2]. The most obvious advantage of this technology is the opportunity to eliminate congestion in tollbooths, especially during festive seasons when traffic tends to be heavier than normal. It is also a method by which to curb complaints from motorists regarding the inconveniences involved in manually making payments at the tollbooths. Other than this obvious advantage, applying ETC could also benefit the toll operators.

The benefits for the motorists include:

1. Fewer or shorter queues at toll plazas by increasing toll booth service turnaround rates;
2. Faster and more efficient service (no exchanging toll fees by hand);
3. The ability to make payments by keeping a balance on the card itself or by loading a registered credit card; and
4. The use of postpaid toll statements (no need to request for receipts).

Other general advantages for the motorists include fuel savings and reduced mobile emissions by reducing or eliminating deceleration, waiting time, and acceleration.

Meanwhile, for the toll operators, the benefits include:

5. Lowered toll collection costs;
6. Better audit control by centralized user accounts; and
7. Expanded capacity without building more infrastructures.

Thus, the ETC system is a win-win situation for both the motorists and toll operators, which is why it is now being extensively used throughout the world..

An ETC system commonly utilizes radio frequency identification (RFID) technology. RFID is a generic term used to identify technologies utilizing radio waves to automatically identify people or objects [3]. RFID technology was first introduced in 1948 when Harry Stockman wrote a paper exploring RFID technology entitled, "Communication by Means of Reflected Power" [4]. RFID technology has evolved since then, and has been implemented in various applications, such as in warehouse management, library system, attendance system, theft prevention, and so on. In general, RFID is used for tracking, tracing, and identifying objects.

A complete RFID system consists of a transponder (tag), reader/writer, antenna, and computer host. The transponder, better known as the tag, is a microchip combined with an antenna system in a compact package. The microchip contains memory and logic circuits to receive and send data back to the reader [5]. These tags are classified as either active or passive tags. Active tags have internal batteries that allow a longer reading range, while passive tags are powered by the signal from its reader and thus have shorter reading range [6].

Tags could also be classified based on the content and format of information. The classifications range from Class 0 to Class 5. These classes have been determined by the Electronic Product Code (EPC) Global Standard. In the table below, classes refer to a tag's basic functionality (i.e., it either has a memory or an on-board power), while generation refers to the tag specification's major release or version number. The class structure for the tags is shown in the table below.

Table 1: Class Structure for Tags [5]

EPC Class	Definition	Programming
lass-0 Gen-1	Read only, Passive tags	Programmed by the factory
Class -1Gen-1	Write once, read-many, passive tags	Programmed by the user and then locked
Class-1Gen-2	Write-many, read-many, passive tags	Programmed by the user and then locked
Class-2	Rewritable passive tags with extra functionality, including encryption and emulation	Can be re-programmed
Class-3	Semi-passive tags that support broadband communication	
Class-4	Active tags that can communicate with other peers	
Class-5	Readers, they can power other tags of Class 1, 2 and 3, can communicate with Class 4 wirelessly	Not applicable

A reader contains an antenna to transmit and receive data from the tag. The reader also contains a decoder and an RF module. It could be mounted or built as a portable handheld device. The computer host acts as an interface to an IT platform for exchanging information between the RFID system and the end-user. This host system then converts the information obtained from the RFID system into useful information for the end-user.

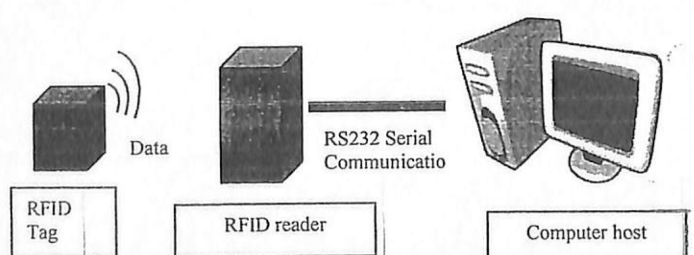

Fig. 1 Complete RFID System

II. Related Work

The ETC system is currently being used throughout the world. In the United States alone, various states have implemented an ETC system called E-Z Pass [1]. Other countries that have applied the ETC system are Canada, Poland, the Philippines, Japan and Singapore, among many others.

Some of the applied ETC systems are discussed in the proceeding section.

A. Canada

The ETC system used in Canada is known as the Canada 407 Express toll route (ETR). It is one of the most sophisticated toll roads in the world [7]. The Canada 407 ETR is a closed-access toll road, which means that there are gantries placed at the entrance and exit points of each toll. In this system, cameras are equipped with Optical Character Recogntion (OCR). The OCR cameras are used to photograph license plate numbers of vehicles that do not have transponders. The toll bill will then be sent directly to the registered address of the vehicle owners. Other than that, two laser beam scanners are placed above the roadway to detect the types of vehicles passing through the gantries. Nevertheless, this toll road bears a very high infrastructure cost, and the users are the ones who help recover the cost through increments in their toll bills [8].

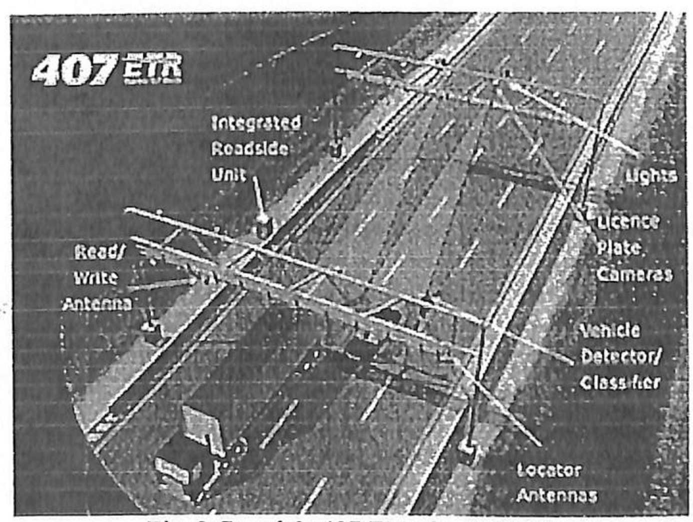

Fig. 2 Canada's 407 ETR for ETC [7]

B. Poland

The ETC system used in Poland has been proposed by the Motor Transport Institute along with the University of Technology in Warsaw and Dublin. This system is called the National Automatic Toll Collection System (NATCS), and consists of the National Automatic Toll Collection Center

(NATCC), control gates, and on-board units (OBU). The NATCS uses a combination of mobile telecommunication technology (GSM) with satellite-based Global Positioning System (GPS). Using GPS technology, the OBUs determine the kilometers that have been driven, calculate the toll fees and rates, and then transmit the information to the NATCS mputer center. Each vehicle will be charged from the highway entrance up until the end of the highway. In order to identify the plate numbers of trucks, the system has control gates equipped with digital short range communication (DSRC) detection equipment and high resolution cameras. [9] ue to the technical specifications, this system incurs a high cost for motorists.

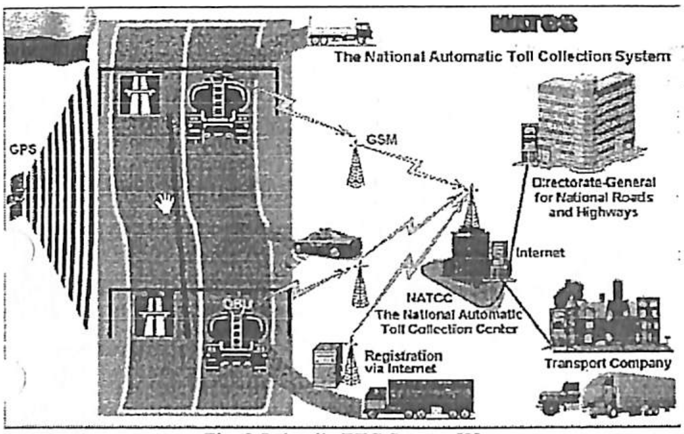

Fig. 3 Poland's ETC System [9]

C. Philippines

The ETC system used in the Philippines has been implemented at the South Luzon Expressway (SLEX) since August 2000. The ETC is referred to as the E-PASS system, which uses Transcore technology. Here, electronic transponders are placed in front of a vehicle's rearview mirror. Each time a vehicle enters the toll booth, the tag is read by the receiver, automatically identifying the account and debiting the toll fee amount from the corresponding account. Once the amount has been debited, the control gate will lift and the hicle is allowed to pass through [10].

D. US Patent

In 2007, Tang et al. [11] filed a US patent on their proposed ETC system. Their proposed system provides two lanes: one on the side and the other where overhead-based antennas are installed per lane. Both antennas are used for conducting toll transactions. Of the two, the side antenna will act as a backup in case the overhead antenna fails to capture the signal emitted from the vehicles. In the case of a failure, the overhead antenna will be deactivated, and the side antenna will be activated. If the side antenna also fails, then an error signal will be issued.

III. PROPOSED ETC SYSTEM

The main objective behind this proposal is to create a suitable ETC system to be implemented in Malaysia. The term "suitable" here refers to minimal changes in the current infrastructure with maximum increase in efficiency.

The ETC system in Malaysia has been introduced in the year 1994. It has evolved since then, and many changes have been done. The most recent ETC system consists of the TouchNGo and SmartTAG, referred to as the single ETC system in the country [12]. This system uses IR technology, making it very vulnerable to failure. Other than that, users also have to bear the high cost of owning the two-piece tag required for this system. Thus, Malaysian highway authorities have been looking for alternatives, such as the multi-lane free-flow (MLFF) ETC system [12]. However, this proposed system requires major changes in the infrastructure of the existing toll roads. In contrast, the ETC system proposed in this paper will require only minimal changes. Moreover, the existing toll booths could be re-used with only slight modifications.

Instead of IR technology, the proposed ETC system will apply RFID technology. The concept is based on existing toll booths; however, human interaction is no longer required. The vehicles will be given a passive tag in the form of a sticker which could be affixed on the windshield, just like in the existing road tax system. Each time the vehicle passes the toll booth, the tag will be read and information will be transmitted to the main computer.

Road users also have the chance to choose either a prepaid or a postpaid tag. At the entrance point, the system will record the users' information with their preferred method (i.e., prepaid or postpaid). Then, at the end of the entrance point, the system will calculate the kilometers driven and then deduct payment straight from the tag (for prepaid users); if the balance is not enough, the barrier will still be lifted, but a warning email or an SMS will be sent to the owner. If the owner fails to pay the excessive amount, the tag will be barred. For the postpaid system, a bill will be sent to their respective homes at the end of every month. If the users fail to pay the amount, their tags will also be barred.

Using this system, all problems related to manual toll fee collection will be eliminated, thereby achieving a higher efficiency rate per transaction. This is because this system requires no human interactions that could lead to cheating and human errors. In addition, compared with the existing system, in which motorists need to pay hundreds of Ringgits in order to own the two-piece tag required, the proposed system would only motorists to pay minimal fees as the cost of the whole system is not as high as the existing system.

The proposed system also considers the size issue. All the system requires is a tag the size of a sticker, which could be affixed on the windshield. In this system, the tag used is is capable of withstanding all kinds of weather, and is much more durable compared with the one used in the existing system. The advantages of this proposed system is summarized as follows:

1. Higher efficiency in toll collection;
2. Cheaper cost;
3. Smaller in size compared with the existing system; and.
4. Durable tags.

Figures 4(a)-(c) below illustrate the flow of the proposed system.

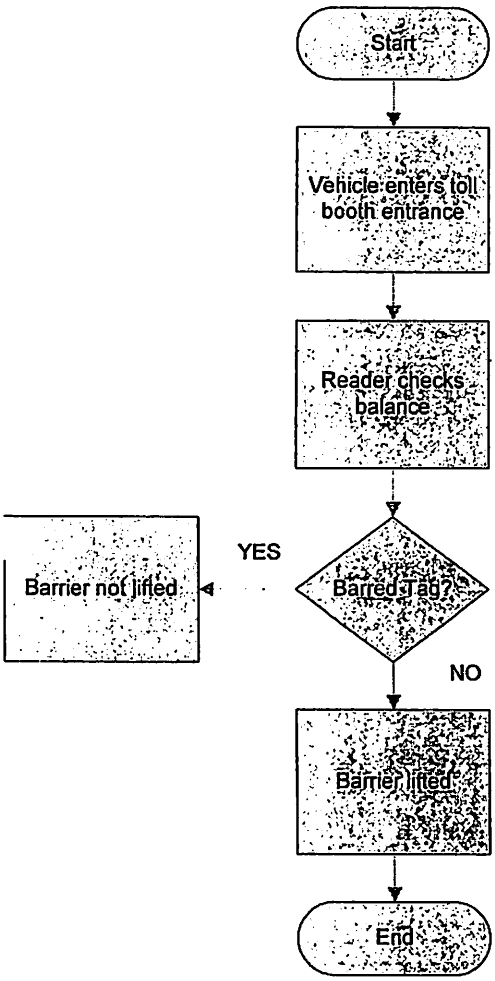

Fig. 4a Toll Gate Entrance Flow Chart (Prepaid and Postpaid)

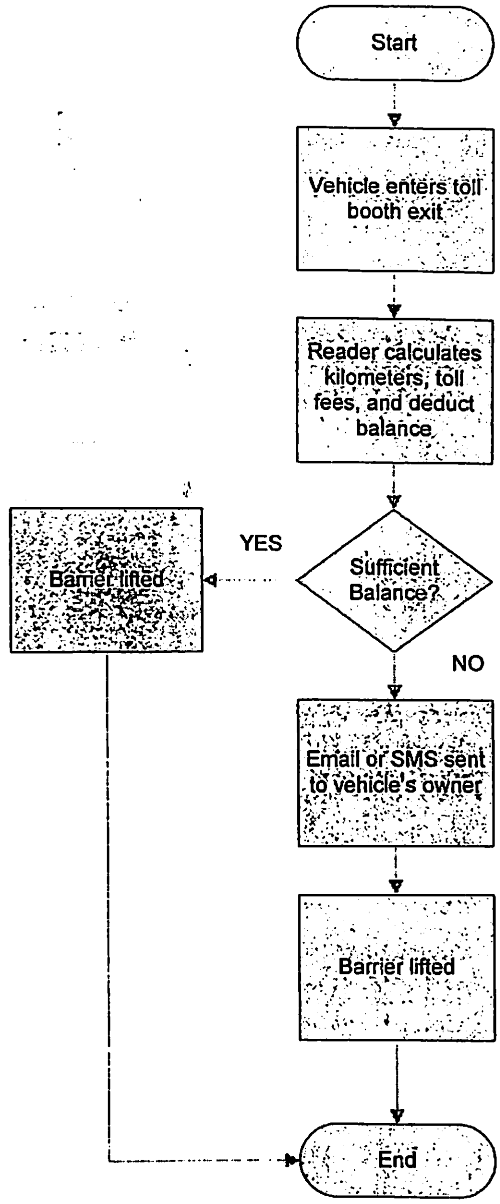

Fig. 4b Toll Gate Exit Flow Chart (Prepaid)

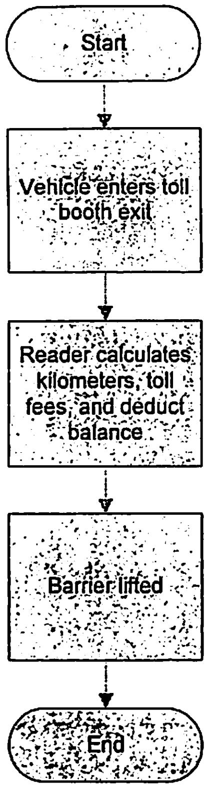

Fig. 4c Toll Gate Exit Flow Chart (Postpaid)

The differences among the proposed system and the ones discussed previously are illustrated in the table below.

able 2: Differences Among the Other Systems and the Proposed System

	Toll Type	System Used	Payment Method	Cost
Canada	Closed Access (Gantries at the entrance and exit points)	OCR, Laser Beam	Postpaid	High
Poland	Closed Access (Gantries at the entrance and exit points)	GSM,GPS	Postpaid	High
Manila	Toll Booth	-	Postpaid	-
US Patent	Two lanes with gantries	Two antennas	-	-
Proposed System	Toll Booth	Passive RFID	Postpaid Prepaid	Low

CONCLUSION

In this article, the authors have discussed various types of ETC systems applied in some countries. The proposed ETC system discussed in this work applies passive RFID technology. By doing so, increased efficiency will be guaranteed since RFID is known as a highly stable technology. With the elimination of human interaction in the entire toll collection process, we can create a better ETC system to be ıplemented in Malaysia. It can also significantly improve the efficiency of toll stations and the traffic abilities of the toll road.

ACKNOWLEDGMENT

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Electronic Toll Collection System Using Passive RFID Technology

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Abstract— **This paper focuses on an electronic toll collection (ETC) system using radio frequency identification (RFID) technology. Research on ETC have been around since 1992, during which RFID tags began to be widely used in vehicles to automate toll processes [1]. The proposed RFID system uses tags that are mounted on the windshields of vehicles, through which information embedded on the tags are read by RFID readers, The proposed system eliminates the need for motorists and toll authorities to manually perform ticket payments and toll fee collections, respectively. Data information are also easily exchanged between the motorists and and toll authorities, thereby enabling a more efficient toll collection by reducing traffic and eliminating possible human errors.**

Index Terms—**Electronic toll collection, RFID**

I. Introduction

Electronic toll collection (ETC) is a technology enabling the electronic collection of toll payments. It has been studied by researchers and applied in various highways, bridges, and tunnels requiring such a process. This system is capable of determining if the car is registered or not, and then informing the authorities of toll payment violations, debits, and participating accounts [2]. The most obvious advantage of this technology is the opportunity to eliminate congestion in tollbooths, especially during festive seasons when traffic tends to be heavier than normal. It is also a method by which to curb complaints from motorists regarding the inconveniences involved in manually making payments at the tollbooths. Other than this obvious advantage, applying ETC could also benefit the toll operators.

The benefits for the motorists include:

1. Fewer or shorter queues at toll plazas by increasing toll booth service turnaround rates;
2. Faster and more efficient service (no exchanging toll fees by hand);
3. The ability to make payments by keeping a balance on the card itself or by loading a registered credit card; and
4. The use of postpaid toll statements (no need to request for receipts).

Other general advantages for the motorists include fuel savings and reduced mobile emissions by reducing or eliminating deceleration, waiting time, and acceleration.

Meanwhile, for the toll operators, the benefits include:

5. Lowered toll collection costs;
6. Better audit control by centralized user accounts; and
7. Expanded capacity without building more infrastructures.

Thus, the ETC system is a win-win situation for both the motorists and toll operators, which is why it is now being extensively used throughout the world..

An ETC system commonly utilizes radio frequency identification (RFID) technology. RFID is a generic term used to identify technologies utilizing radio waves to automatically identify people or objects [3]. RFID technology was first introduced in 1948 when Harry Stockman wrote a paper exploring RFID technology entitled, "Communication by Means of Reflected Power" [4]. RFID technology has evolved since then, and has been implemented in various applications, such as in warehouse management, library system, attendance system, theft prevention, and so on. In general, RFID is used for tracking, tracing, and identifying objects.

A complete RFID system consists of a transponder (tag), reader/writer, antenna, and computer host. The transponder, better known as the tag, is a microchip combined with an antenna system in a compact package. The microchip contains memory and logic circuits to receive and send data back to the reader [5]. These tags are classified as either active or passive tags. Active tags have internal batteries that allow a longer reading range, while passive tags are powered by the signal from its reader and thus have shorter reading range [6].

Tags could also be classified based on the content and format of information. The classifications range from Class 0

Bassam M. Al-Mahadeen from the Tafila Technical University in Jordan, **Widad Ismail** from the Universiti Sains Malaysia and **Mokhled Altarawneh** from the Mutah University in Jordan present an early warning system describing desert roads that also provides feedback to the local authorities and travellers to avoid any road-related problems

A Wireless Image Sensors Network for Monitoring Dust on Roads in ARID CONDITIONS

DESERT ROADS have casual dust events in which the dust may completely cover several kilometers of the road for several hours and this usually causes breathing problems and may deadly accidents for travellers.

Here, we present an early warning system ribing such roads, which will also provide feedback to the local authorities to take the proper action and give travellers the current status of the road to avoid such problems.

The system is based on a real-time analysis to classify the activity of the dust of the acquired images. The analysis is performed by processing the images within the wireless nodes and extracting information about the dust events. The system output will be used to generate a real-time alert to the authorities and travellers in the event of an emergency caused by dust.

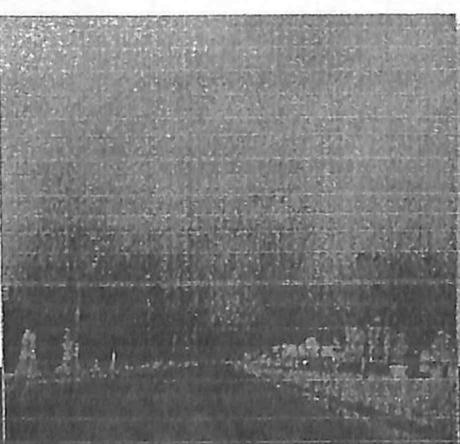

Figure 1: A sample image of dust storm on desert roads

Traditional versus Modern Systems

Normal video surveillance systems need continuous human monitoring for the acquired images in real time and to alert the authorities if any unusual events happen in the scene that is being monitored. In desert environments, it is hard to deploy traditional video surveillance systems due to resource constraints. As such, wireless sensor networks would be more appropriate due to their attractive features such as rapid deployment, self-organization and fault tolerance.

Recently wireless image sensor networks have become of a great importance due to their wide application range such as video surveillance, remote sensing, tracking, face recognition and so on. A wireless sensors network consists of low cost and low energy sensors which are deployed in a region of interest to observe a phenomenon, and send the observations to a fusion centre or a base station to make a global assessment. In a wireless sensor network, communication bandwidth and energy are a limited resource. Hence it is very essential to limit the communication between the sensors and the fusion centre as much as possible, since not all the data transmitted from all sensor nodes will be useful always.

Desert roads have casual dust storm events in which the dust may completely cover several kilometers of the road for several hours and this usually causes breathing problems and accidents for travellers.

Dust storm as in **Figure 1** is a meteorological phenomenon common in arid and semi-arid regions and arises when a gust-front passes. It is unpredictable phenomena where high winds lift dust or sand into the air, creating suffocating clouds of particles and reducing visibility to nearly nothing in a matter of seconds.

System Model and Design

Our system is based on a real-time analysis to classify the activity of the dust of the acquired images to three levels: High, Medium or Normal. The analysis is performed by processing the images and extracting information of dust events within the wireless node.

To manage the huge flow of information, to avoid sending useless transmission from sensor nodes and local base-stations, and at the same time manage the power very efficiently for a long battery life, the sensor nodes are made to transmit only useful results of the analyzed images to the local base-stations.

A wireless image sensors network consists of image sensors or cameras as nodes. The image sensors capture images at fixed

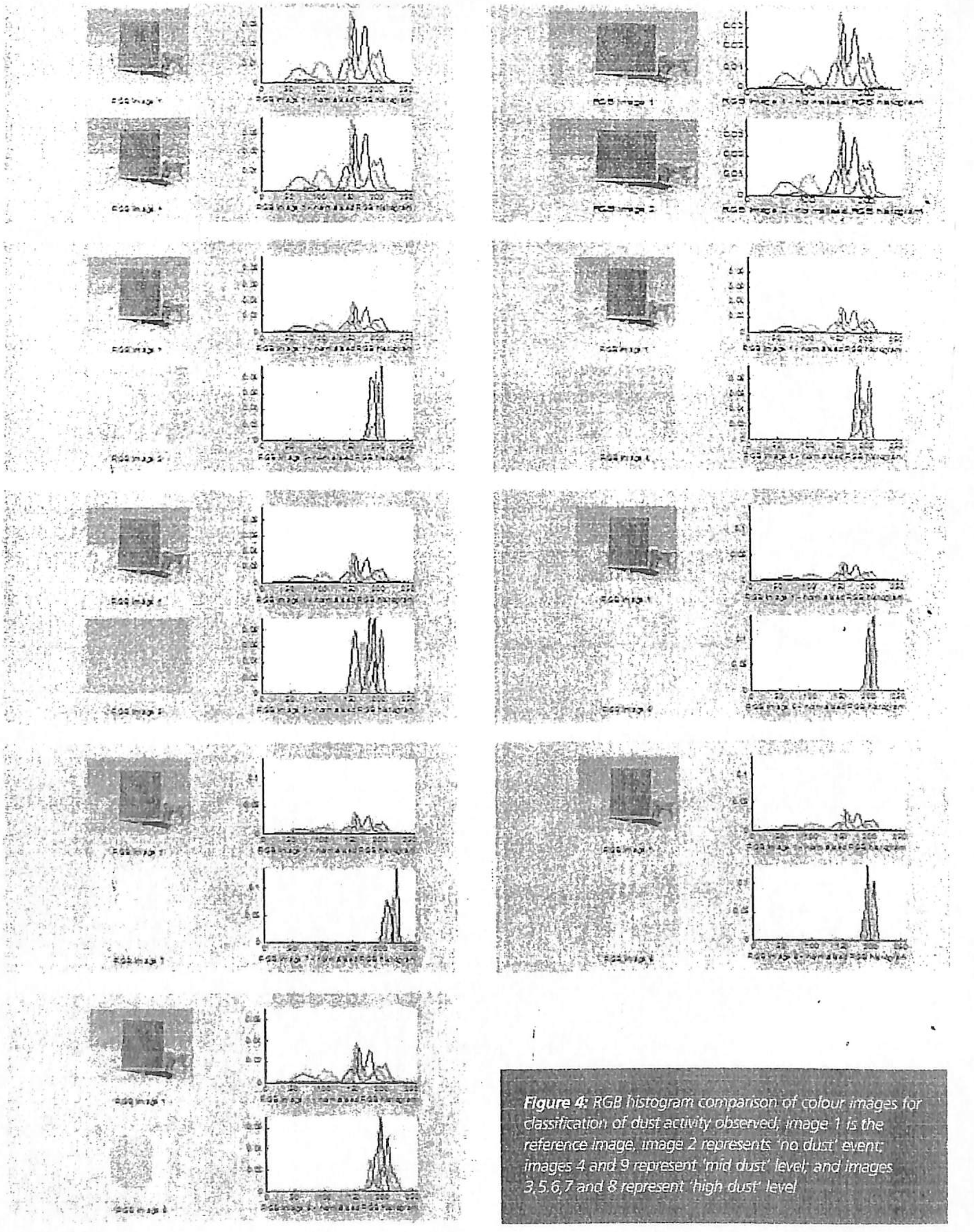

Figure 4: RGB histogram comparison of colour images for classification of dust activity observed; image 1 is the reference image, image 2 represents 'no dust' event; images 4 and 9 represent 'mid dust' level; and images 3,5,6,7 and 8 represent 'high dust' level

to a remote base station via the base station gateway. The base station provides Internet connectivity services. It should handle disconnected operation from the Internet. Remote management facilities are a crucial feature of a base station.

For distributed image sensing applications in wireless sensor networks, the processing and memory limitations in current mote designs are

Fig.1	Bhattachar. Distance	chiSquared Distance	Euclidean Distance
Fig.1	0	0	0
Fig. 2	0.4322	0.5931	0.0644
Fig. 3	0.6818	1.1513	0.1233
Fig. 4	0.6488	1.0315	0.1108
Fig. 5	0.6751	1.1316	0.1157
Fig. 6	0.8333	1.6246	0.1791
Fig. 7	0.9492	1.9383	0.1614
Fig. 8	0.7712	1.4317	0.1527
Fig. 9	0.6718	1.1576	0.1024

Table 1: Values of Bhattachar., chiSquared and Euclidean Distance of the images in Figure 1

the critical factors. Generally, as seen in Figure 3, the sensor node is based on a microcontroller and accessing an on-chip RAM. An expansion interface is provided to support multiple mid- and low-resolution image sensors concurrently, as well as traditional sensors.

Wireless communication is also provided by RF which operates in the 2.4GHz band and is compliant with the IEEE 802.15.4 standard. Integrated USB and serial debug interface allows simple programming and debugging of applications. The node can either be powered by a stationary power supply if available or battery-operated for mobile applications or deployment. Flash memory card provides sufficient and scaleable non-volatile memory for temporary frame buffering or even image storing.

Wireless Communications

In the proposed system, as shown in Figure 3, image sensor data flow from the wireless nodes to a gateway using RF over the IEEE 802.15.4 protocol, then from the gateway over wired Internet back-end to centralized server, and finally from the server to the travellers.

The maximum data rate of 802.15.4 is 250kbps, which is too low for wireless image nodes to transmit images back to the server at a high enough quality and frame rate for real-time applications. The basic idea of the design is to localize the computation within the wireless nodes and send only post-processed data in real time back to the centralized server and travellers. The Zigbee sensor network environment could be used, which is a low rate and low power network technology for short range communication.

Strategy Adopted and Experimental Results

To classify dust events, each wireless node is placed in a fixed position with respect to a road sign, without any obstruction, to define the target area being analyzed. The dust event will be classified as a high (2), medium (1) and low event (0).

Each wireless image sensor captures images in fixed interval of time to minimize the power consumption, to reduce the communication between nodes and local base stations. Each node should process and analyze the acquired images locally and sends only its final decision to the local base station using RF in form of 2, 1, or 0.

A software tool for RGB image comparison is implemented and used in each node to extract certain features from the captured images, without the need for human intervention. So, a reference image is used in each node, then each captured image should be compared with the reference image and as a result a Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance are calculated. The threshold ranges for worst, fair and normal cases are empirically defined, according to the visual images.

The critical dust events can be classified or the absence of any meaningful activity can be notified. A road sign is placed in front of each wireless image node with a distance that represents the minimum possible vision that should be between two consecutive vehicles.

As an example, **Figure 4** shows the RGB histogram comparison of images 1 to 9, where image 1 represent the reference image that shows the absence of dust activity and images 2 to 9 represent different levels of dust activity. **Table 1** shows the calculated values of the Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance for the images in Figure 4.

The classification algorithm uses three levels of threshold values empirically defined and based of these values dust event is classified to high, low or normal. Once the event has been classified, a suitable alert is sent to the locale base station, then the base station collects the alert messages from its wireless nodes to form its local decision based on the incoming values, and sends the local decision to a road sign screen to notify the drivers as well as the authorities to take the proper action in case of dust event and its level.

Table 1 shows the values of Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance for the images in Figure 4. The threshold for event classification can be based on any of these values, if the chiSquaredDistance is selected, from the table the threshold can be defined as follows: if the chiSquaredDistance < 0.6 the dust level is accepted (send value 0 to the local base station); if chiSquaredDistance > 0.6 and < 1.16 indicates a mid dust level (sends value 1 to the local base station), so an awareness message is sent to travellers; and if the chiSquaredDistance > 1.16 then the dust level is high (sends value 2 to the base station), so the road might be closed or an alternative way might be suggested for travellers.

If the classification of dust event should be based on the computed values of Bhattacharyya Distance, the threshold values for the classification of dust event can be defined empirically from the table as follows: < 0.44 for the normal case, 0.44 to 0.675 for the mid dust level and > 0.675 for high dust level.

As can be noted from the previous discussion, the communication bandwidth will be at its minimum level, also the power consumption needed for the communication will be very low and these are the main important factors for the wireless image sensors network system.

Early Warning System

This system is structured to work as an early warning system describing the desert roads status and to provide a feedback for the authorities to take the proper action and to give travellers up-to-date information about current status of the road to avoid breathing and vehicle accident problems.

The proper action might be closing the road during the dust event or taking an alternative way if possible. The basic idea of the system is the in-node processing of the captured images to reduce the power consumption and communication bandwidth. By sending only the final results to local base station inform of 2, 1, or 0 local base stations are guaranteed to be free of bottlenecks.

PLC with PIC16F648A Microcontroller

Part 22

Professor Dr Murat Uzam from Nigde University in Turkey presents a series of articles on a project that focuses on a microcontroller-based PLC. This article is the last in the series and it explains seven solutions for the seven control scenarios for a remotely-controlled model gate system described in the last issue

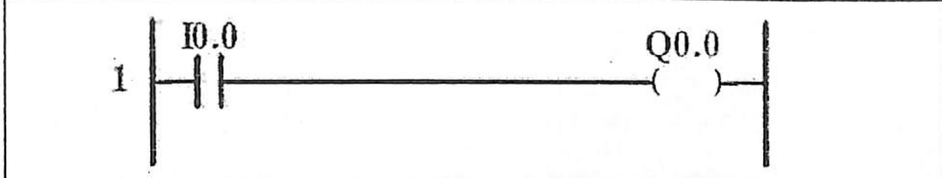

Figure 1: Ladder diagram for the user programUZAM_plc_8i8o_ex38.asm

```
#include <definitions.inc>     ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>   ;Contact & Relay based macros

;--------------- user program starts here ------------------------

        ld          I0.0           ;rung 1
        out         Q0.0

;--------------- user program ends here -------------------------
```

Figure 2: The user program UZAM_plc_8i8o_ex38.asm

IN THIS SECTION, we will explain the solutions to the seven control scenarios described in the previous article for the remotely controlled model gate system, namely UZAM_plc_8i8o_exN.asm, N = 38, 39...44.

In order to test the example, you can download the files from http://host.nigde.edu.tr/muzam/ and then open the UZAM_plc_8i8o_exN.asm, N = 38, 39...44 program by MPLAB IDE and compile it. After that by using the PIC programmer software, take the compiled file "UZAM_PLC_8i8o_ exN.hex" and with your PIC programmer hardware send it to the program memory of PIC16F648A microcontroller within the UZAM_PLC. After loading the "UZAM_PLC_8i8o_exN.hex", switch the 4PDT in "RUN" and the power switch in "ON" position. Finally, the program is ready to run.

The ladder diagram for the first scenario is shown in **Figure 1** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex38.asm", is shown in **Figure 2**. In this example, when B0 (I0.0) is being pressed, the gate will open (Q0.0 will be ON). However, in this case if B0 is released then the gate will stop. This means that the program does not remember whether or not the B0 was pressed.

The ladder diagram for the second scenario is shown in **Figure 3** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex39.asm", is shown in **Figure 4**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 that is connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, the NO contact Q0.0 is a "sealing contact", which helps the program to remember whether B0 was pressed. The problem here is that when the gate is completely opened, the motor will not stop.

The ladder diagram for the third scenario is shown in **Figure 5** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex40.asm", is shown in **Figure 6**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, when the gate is opened completely, the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

The ladder diagram for the fourth scenario is shown in **Figure 7** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex41.asm", is shown in **Figure 8**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, when the gate is opened completely, the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

Similarly, once B1 (I0.1) is pressed, with the help of NO contact of Q0.1 connected in parallel to the NO contact I0.1, the gate will close (Q0.1 will be ON). Here, when the gate is closed completely, the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. The problem with this example is that if both B0 and B1 are pressed at the same time, then both outputs will be ON. This is not a desired situation. The solution to this problem is given in the next example.

The ladder diagram for the fifth scenario is shown in **Figure 9** and its UZAM_PLC representation, the user program "UZAM_plc_8i8o_ex42.asm", is shown in **Figure 10**. In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact of Q0.0 connected in parallel to the NO contact I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

Similarly, if the gate is not opening (Q0.0=0) once B1 (I0.1) is pressed, then the gate will close

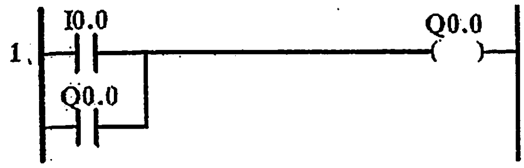

Figure 3: Ladder diagram for the user program UZAM_plc_8i8o_ex39.asm

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ----------------------

ld        I0.0       ;rung 1
or        Q0.0
out       Q0.0

;--------------- user program ends here ------------------------
```

Figure 4: The user program UZAM_plc_8i8o_ex39.asm

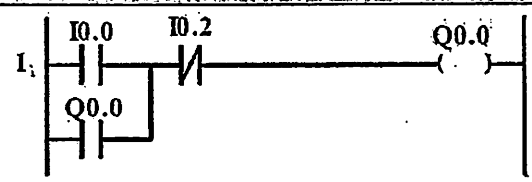

Figure 5: Ladder diagram for the user program UZAM_plc_8i8o_ex40.asm

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ----------------------

ld        I0.0       ;rung 1
or        Q0.0
and_not   I0.2
out       Q0.0

;--------------- user program ends here ------------------------
```

Figure 6: The user program UZAM_plc_8i8o_ex40.asm

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ----------------------

ld        I0.0       ;rung 1
or        Q0.0
and_not   I0.2
out       Q0.0

;--------------- user program ends here ------------------------
```

Figure 7: Ladder diagram for the user program UZAM_plc_8i8o_ex41.asm

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ----------------------

ld        I0.0       ;rung 1
or        Q0.0
and_not   I0.2
out       Q0.0

ld        I0.1       ;rung 2
or        Q0.1
and_not   I0.3
out       Q0.1

;--------------- user program ends here ------------------------
```

Figure 8: The user program UZAM_plc_8i8o_ex41.asm

(Q0.1 will be ON) with the help of NO contact Q0.1 connected in parallel to the NO contact of I0.1. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. Therefore, once the gate is being opened we can not force it to close, and vice versa.

The ladder diagram for the sixth scenario is shown in **Figure 11** with its UZAM_PLC representation, the user program "UZAM_plc_8i8o_ex43.asm" in **Figure 12**. In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) or RF transmitter button (I0.5) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact of Q0.0 connected in parallel to the NO contact of I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0. When the gate is completely open (I0.2=1), an on delay timer (TON_8) is used to obtain (10x524.288ms) 5.24 seconds time delay.

After waiting 5.24 seconds, the status bit TON_8Q0 of the on delay timer becomes true. If the gate is not opening (Q0.0=0) and if the NO contact of TON_8Q0 is closed (i.e. 5.24 seconds time delay has elapsed), then the gate will close (Q0.1 will be ON) with the help of NO contact of Q0.1 connected in parallel to the NO contact of TON_8Q0. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1.

The ladder diagram for the seventh and last scenario is shown in **Figure 13a**. The first rung cannot be implemented as it is in UZAM_PLC. Therefore, the ladder diagram shown in Figure 13a is modified. The UZAM_PLC implementation of this ladder diagram is shown in **Figure 13b**, and is provided as the user program "UZAM_plc_8i8o_ex44.asm" as shown in **Figure 14**.

In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) or RF transmitter button (I0.5) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

If the gate is closing (Q0.1=1) and the presence of an obstacle is detected in the gates' path (I0.4=0), then the gate will open (Q0.0 will be ON). When the gate is completely open (I0.2=1), an on delay timer (TON_8) is used to

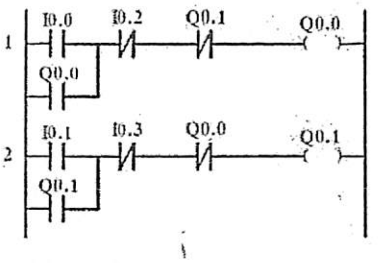

Figure 9: *Ladder diagram for the user program UZAM_plc_8i8o_ex42.asm*

```
#include <definitions.inc>     ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>   ;Contact & Relay based macros

;-------------- user program starts here ----------------------

        ld          I0.0          ;rung 1
        or          Q0.0
        and_not     I0.2
        and_not     Q0.1
        out         Q0.0

        ld          I0.1          ;rung 2
        or          Q0.1
        and_not     I0.3
        and_not     Q0.0
        out         Q0.1

;-------------- user program ends here ------------------------
```

Figure 10: *The user program UZAM_plc_8i8o_ex42.asm*

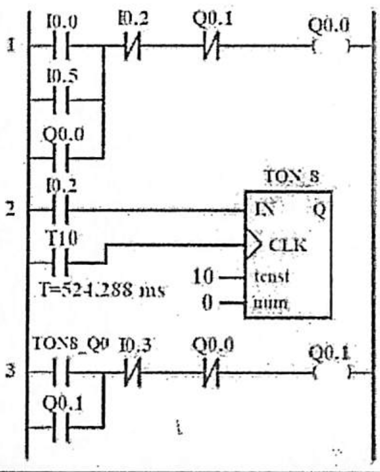

Figure 11: *Ladder diagram for the user program UZAM_plc_8i8o_ex43.asm*

```
#include <definitions.inc>     ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>   ;Contact & Relay based macros
#include <tmr_mcr_def.inc>     ;Timer macros

;-------------- user program starts here ----------------------

        ld          I0.0          ;rung 1
        or          I0.5
        or          Q0.0
        and_not     I0.2
        and_not     Q0.1
        out         Q0.0

        ld          I0.2          ;rung 2
        TON_8       0,T10,.10

        ld          TON8_Q0       ;rung 3
        or          Q0.1
        and_not     I0.3
        and_not     Q0.0
        out         Q0.1

;-------------- user program ends here ------------------------
```

Figure 12: *The user program UZAM_plc_8i8o_ex43.asm*

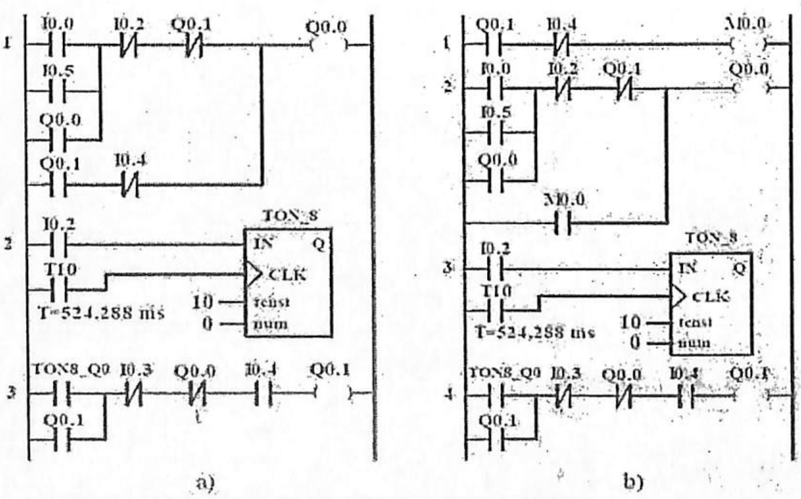

***Figure 13a (left)** and **(b) right:** Ladder diagrams for the user program UZAM_plc_8i8o_ex44.asm*

```
#include <definitions.inc>     ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>   ;Contact & Relay based macros
#include <tmr_mcr_def.inc>     ;Timer macros

;------------ user program starts here -----------------------

        ld          Q0.1          ;rung 1
        and_not     I0.4
        out         M0.0

        ld          I0.0          ;rung 2
        or          I0.5
        or          Q0.0
        and_not     I0.2
        and_not     Q0.1
        or          M0.0
        out         Q0.0

        ld          I0.2          ;rung 3
        TON_8       0,T10,.10

        ld          TON8_Q0       ;rung 4
        or          Q0.1
        and_not     I0.3
        and_not     Q0.0
        and         I0.4
        out         Q0.1

;------------ user program ends here -------------------------
```

Figure 14: *The user program UZAM_plc_8i8o_ex44.asm*

obtain (10×524.288ms) 5.24 seconds time delay. After waiting 5.24 seconds, the status bit TON_8Q0 of the on delay timer becomes true.

If the gate is not opening (Q0.0=0) and if the NO contact of TON_8Q0 is closed (i.e. 5.24 seconds time delay has elapsed), then the gate will close (Q0.1 will be ON) with the help of NO contact Q0.1 connected in parallel to the NO contact of TON_8Q0. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. If the gate is closing (Q0.1=1) and the presence of an obstacle is detected in the gate's path (I0.4=0), then the output Q0.1 will be switched OFF by means of the NO contact of I0.4 inserted before the output Q0.1. ■

*This is the last article in the series of the "PLC with PIC16F648A Microcontroller" project. If you missed any of the previous articles, you can order them on line at **www.electronicsworld.co.uk***

Implementation of WIMAX IEEE 802.16e Baseband Transceiver on Multi-Core Software Defined Radio Platform

Mohammed Aboud Kadhim[1] and Widad Ismail IEEE Member [2]

***Abstract*—Advancements in broadband and mobile communication have provided many privileges to its subscribers, such as high-speed data connectivity and good quality voice and video application services for economical rates. WIMAX is an eminent technology that provides broadband and IP connectivity to "last mile" scenarios. It offers both line of sight and non-line of sight wireless communication. Orthogonal frequency division multiple access, which uses the concept of cyclic prefix to add additional bits at the transmitter end, is used by WIMAX on its physical layer. The signal is transmitted through the channel and then received at the receiver end. Afterwards, the receiver removes these additional bits in order to minimize the inter symbol interference, improve the bit error rate, and reduce the power spectrum. In our research work, we investigated the physical layer performance on the basis of bit error rate and of signal-to-noise ratio. These parameters are discussed in four different models. This paper seeks a new approach to the adaptation of the WIMAX IEEE802.16e baseband for the SFF SDR Development Platform. The original implementation of the signal processing phase is proposed in order to dynamically support incoming signals of the WIMAX baseband.**

***Index Terms*—WIMAX, SFF SDR, OFDM, RS, Coding, AWGN, FFT, IFFT.**

I. Introduction

Some decades ago, we were purely dependent on analog system. Both the sources and transmission system were on analog format but the advancement of technology made it possible to transmit data in digital form. Along with those, the computer was getting faster to the fastest, the data payload capacity and transmission rate increased from kilobit to megabit and megabit to gigabit. From wire to wireless concept emerged and after researching and investing so much money, engineers became successful to invent wireless transmitter to transmit data. Applications like voice, Internet access [1], instant messaging, SMS, paging, file transferring, video conferencing, gaming and entertainment etc became a part of life. Cellular phone systems, WLAN, wide-area wireless data systems, ad-hoc wireless networks and satellite systems etc are wireless communication. All emerged based on wireless technology to provide higher throughput, immense mobility, longer range, robust backbone to thereat. The vision extended a bit more by the engineers to provide smooth transmission of multimedia anywhere on the globe through variety of applications and devices leading a new concept of wireless communication which is cheap and flexible to implement even in odd environment. This is a fact that, Wireless Broadband Access (WBA) via DSL, T1-line or cable infrastructure is not available especially in rural areas. The DSL can covers only up to near about 18,000 feet (3 miles), this means that many urban, suburban, and rural areas may not served [2]. The Wi-Fi standard broadband connection may solve this problem a bit but not possible in everywhere due to coverage limitations. But the Metropolitan-Area Wireless standard which is called WIMAX can solve these limitations. The wireless broadband connection is much easier to deploy, have long range of coverage, easier to access and more Performance Evaluation of IEEE 802.16e (Mobile WIMAX) in OFDM Physical Layer flexible. This connectivity is really important for developing countries and IEEE 802.16 family helps to solve the last mile connectivity problems with BWA connectivity. IEEE 802.16e can operate in both Line-Of-Sight (LOS) and Non-Line-Of-Sight (NLOS) environments. In NLOS, the PHY specification is extended to 211 GHz frequency band which aim is to fight with fading and multipath propagation [3, 4]. The OFDM physical layer based IEEE 802.16 standard is almost identical to European Telecommunications Standard Institute's (ETSI) High performance Metropolitan Area Network (HiperMAN) as they cooperate with each other [5]. This paper is all about WIMAX OFDM PHY layer performance where we analyzed the results using the SFF SDR Development Platform with different modulation techniques. SDR allows the coexistence of different independent standards, protocols, and services. This signal processing approach is broadly spreading given that reprogramming and reconfiguring of fixed and mobile devices is of great importance. Due to the availability of SDR in the device architecture, a user can update and replace necessary services without changing the hardware [6].

II. WIMAX IEEE 802.16 E

WIMAX IEEE 802.16e was an amendment of 802.16d standard which finished in 2005 and known as 802.16e-2005. Its main aim is mobility including large range of coverage. Sometimes it is called mobile WIMAX. This standard is a technical updates of fixed WIMAX which has robust support of mobile broadband. Mobile WIMAX was built on

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Orthogonal Frequency Division Multiple Access (OFDMA). It mentioned that, both standards (802.16d-2004 and 802.16e-2005) support the 256-FFT size. The OFDMA system divides signals into sub-channels to enlarge resistance to multipath interference. For instance, if a 30 MHz channel is divided into 1000 sub-channels, each user would concede some sub-channels which are based on distance[3].

III. SFF SDR Development Platforms

The SFF SDR Development Platform is shown in Figure 1 consists of three distinct hardware modules that offer flexible development capabilities: the digital processing, data conversion, and RF module. The digital processing module uses a Virtex-4 FPGA and a DM6446 SoC to offer developers the necessary performance for implementing custom IP and acceleration functions with varying requirements from one protocol to another supported on the same hardware. The data conversion module is equipped with dual-channel analog-to-digital and digital-to-analog converters. The RF module covers a variety of frequency ranges in transmission and reception, allowing it to support a wide range of applications [7].

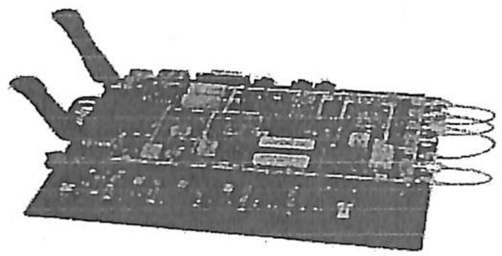

Fig .1. SFF SDR Development Platform[7]

A. System performance analysis and optimization target

MathWorks and Texas Instruments (TI), the two companies responsible for the development of Matlab/Simulink, are currently working on the development of a DSP development tool that users can use through Simulink. The object modules, designed to meet their own needs, the programming system, which is implemented through Real- Time Workshop, and the S-function with the TLC (Target Language Compiler) Function of the system design, when completed, can be directly converted to the most commonly used DSP programming language. The DSP, in conjunction with the TI software, Code Composer Studio, is completed in combination with the DSP hardware. Thus, through this development tool, users can work together to complete the design and simulation on the Simulink; however, it cannot provide the convenience of design that could increase the set count on the efficiency.

B. A-1 System integration and implementation of workflow

In the development and testing of IEEE 802.16e Wireless MAN-OFDM PHY, the specifications of communication Transfers have varying systems, which are based on our needs under Simulink mentioned in the proposed system for WIMAX. IEEE 802.16e for our study, we used the standard communication system box with a map provided by Matlab, which contains the following: Internal Communications Blockset, Signal processing Blockset, and Simulink Blockset. These correspond to our use of the hardware development platform for SFF SDR DP Blockset. The overall WIMAX PHY system construction is opened in the Simulink interface and Matlab is used to communicate the internal functions of RTW and TLC. We intend to build a finished system into a module, in accordance with the code of each block. Through this, we can perform the compilation and completion that will be automatically compiled in Matlab CCS connecting knot. The CCS establishes a corresponding module under the file name "Project." We then correct the generated C code and conduct compilation, debugging, and analysis. We then download our work into to the DSP. The overall system workflow is shown in Figure 2. The figure shows the system built based on the Simulink-established IEEE 802.16e Wireless MAN-OFDM PHY standard modules. The first step is the configuration by Simulink of the parameters interface and development platform into the conduct of the connecting node configuration. Information will be set to leave the bulk form of a fixed number of patterns, and the RTW system development module is set to be transferred and replaced by C language. Meanwhile, the TLC file option SDR development of modules and the set up Simulink system development are scheduled for DSP link module by an external module through the executive. Configuration of the IEEE 802.16e Wireless MAN-OFDM PHY may be achieved through the DSP Options Block Simulink to develop interfaces connecting node, development platform, and CCS. The use of the DSP Options Block and the Compiler Options allow us to optimize the system and the executive profit use. Moreover, future compiler optimization can be conducted through the Block. In the SFF SDR Development Platform of the DSP configuration, three kinds of memory are used: L1DRAM (8 KB), L2RAM (64 KB), and SDRAM (8 MB). The L1DRAM and L2RAM are used for the internal memory, while the SDRAM is used for the external memory. Due to the retention of internal memory, the speeds become quicker; thus, if information is to be placed in the internal memory in the system as a whole, the speeds and the executive would enhance performance Thus, the CMD File Generator Block for Development Platform can be conducted into the memory settings [7].

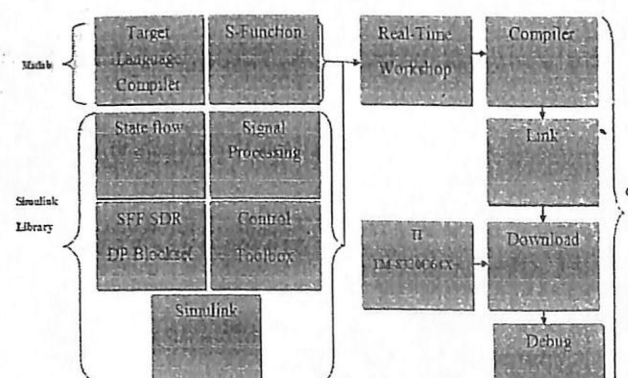

Fig .2. Schematic diagram of the system workflow actions [7]

C. A-2 TLC and RTW.

Target Language Compiler (TLC) is a Matlab program that uses syntax. Developers using the RTW tool can use the TLC to create self-designed C syntax language code by adding to the executive after the RTW-generated C language code or design. The use the S-function in the input and output of the set can design its own system for C programming and create Simulink objects in the box to use; however, RTW is only responsible for producing the C language program yards. It will not check the correct use of grammar; thus, performing actions or debugging code requires conducting C into the editor. Moreover, in the design of TLC, all of the program features in metropolis are the function of the type, as shown in Figure 3. Thus, the designer can use the RTW to generate the required developer as long as the C program is appropriately used together with the TLC syntax. The source code, TLC, and RTW program application flowchart is shown in Figure 4 [8].

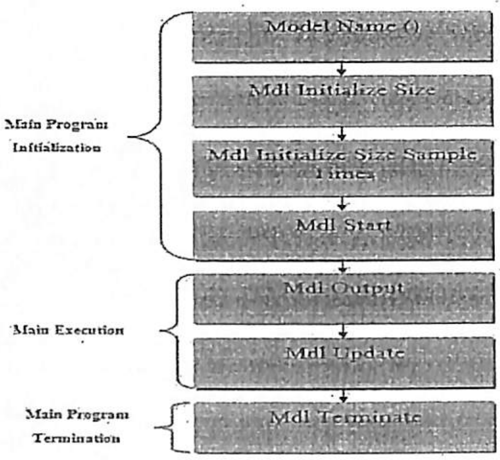

Fig .3. Target Language Compiler grammatical structure[8]

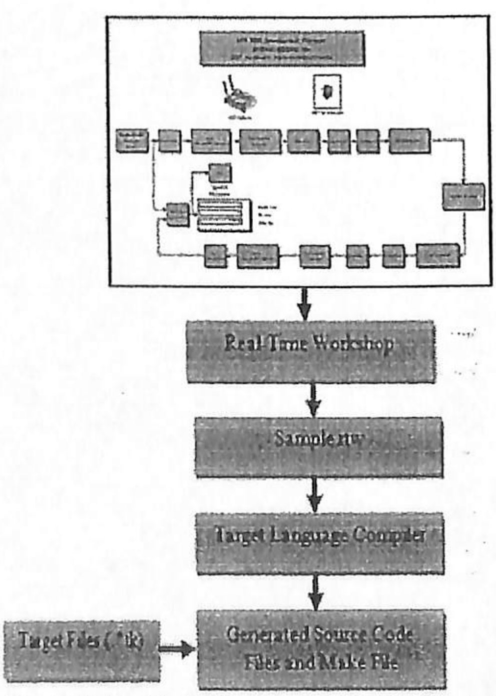

Fig. 4. TLC and the RTW program application flowchart

IV. Block Diagram Of WiMAX IEEE802.16e

The Block diagram in Figure 5

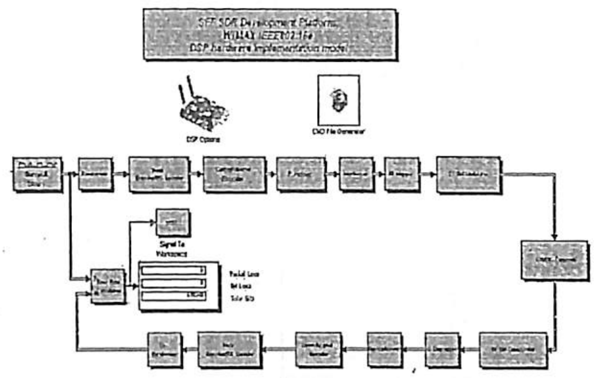

Fig.5. WIMAX IEEE802.16e Software Defined Radio DSP Hardware Implementation.

Represents the whole system model or the signal chain at the base band. The block system is divided into three main sections, namely, the transmitter, the receiver, and the channel. The model has been tested with the channel coding (the part in the dotted box representing the channel coding and decoding). The bit error rate (BER) plots have been obtained for at least 2,000 errors in order to get a good confidence limit.

A. *Transmitter model*

Figure 5 shows how the transmitted signal is generated. The functions of the sub-modules are also briefly described below.

B. *A-1 Data Generation*

Data are generated from a random source and consist of a series of ones and zeros. Since the transmission is done block wise, the size of the data generated depends on the block size used, the modulation scheme used to map the bits to symbols (BPSK, QPSK, 16QAM, and 64QAM [4]. The generated data is passed on to the next stage, either to the FEC block

C. *A-2 Forward error correction*

The data generated are randomized so as to avoid a long run of zeros or ones. The result is ease in carrier recovery at the receiver. The randomized data are encoded when the encoding process consists of a concatenation of an outer Reed-Solomon (RS) code. The implemented RS encoder is derived from a systematic RS Code using field generator GF (2^8) and an inner convolutional code (CC) as an FEC scheme. This means that the first data pass in block format through the RS encoder, and then go across the convolutional encoder. It is a flexible coding process due to the puncturing of the signal, and it allows different coding rates. The last part of the encoder is a process of interleaving to avoid long error bursts using tail biting convolutional codes(CC) with a different coding rate of (puncturing of codes is provided in the standard). Finally, interleaving is done by a two-stage permutation; the first aims to avoid the mapping of adjacent coded bits on adjacent subcarriers, and the second insures that adjacent coded bits are mapped alternately onto more or less significant bits of the constellation, thus avoiding long runs of lowly reliable bits[4].

D. A-3 Symbol mapping

The coded bits are then mapped to form symbols. The modulation scheme used is BPSK, QPSK, 16QAM, or 64QAM with gray coding in the constellation map. The symbol is normalized so that the average power is unity irrespective of the modulation scheme used [4].

E. A-4 Guard Band Intervals:

In OFDM, the data symbols are grouped in a block and called OFDM block symbols. A block consisting of T seconds can be formulated as Ts = LT here, where L is the number of sub stream and Ts is the time it takes to complete one symbol. To avoid interference among symbols while they pass through a wireless channel, the guard time is introduced between the OFDM symbols. The guard time, Ts which is greater than the channel delay spread time then in that scenario, OFDM symbols only experiences the interfere with itself. If the guard time between the two consecutive symbols is increased, then rectification of the symbol interference is possible [4].

F. A.5 IFFT and Cyclic Prefix

The t-th time domain sample at the n-th subcarrier at the output of IFFT is given by

$$X_t = \sum_{n=0}^{N-1} X_n e^{j\frac{2\pi t n}{N}} \quad 0 \le t \le N-1 \quad (1)$$

Where N is the number of subcarriers and is the data symbol on the n-th subcarrier. From the equation it can inferred that this is equivalent to generation of OFDM symbol. An efficient way of implementing IDFT is by inverse fast Fourier transform (IFFT). Hence IFFT is used in the generation of the OFDM symbol. The addition of a cyclic prefix is done on the time domain symbol obtained after IFFT. The IFFT size ('N' value) is considered as 256 in simulations. These data are fed to the channel that represents the AWGN channel model. OFDM uses cyclic prefix to achieve a channel that is free from ISI. This is accomplished by using circular convolution. Each OFDM symbol is inserted with an acyclic extension of length L that is greater than the delay of the channel. The cyclic prefix combats against ISI in a very simple manner, but it degrades the data rate and efficiency of the system. If the multipath delay in the channel is less than the prefix, then the system will not observe any ISI or Inter carrier Interference (ICI) [4].

G. B. Receiver model

The receiver performs the same operations as the transmitter, but in a reverse order. It also includes operations for synchronization and compensation for the destructive channel. These extra operations are the main focus, and they will be presented and explained throughout the paper. All signal processing is completed in the frequency-domain, and the essential block of the receiver is the FFT. A simplified overview of the receiver is seen in Figure 5.

H. C. System parameters

The reference model specifies a number of parameters that can be found in Table (1, 2).

TABLE (1) SYSTEM PARAMETERS

BW	N-Sampling Factor	G-Cyclic Prefix Time	N-FFT
20MHz	57/50	1/4,1/8,1/16,1/32	256

TABLE (2) SYSTEM PARAMETERS

Modulation	BPSK	QPSK	16-QAM	64-QAM
N cpc	1	2	4	6
N cbps	192	384	768	115

V. SIMULATION & RESULTS:

The simulations implemented in this paper are done in a WIMAX baseband transceiver on a multi-core SDR platform. An OFDM symbol means a group of L data symbols (all the data symbols are transmitted in a parallel manner) and it lasts T seconds, where T=Ls. As the spectrum of OFDM is not band limited (sinc (f) function), linear distortion caused by multipath can cause ISI. To avoid this effect, it is important to transmit a guard interval between OFDM symbols. The duration of each guard interval (Tg) has to be longer than the delay spread (τ) of the channel to ensure that each symbol interferes only with itself. After its introduction, the duration of each symbol is T total=T+Tg. Its introduction also reduces the synchronization problems. The ratio *TG/Td* is very often denoted by *G* in WIMAX/802.16e documents. If the channel conditions are good, a lighter value of G has to be used. If the multipath effect is important and the channel is bad, a high value of G is required. For OFDM PHY layers, 802.16e defines the following values for *G:* 1/4, 1/8, 1/16, and 1/32. Channel coding improves the performance significantly. The next simulation was done for the AWGN channel with QPSK modulation scheme and with a different rate tail biting convolutional code. The system model has been tested for PBSK QPSK, 16QAM, and64 QAM modulations with an AWGN channel having the following values for *G:* 1/4, 1/8, 1/16, and 1/32. The simulation results are shown in the figures and Table (3) below.

TABLE (3) SNR REQUIRED TO ATTAIN BER LEVEL.

Modulation	SNR(dB) at G(cyclic prefix)				Level BER
	1/4	1/8	1/16	1/32	
BPSK1/2	0.5	1	1.5	0.2	$10^{-0.29}$
QPSK1/2	3.5	3.8	4	4.1	10^{-1}
QPSK3/4	5.5	6	6.1	6	10^{-1}
16QAM1/2	10	9.9	10	10.1	10^{-1}
16QAM3/4	11.2	12.9	12.5	13	10^{-1}
64QAM2/3	17.5	16.5	16.7	17	10^{-1}
64QAM3/4	18	17.5	17.6	18	10^{-1}

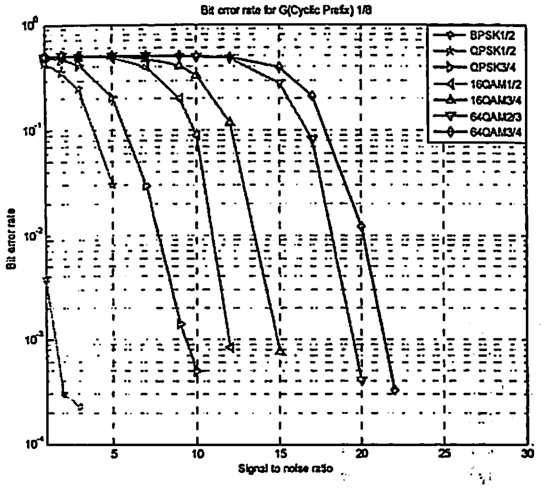

Fig .6. BER of the received symbols (G=1/4, BW=20MHz, AWGN Channel)

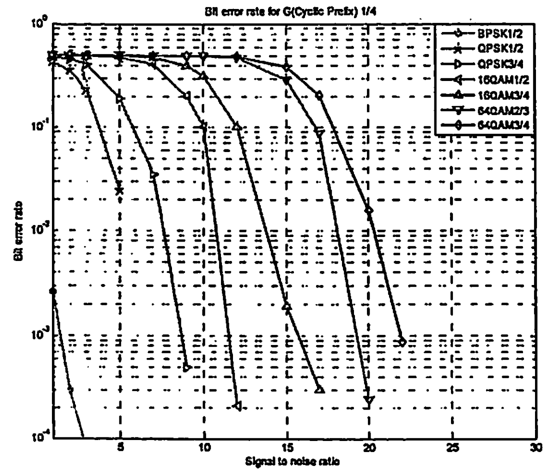

Fig .7. BER of the received symbols (G=1/8, BW=20MHz, AWGN Channel).

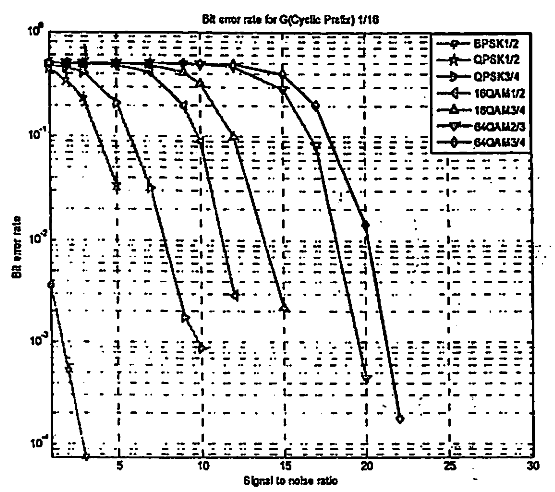

Fig .8. BER of the received symbols (G=1/16, BW=20MHz, AWGN Channel)

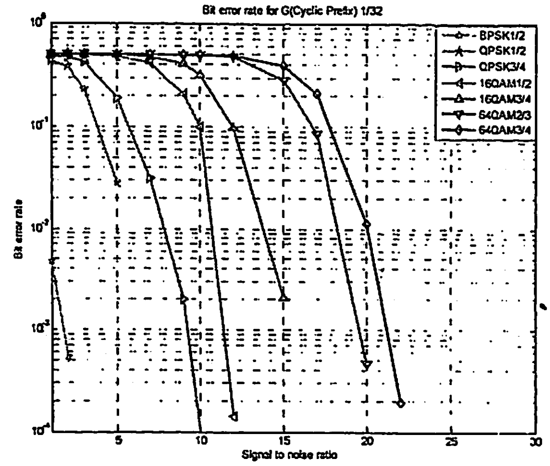

Fig .9. BER of the received symbols (BW=20MHz, AWGN Channel)

VI. Conclusion

The DSP of the SFF SDR Development Platform are completely integrated to the model based design flow, which integrates MATLAB, Simulink, and Real-Time Workshop from The MathWorks. The SFF SCA Development Platform optional package allows SCA waveform development and implementation. The key contribution of this paper was the implementation of the IEEE 802.16e PHY layer using MATLAB in order to evaluate the PHY layer performance under a reference channel model. The implemented PHY layer supports all the modulation and coding schemes, as well as the CP lengths defined in the specification. To keep matters simple, over-sampling was avoided before the AWGN was used. Nonetheless, it can be implemented by minor modifications on the receiver side. The developed Simulator can be easily modified to implement new features and enhance the PHY layer performance. Simulation was the methodology used to investigate the PHY layer performance. The performance evaluation method was mainly concentrated on the effect of channel coding on the PHY layer. The overall system performance was also evaluated under different guard periods. We concluded that BPSK is more power-efficient and needs less bandwidth among all other modulation techniques. In case of bandwidth utilization, the 64QAM modulation requires higher bandwidth and gives excellent data rates as compared with the others. On the other hand, the QPSK and the 16QAM techniques, which are in the middle of these two, need higher bandwidth and are less power-efficient than BPSK. However, they require lesser bandwidth and lower data rates than 64QAM. In addition, BPSK has the lowest BER, while the 64-QAM has highest. There is another conclusion that we arrived at: The inclusion of the Cyclic Prefix reduces the Inter symbol Interference (ISI) that causes the lower BER in the OFDM system but increases the complexity of the system.

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Performance Transmit and Receive Diversity Techniques for Different Modulation Signal

Mohammed Aboud Kadhim and Dr Widad Ismail

Abstract—The use of multiple communication paths or channels to achieve efficiency and error protection. The main types of diversity used in communications system one is transmit diversity and the other is receive diversity to exploit multipath effect. Diversity is usually between two antennas and each antenna has one channel. One antenna is at the base station and the other is at the service station. The base stations keeps record of the transmission and receive signal information with each channel. However, there can be many antennas at the base station and the service station. In this paper we have simulated the system by using Transmit Diversity (Space Time Coding) and Receiver Diversity (Maximum Ratio Combining) techniques. Based on the mathematical calculations for different modulation signals.

Index Terms Diversity, MRC, STC, BER, SNR, MIMO

1. INTRODUCTION

THE latest wireless communication techniques such as high speed wireless internet application demand higher data rates and better quality of service (QoS). However, transmission reliability is still degraded by harsh propagation channels. Diversity techniques can increase the system capacity and improve transmission reliability. By transmitting multiple copies of data, a MIMO system can effectively combat the effects of fading. Due to the high hardware cost of a MIMO system, antenna diversity techniques have been applied in MIMO system design to reduce the system complexity and cost. In this paper discuss two diversity applied to improvement wireless communication system one known transmitter diversity (STC) and other receiver diversity (MRC).Space–time block coding is a technique used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer. The fact that the transmitted signal must traverse a potentially difficult environment with scattering, reflection, refraction and so on and may then be further corrupted by thermal noise in the receiver means that some of the received copies of the data will be better than others. This redundancy results in a higher chance of being able to use one or more of the received copies to correctly decode the received signal. In fact, space–time coding combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible. Most work on wireless communications had focused on having an antenna array at only one end of the wireless link — usually at the receiver. Seminal papers by Gerard J. Foschini and J. Gans[1], Foschini[2] and Emre Telatar[3] enlarged the scope of wireless communication possibilities by showing that for the highly-scattering environment substantial capacity gains are enabled when antenna arrays are used at both ends of a link. An alternative approach to utilizing multiple antennas relies on having multiple transmit antennas and only optionally multiple receive antennas. Proposed by Vahid Tarokh, Nambi Seshadri and Robert Calderbank, these space–time codes[4](STCs) achieve important error rate improvements over single-antenna systems. Their original scheme was based on trellis codes but the simpler block codes were utilised by Siavash Alamouti[5], and later Vahid Tarokh, Hamid Jafarkhani and Robert Calderbank[6] to develop space–time block-codes (STBCs). STC involves the transmission of multiple redundant copies of data to compensate for fading and thermal noise in the hope that some of them may arrive at the receiver in a better state than others. In the case of STBC in particular, the data stream to be transmitted is encoded in blocks, which are distributed among spaced antennas and across time. While it is necessary to have multiple transmit antennas, it is not necessary to have multiple receive antennas, although to do so improves performance. This process of receiving diverse copies of the data is known as diversity reception and is what was largely studied until Foschini's 1998 paper. Antenna arrays can provide diversity paths to combat multipath fading of the desired signal and are able of reducing the power of interfering signals at the receiver. The Combining methods considered in this paper are maximal ratio combining (MRC) Maximal ratio combining represents a theoretically optimal combiner over fading channels as a

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diversity type in receiver diversity in a communication system. Theoretically, multiple copies of the same information signal are combined so as to maximize the instantaneous SNR at the output [7]. However system designs often assume that the fading is independent across multiple diversity channels. Physical constraints often restrain the use of antenna spacing that is necessary for independent fading across multiple antennas [8]. So it is necessary to consider spatial correlation characteristics between the antennas. Maximal ratio combining (MRC) of correlated fading signals with binary phase-shift keying (BPSK) has first been considered by Pierce and Stein in [9]. MRC of correlated fading signals with PSK modulation has been further considered in [10]–[11], and more recently in [12] where only one distribution function is considered for typical antenna shape. In [11] results are given for maximal ratio combining for complex Gaussian fading channels with correlated diversity for BPSK in Rician and Rayleigh fading, which can be applied to a diversity scenario across space. This paper extends this work by establishing closed form expressions for performance in terms of the antenna array and scattering environment which can be applied to general distribution functions for arbitrary antenna configurations. The expressions that are given in [12] for the spatial correlation of distributions of scatterers which can be applied to various non-isotropic scatterer distributions over multiple antennas are used. The spatial correlation formulation in [12] is applied with maximal ratio combining of PSK modulation to typical antenna type for 3 to 6 receive antennas in two typical non-isotropic Rayleigh fading nature, and a Rayleigh isotropic scattering scenario. Related to this study a closed form appearance for the bit error probability (BEP) for BPSK modulation is given, related to a generalized correlation function expression. Unlike the previous formulation, [9], [11], the closed form expression for the BEP allows for non-distinct eigen values in the correlation matrix. This is expanded to a closed form expression for the probability of bit error (BER) for different modulation. This paper is organized as follows. The next section describes the STC and MRC equation, Section 4 describes Simulation &Result in the error probability (BER) of different modulation for STC and MRC in transmit and receive diversity with different number of antenna in multipath fading, channel Section 5 provides some conclusions.

2. Space Time Coding (STC)

Space Time Coding is the popular type of transmits diversity. In this method, we send the information during two different antennas which are called transmitters. Thus, we are using two mediums space and time to transmit the information so this technique is called space time coding and this technique is like to the Alamouti scheme according to the 802.16 standard. Our main focus of using this type is to improve the error rate performance of the systems which send the information through coded medium. We will take two antennas at the base station as shown in the Figure 1, we have to use the modulator to send the data bits. The modulator converts these data bits into symbols called s_1 and s_2. After this, these symbols enter an encoder known as space time encoder, which then sends s_1 followed by - s_2^* to antenna 1 and s_2 followed by s_1^* to antenna 2. In the figure, the (*) is the complex conjugate of the symbols. When these symbols are transmitted from the base station, then it will be transmitted two different symbols towards the receiver antenna.

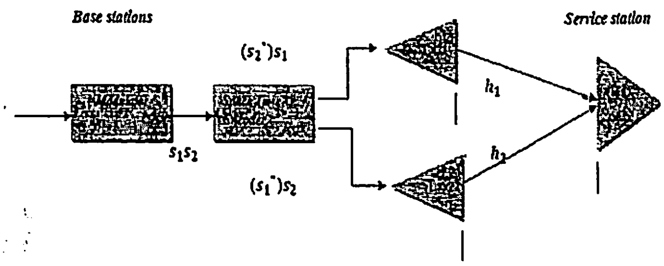

Fig.1.Space Time coding scheme [13]

The 2 × 4 Space Time Coding (Alamouti) is known as rate 1 code because data is neither decreased nor increased. As shown in above scenario, there are complex channel gains h_1 and h_2 from antenna 1 and 2 to the receive antenna and we assumed that over two symbol time, the channel is constant; that is, h_1 (t=0) = h_1 (t=T) =h_1.

The received signal r (t) is written as

$$r(0) = h_1 s_1 + h_2 s_2 + n(0),$$
$$r(T) = -h_1 s_2^* + h_2 s_1^* + n^*(T) \qquad (1)$$

Where n (T) is a White Gaussian noise sample. We assume that channel is known at the receiver, so we can use the following diversity combining type

$$y1 = h_1^* r(0) + h_2 r^*(T)$$
$$y2 = h_2^* r(0) - h_1 r^*(T) \qquad (2)$$

This can be expressed as

$$y_1 = h_1^*(h_1 s_1 + h_2 s_2 + n(0)) + h_2(-h_1^* s_2 + h_2^* s_1 + n^*(T))$$
$$y_1 = (|h_1|^2 + |h_2|^2) s_1 + h_1^* n(0) + h_2 n^*(T) \qquad (3)$$

Also,

$$y_2 = (|h_1|^2 + |h_2|^2) s_2 + h_2^* n(0) - h_1 n^*(T) \qquad (4)$$

Thus, the two received samples r (0) and $r^*(T)$ combines linearly with the assist of this simple decoder. This also eliminates all the interference so the resulting signal-to-noise ratio can be computed as

$$\gamma_\Sigma = \frac{(|h_1|^2 + |h_2|^2)^2 \varepsilon_x}{|h_1|^2 \sigma^2 + |h_2|^2 \sigma^2 2}$$
$$\gamma_\Sigma = \frac{(|h_1|^2 + |h_2|^2)^2 \varepsilon_x}{\sigma^2 2}$$
$$\gamma_\Sigma = \frac{\sum_{i=1}^{2} |h_i|^2 \varepsilon_x}{\sigma^2 2} \qquad (5)$$

Thus for space and time coding, the total transmit energy per data symbol will be ε_x and each is send twice $\frac{\varepsilon_x}{2}$. The linear decoder used here is the simplest decoder with zero mean noise.

3. Maximum Ratio Combining (MRC)

Maximum Ratio Combining combines the information from all received branches for a multiple antenna system in order to increase the SNR. We employ different gains to each antenna to get better the signal to noise ratio for the joint signals. We use the different proportional constant factors and gain is approximately equal to the route mean square of the signal level. Maximum Ratio Combining can provide the diversity gain and array gain but it does not assistance in spatial multiplexing scenario. A simple diagram of Branch Antenna Diversity is shown in Figure 2.

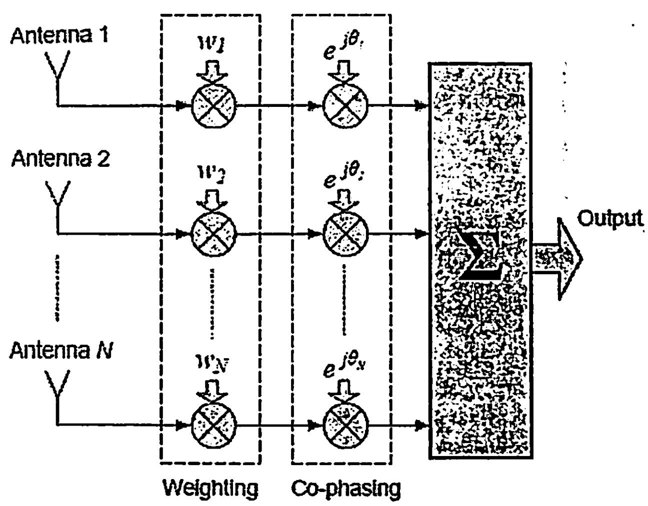

Fig .2 Branch Antenna Diversity [14]

Maximum Ratio Combining generally works by weighting each branch with a complex factor of w_i and then adding up the N_r branches.The received signal can be write as x(t)h_i.
The overall signal can be writing as

$$y(t) = x(t)\sum_{i=1}^{N_r}|w_i||h_i|\exp\{j(\emptyset_i + \theta_i)\} \quad (6)$$

If we allow the phase $\emptyset_i = -\theta_i$ for branches, then SNR of y(t) can be writing as

$$\gamma_{MRC} = \frac{\varepsilon_x(\sum_{i=1}^{N_r}|w_i||h_i|)^2}{\sigma^2\sum_{i=1}^{N_r}|w_i|^2} \quad (7)$$

ε_x is the transmitted energy signal. Solving the above expression by taking the derivation with respect to $|w_i|$ provides maximum combining values. In other words, each branch is multiplied with its signal-to-noise ratio. The resulting SNR can be written as

$$\gamma_{MRC} = \frac{\varepsilon_x(\sum_{i=1}^{N_r}|h_i|^2)}{\sigma^2} = \sum_{i=1}^{N_r}\gamma_i \quad (8)$$

When adding up the branches of SNR, the total SNR will be accomplished.

4. Simulation &Result

We have simulated the system by using Transmit Diversity (Space Time Coding) and Receiver Diversity (Maximum Ratio Combining) techniques. We have simulated our system first by using 1 transmit antenna and 1 receive antenna (means no diversity). Then we used 2 transmit antennas and 1 receive antenna for Space Time Coding. And for Maximum Ratio Combining (MRC), we used 1 transmit antenna and 2 receive antennas. In this simulation, we assume that the Rayleigh channel is using in this simulation. We generated a stream of random numbers and then fed these numbers into a modulator. The modulated signals are then fed into an encoder. The encoded signals are then transmitted through the Rayleigh channel. At the receiver side, the signals are decoded and demodulated giving the real data.

4.1 Transmit and Receive Diversity using BPSK

Figure 3 shown the BER for different values of the SNR for the three transmit and receive diversity schemes using BPSK modulation scheme.

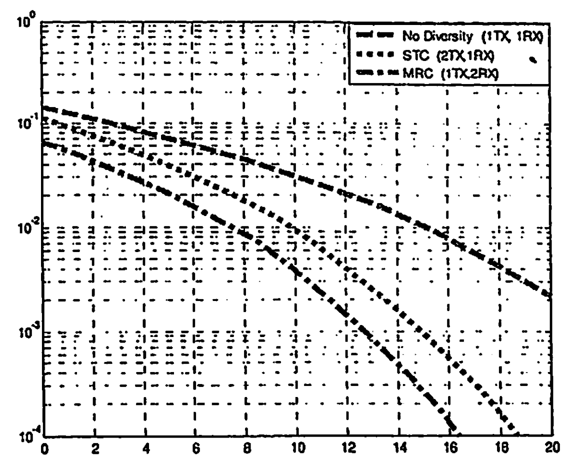

Fig.3. BER / SNR Representation of Transmit and Receive Diversity using BPSK

The simulation shows that by using 2 transmit and 1 receive antenna for Space Time Coding, we get the equal diversity order (which is 2x1 = 2) as we get for 1 transmit and 2 receive antennas for Maximum Ratio Combining (which is 1x2 = 2). As clearly able to be seen, Maximum Ratio Combining technique gives better performance in terms of BER as compared to Space Time Coding. The simulation also shows large improvement in system performance by using diversity techniques as compared to the case of no diversity.

4.2 Transmit and Receive Diversity using QPSK

Figure 4 shows the BER for different values of the SNR for the three transmit and receive diversity techniques using QPSK modulation type.

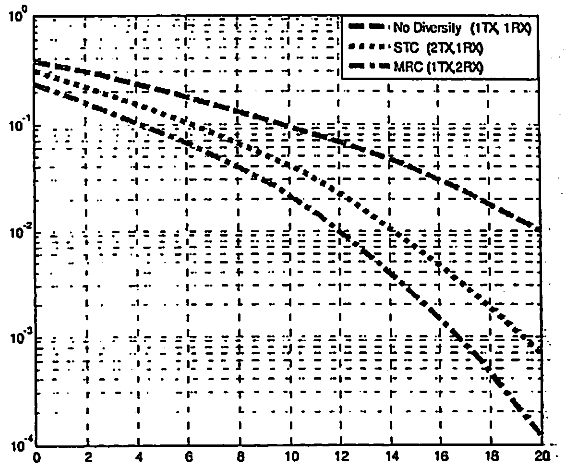

Fig .4.BER / SNR Representation of Transmit and Receive Diversity using QPSK

Using the same parameters but changing the modulation type from BPSK to QPSK, we get the above plot. By analyses Figure 3 and Figure 4, we are able to say that by using higher modulation type the scales shift upwards as QPSK puts twice as many bits in each symbol. By using BPSK, Maximum Ratio Combining was giving zero BER at SNR = 16 but with QPSK it is shifted to SNR = 20. But still Maximum Ratio Combining provides better performance results.

4.3 Transmit and Receive Diversity using 4QAM

Figure 5 shows the BER for different values of the SNR for the three transmit and receive diversity techniques using 4QAM modulation scheme. By using 4QAM, the scale shifts up as compared to BPSK but Maximum Ratio Combining technique is still giving the greatest performance. This shows that modulation schemes are giving here only scaling factor due to multiple bits in each symbol and doesn't have much effect on the system in terms of BER.

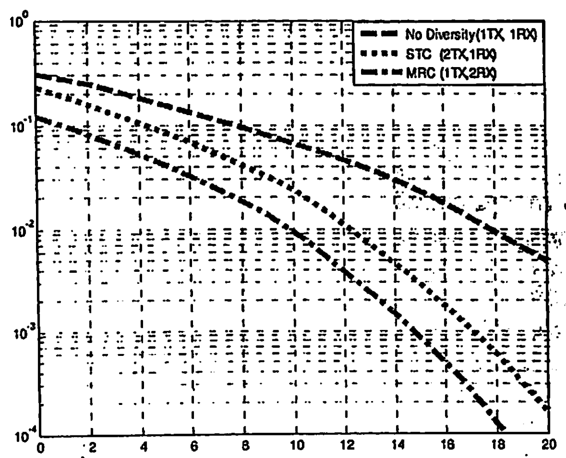

Fig.5. BER / SNR Representation of Transmit and Receive Diversity using 4QAM

4.4 Comparison of Different Diversity Techniques

Figure 6 shows comparisons among different diversity type where all the systems have diversity order of 4. For this simulation, we have compared Space Time Coding with 4 transmit and 1 receive antenna using QPSK modulation (Diversity order: 4x1=4), Space Time Coding with 2 transmit and 2 receive antennas using BPSK modulation (Diversity order: 2x2=4) and Maximum Ratio Combining with 1 Transmit and 4 Receive antennas using BPSK modulation (Diversity order: 1x4=4). By analyses the plots, we can say that by using higher modulation type same QPSK if we increase the antennas at transmitter side, the BER decreases and performance of the system increases in Space Time Coding Technique. We also analyses that by using BPSK modulation type and by using 2 antennas at transmitter and 2 antennas at receiver side, the BER of system decreases as compared to 1 Transmit antenna and 4 Receive antennas using QPSK modulation type. We in further analyses that by using BPSK modulation and by increasing the number of antennas to 4 at receiver side in Maximum Ratio Combining, it provides the better BER performance than all other systems.

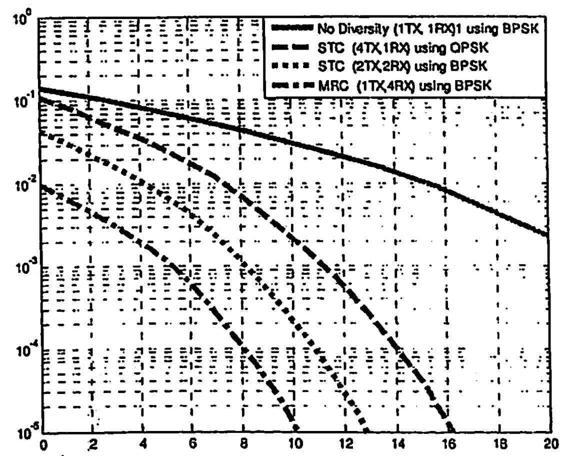

Fig.6. Comparison among different Diversity Techniques

5. Conclusion

In Diversity techniques, we used different antenna scenarios and different modulation schemes for simulating Space Time Coding and Maximum Ratio Combining. After carefully comparing the plots of these scenarios, we came to the conclusion that Maximum Ratio Combining system gives us better BER performance in Diversity techniques regardless of modulation type.

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Analysis of MISO WIMAX IEEE802.16d in SUI Multipath Fading Channels

Mohammed Aboud Kadhim and Dr.Widad Ismail

Abstract—This paper presents a physical scattering model that predicts multiple-input multiple-output (MIMO) channel characteristics conforming well to experimental observations in WIMAX IEEE802.16d. Our approach is to start with a given single-input single-output power-delay profile (defined for specific range, bandwidth and antenna parameters) and fit a scattering model that characterizes the MIMO channel. From the derived scattering model and antenna array configurations. Simulations of SUI MIMO channels are shown to observed channel correlations, antenna beamwidth effect, range dependency, and frequency selectivity.

Index Terms— WIMAX, SUI, Channel, MISO, Antenna.

1 INTRODUCTION

THE Broadband wireless access (BWA) was originally viewed as a technology for delivering service to fixed business and subscriber user premises, i.e., an alternative to asymmetric digital subscriber lines (ADSL) and cable modem technologies. But more recently, there has been a shift in the service requirements to cover mobile user terminals, and the technical specifications were updated accordingly. Technical specifications for BWA were drafted by the IEEE 802.16 Group, which addressed the 10-66 GHz millimeter-wave frequency band in a first phase and the 2-11 GHz microwave band in a second phase [1]. In the millimeter-wave frequency band between 20 and 45 GHz, there is a wide spectrum usable for this application, but unfortunately, millimeter-wave radio technology is still not mature enough to make BWA systems at these frequencies viable for residential applications. Therefore, millimeter-Wave BWA systems are primarily intended to business customers in urban or suburban areas with high user density, and their commercial deployment remains very small scale. To address the residential subscriber market and compete with digital subscriber lines (DSL) and cable modems, as well as with other emerging wireless technologies, attention was therefore turned to microwave frequency bands between 2 and 11 GHz, where low-cost radio technologies are available. These bands include the 2.5 GHz microwave multi-point distribution service (MMDS) band in the US, the 3.5GHz band all across Europe, and the 10 GHz band, which is available in a number of countries in Europe, Latin America, and some other regions. But although it has been a hot topic for almost a decade, BWA is still in its infancy. Equipment cost is obviously one of the reasons, but this slow development can also be attributed to the lack of industry standards in the past. Fortunately, the IEEE 802.16 standard developed for fixed services and the more recent IEEE 802.16e standard [2] developed for mobile applications close this gap. In addition, the establishment of the WIMAX Forum, which gathers many service providers, network operators, equipment manufacturers and technology companies, is a clear indication that there is today a strong interest in BWA for fixed and mobile applications, and commercial deployments are planned for early 2006. This paper addresses multipath propagation problems in BWA systems at microwave frequency bands between 2 and 11 GHz and discusses the design, and development and testing of technologies suitable for fixed broadband wireless applications this application adopted in IEEE802.16d standard. First, in the next section, we give a brief introduction to SUI channels parameters, next we briefly discuss diversity and multiple input/multiple output (MIMO) techniques then simulation the propagation problems is present in the SUI channel models used. Also, give some performance results. Finally, we give some conclusions.

2. Stanford University Interim (SUI) Channel Models

SUI channel models are an extension of the earlier work by AT&T Wireless and Ercegetal [3]. In this model a set of six channels was selected to address three different terrain types that are typical of the continental US [4]. This model can be used for simulations, design, development and testing of technologies suitable for fixed broadband wireless applications [5]. The parameters for the model were selected based upon some statistical models. The tables below depict the parametric view of the Six SUI channels

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Table 1: Terrain type for SUI channel

Terrain Type	*SUI Channels*
C (Mostly flat terrain with light tree densities)	SUI1, SUI2
B (Hilly terrain with light tree density or flat terrain with moderate to heavy tree density)	SUI3, SUI4
A (Hilly terrain with moderate to heavy tree density)	SUI5, SUI6

Table 2: General characteristics of SUI channels

Doppler	*Low delay spread*	*Moderate delay spread*	*High delay spread*
Low	SUI1,2 (High K Factor) SUI3		SUI5
High		SUI4	SUI6

We assume the scenario [6] with the following parameters:

- Cell Size: 7Km
- BTS antenna height: 30 m
- Receive antenna height: 6m
- BTS antenna beam width:
- Receive antenna beam width: Omni directional
- Polarization: Vertical only
- 90% cell coverage with 99.9% reliability at each location covered

For the above scenario, the SUI channel parameters are tabulated in Table 3, 4 and 5 according to [6]

Table 3: Delay spread of SUI channels

Channel model	*Tap1*	*Tap2*	*Tap3*	*Rms delay spread*
	µs			
SUI-1	0	0.4	0.9	0.111
SUI-2	0	0.4	1.1	0.202
SUI-3	0	0.4	0.9	0.264
SUI-4	0	1.5	4	1.257
SUI-5	0	4	10	2.842
SUI-6	0	14	20	5.240

Table 4: Tap power (Omni directional antenna) of SUI channels

Channel model	*Tap1*	*Tap2*	*Tap3*
	dB		
SUI-1	0	-15	-20
SUI-2	0	-12	-15
SUI-3	0	-5	-10
SUI-4	0	-4	-8
SUI-5	0	-5	-10
SUI-6	0	-10	-14

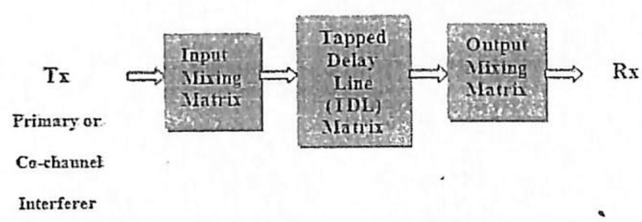
Table 5: 90% K factor (Omni directional antenna) of SUI channels

Channel model	*Tap1*	*Tap2*	*Tap3*
	dB		
SUI-1	4	0	-20
SUI-2	2	0	-15
SUI-3	1	0	-10
SUI-4	0	0	-8
SUI-5	0	0	-10
SUI-6	0	0	-14

In the next section we will talk about t how these parameters have been incorporated to implement SUI channel model for proposed design.

3. SUI Channel model Simulation.

This model can be used for simulations, design, and development and testing of technologies suitable for fixed broadband wireless applications [6]. The parameters for the model were selected based upon some statistical models the channel can be setup to simulate channel coefficients



The above structure is general for Multiple Input Multiple Output (MIMO) channels and includes other configurations like Single Input Single Output (SISO) and Single Input Multiple Output (SIMO) as subsets. The SUI channel structure is the same for the primary and interfering signals. Input Mixing Matrix: This part models correlation between input signals if multiple transmitting antennas are used. Tapped Delay Line Matrix: This part models the multipath fading of the channel. The multipath fading is modeled as a tapped-delay line with 3 taps with non-uniform delays. The gain associated with each tap is characterized by a distribution (Ricean with a K-factor > 0, or Rayleigh with K-factor

= 0) and the maximum Doppler frequency. Output Mixing Matrix: This part models the correlation between output signals if multiple receiving antennas are used. Using the above general structure of the SUI Channel and assuming the following scenario, six SUI channels are constructed which are representative of the real channels [6].

Table (4) Simulation Parameters

Cell size	*BS antenna height*	*Receive antenna height*	*BS antenna Beamwidth*	*Maximum Doppler shift*	*antenna correlation*	*modulator*	*Input symbol rate*	*Type of MI-*
7km	*30m*	*6m*	*120* degree	*0.5*	*0.9*	*Psk 2*		MISO

The simulation in matlab software [7] .below constructs a MISO channel object according to the modified SUI (1, 2, 3, 4,5and 6) channel model, for an Omni-directional antenna and 90% cell coverage. The channels model has 3 paths: the first path is Rician while the remaining two are Rayleigh. Each path has a rounded Doppler spectrum for its spread component: the parameters are as specified in the default Doppler. rounded object. While different maximum Doppler shifts are specified for each path in we use the maximum value of the Doppler shifts for all paths. We use 2 transmit antennas and 1 receive antenna the receive antenna is either Omni-directional or directional (30 degrees), and only vertical polarization is used, the correlation coefficient 0.9 between the two signals on each path is taken equal to the antenna correlation.

3.1 Performance of SUI-1 channel:

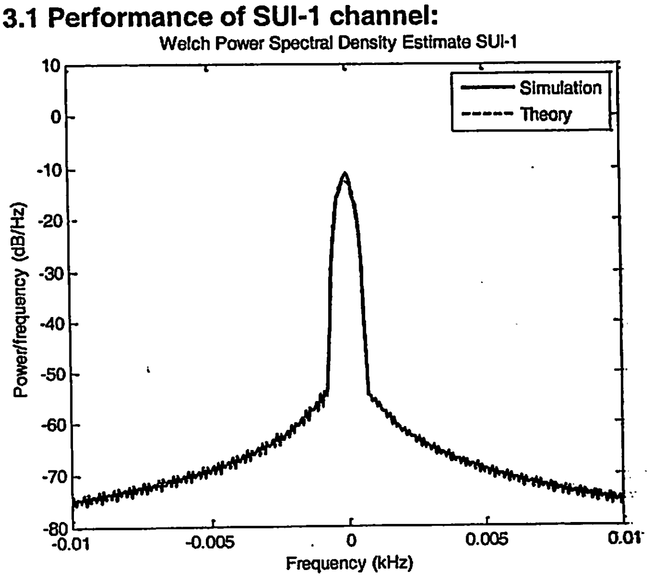


Fig.1. Welch Power Spectral Density Estimate SUI-1

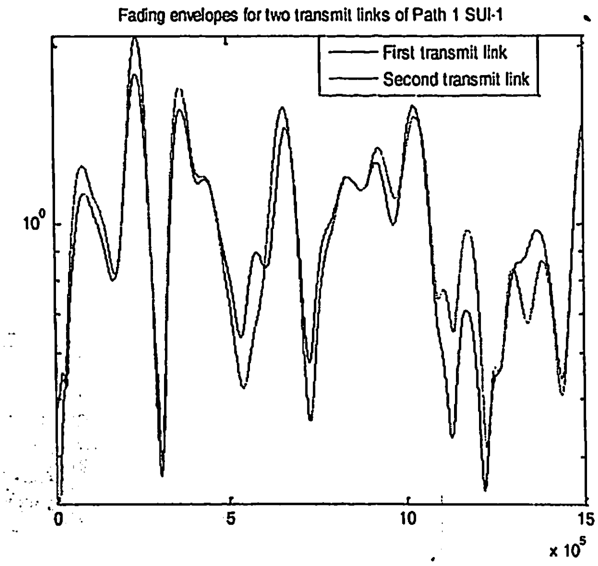


Fig.2. Fading envelopes for two transmit links of path 1 SUI-1

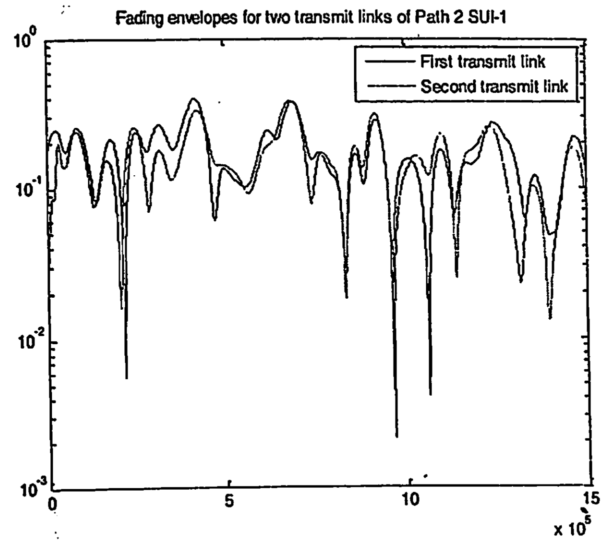


Fig.3. Fading envelopes for two transmit links of path 2 SUI-1

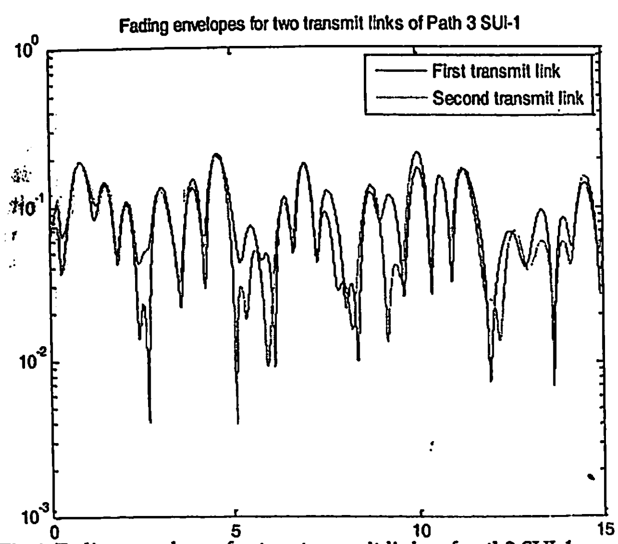


Fig.4. Fading envelopes for two transmit links of path3 SUI-1

3.2 Performance of SUI-2 channel:

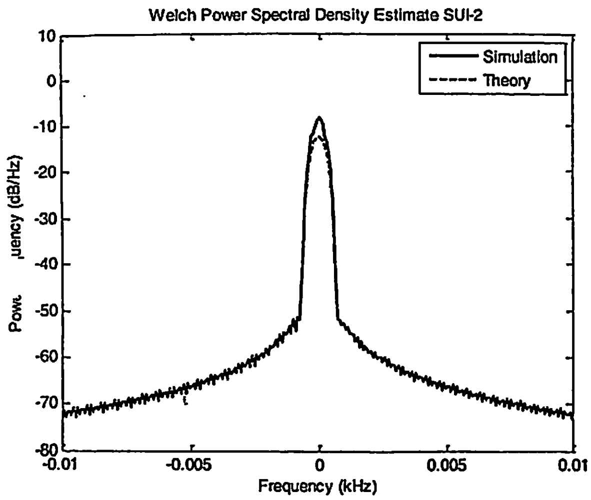


Fig.5. Welch Power Spectral Density Estimate SUI-2

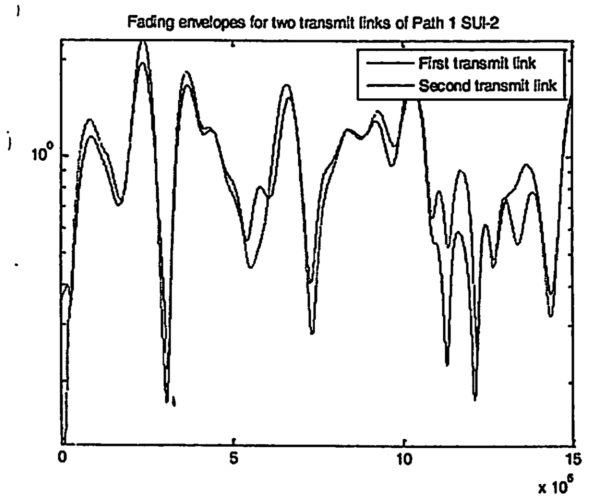


Fig.6. Fading envelopes for two transmit links of path 1 SUI-2

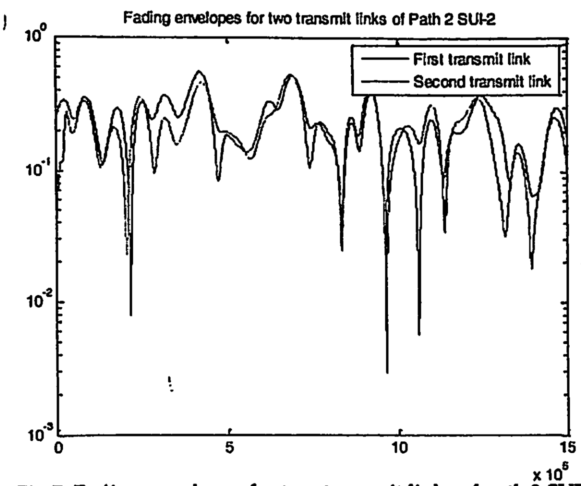


Fig.7. Fading envelopes for two transmit links of path 2 SUI-2

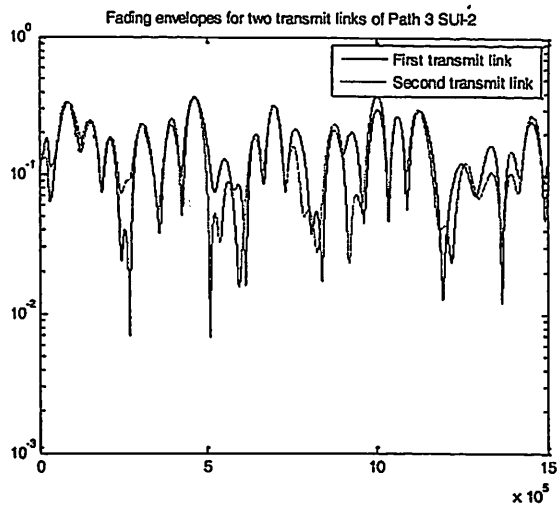


Fig.8. Fading envelopes for two transmit links of path 3 SUI-2

3.3 Performance of SUI-3 channel:

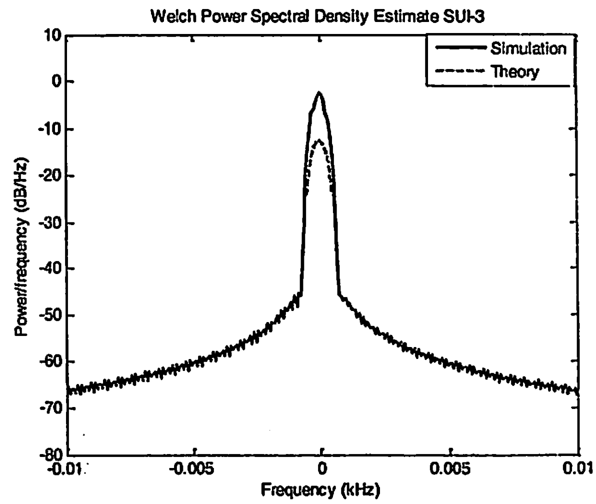


Fig.9. Welch Power Spectral Density Estimate SUI-3

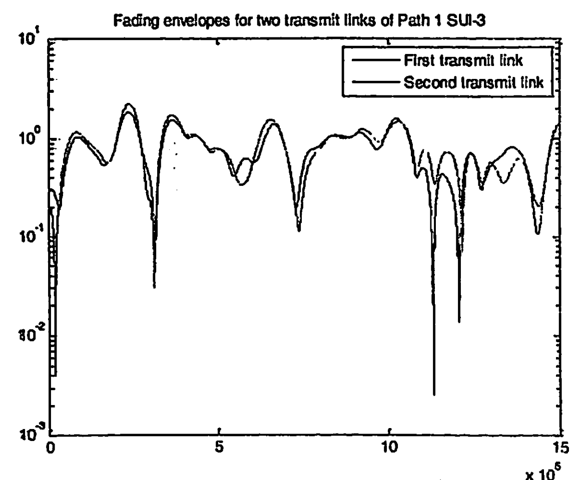


Fig.10. Fading envelopes for two transmit links of path 1 SUI-3

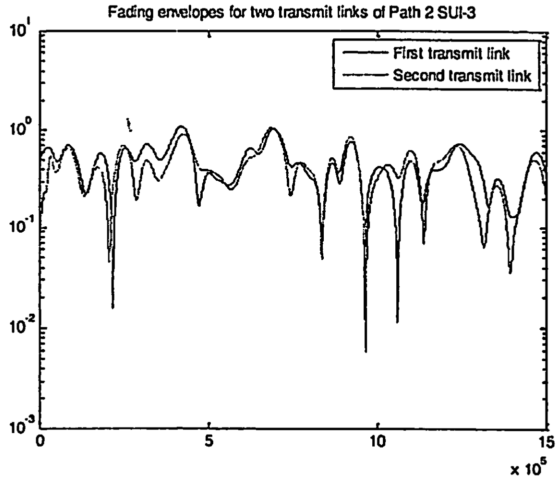


Fig.11. Fading envelopes for two transmit links of path 2 SUI-3

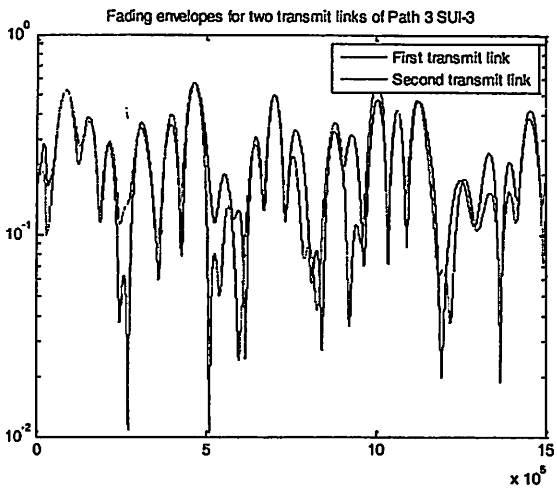


Fig.12. Fading envelopes for two transmit links of path 3 SUI-3

3.4 Performance of SUI-4 channel:

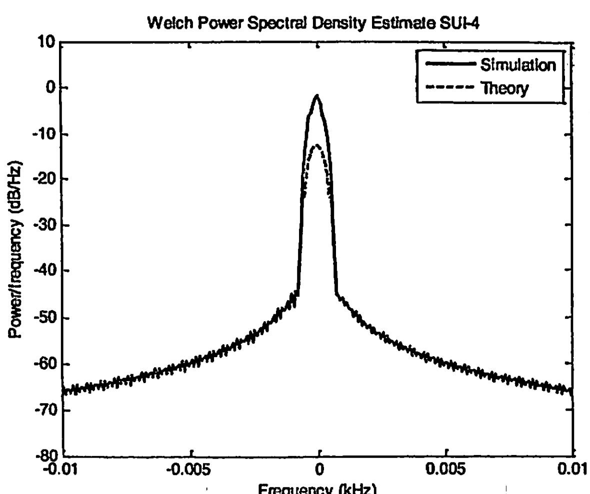


Fig.13. Welch Power Spectral Density Estimate SUI-4

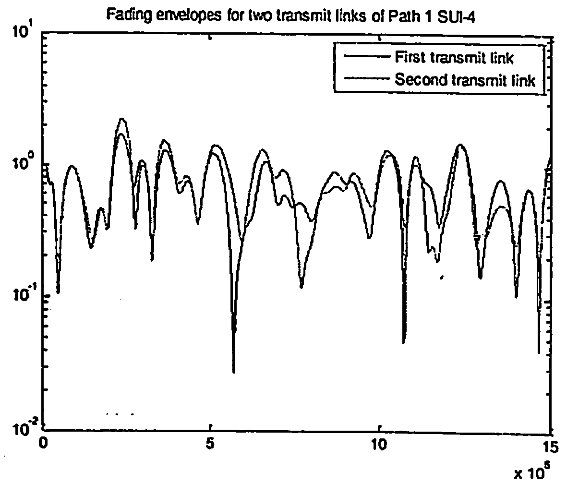


Fig.14. Fading envelopes for two transmit links of path 1 SUI-4

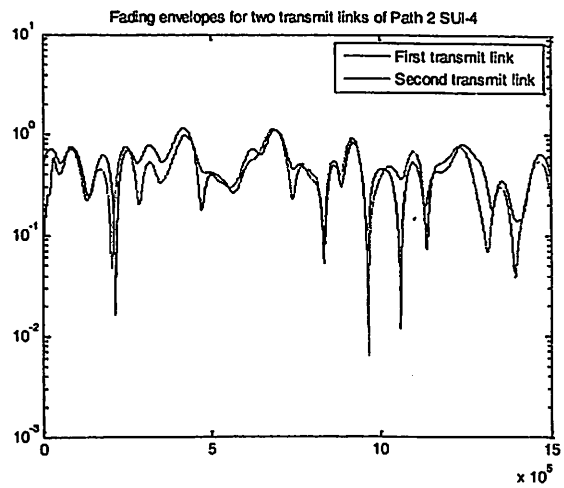


Fig.15: Fading envelopes for two transmit links of path 2 SUI-4

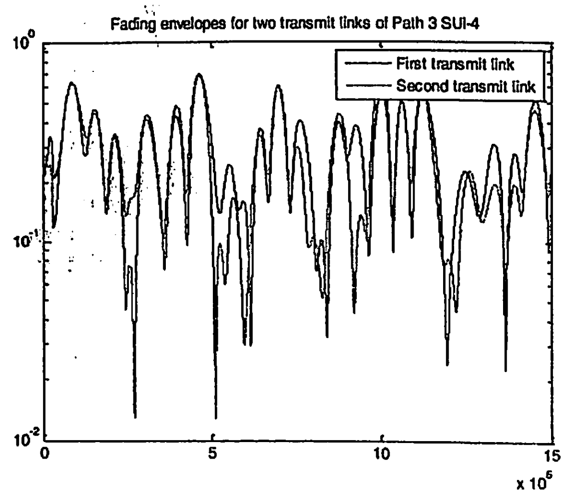


Fig.16. Fading envelopes for two transmit links of path 3 SUI-4

3.5 Performance of SUI-5 channel:

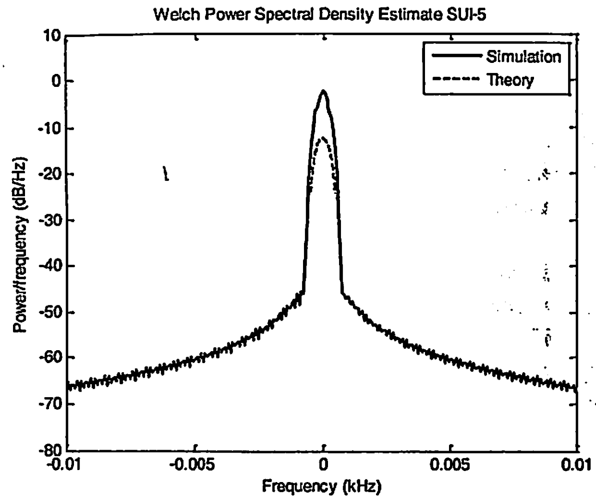


Fig.17. Welch Power Spectral Density Estimate SUI-5

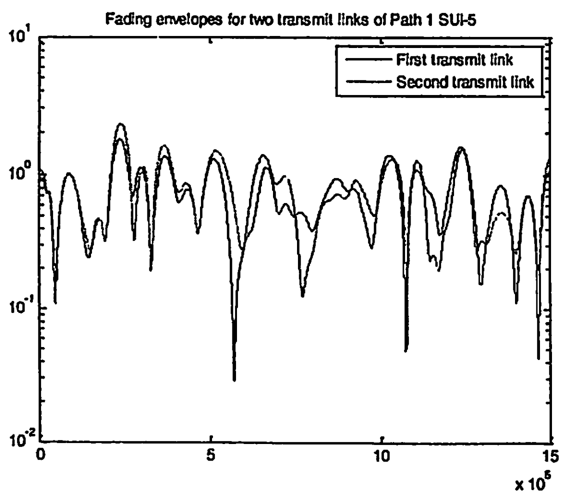


Fig.18. Fading envelopes for two transmit links of path 1 SUI-5

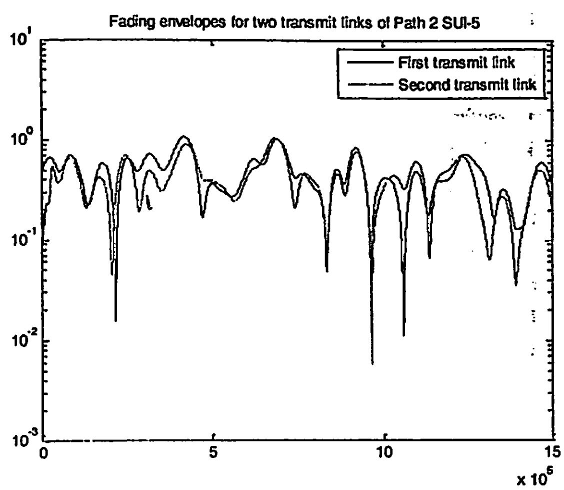


Fig.19. Fading envelopes for two transmit links of path 2 SUI-5

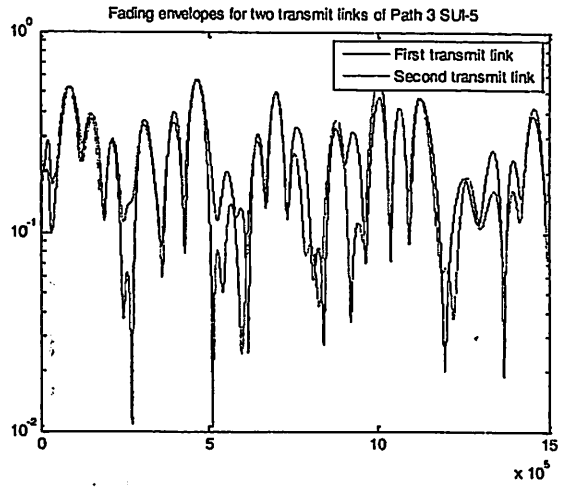


Fig.20. Fading envelopes for two transmit links of path 3 SUI-5

3.6 Performance of SUI-6 channel:

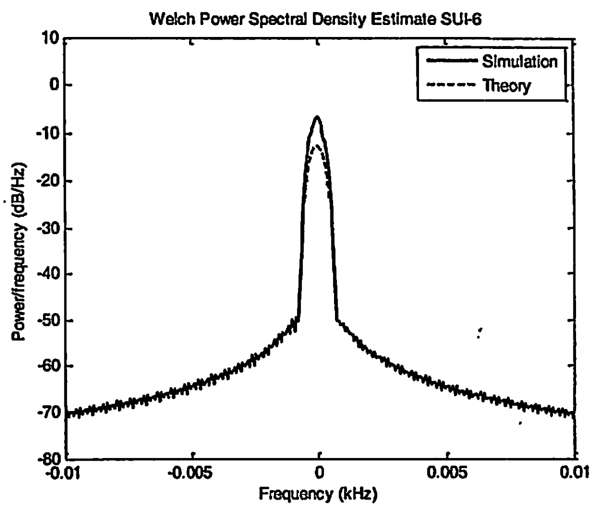


Fig.21. Welch Power Spectral Density Estimate SUI-6

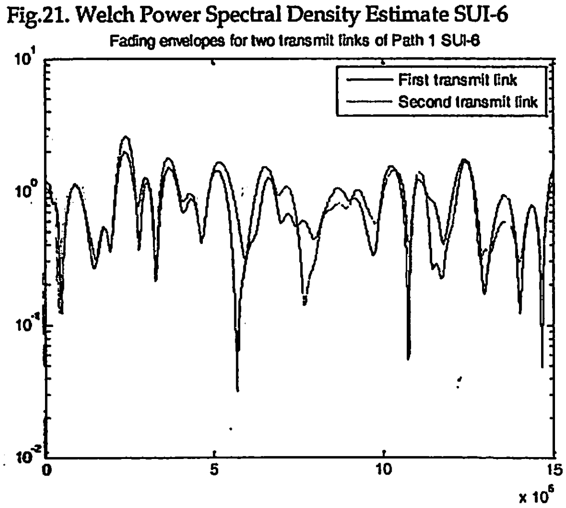


Fig.22. Fading envelopes for two transmit links of path 1 SUI-6

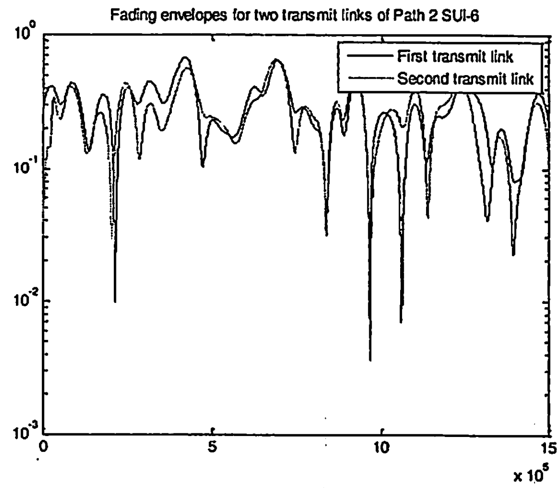


Fig.23. Fading envelopes for two transmit links of path 2 SUI-6

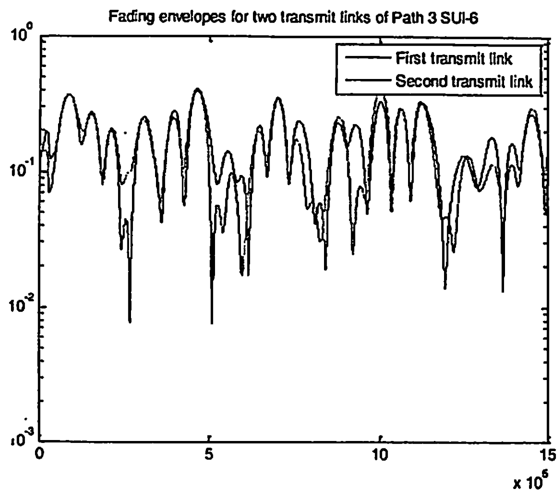


Fig.24. Fading envelopes for two transmit links of path 3 SUI-6

From the above figures is shown The Doppler spectrum of the 1st link of the 2nd path is estimated from the complex path gains and plotted. The Doppler spectrum for the 2nd link of the 2nd path is also estimated and compared to the theoretical spectrum. We also observe a good fit between both. For each path, we plot the fading envelope waveforms of both transmit links. We can notice a correlation between the fading envelopes we compute the correlation matrices for each path. We notice that they explain a match with the theoretical values (compare with h. TX Correlation Matrix specified earlier). IEEE 802.16d models are based on a modified version of the SUI channel models, valid for both Omni-directional and directional antennas. In the standard, the use of directional antennas naturally causes the *K*-factor of the Ricean taps to increase (the same holds true for the global narrowband *K*-factor) and the global delay-spread to decrease. Though, the model does not modify the correlations at the UT when reducing the antenna beams width, although one might have expected the correlation coefficients to increase as the beam width decreases. Additional features of the IEEE 802.16d standard include a path loss model, a model for the narrowband Ricean *K* factor, as well as an antenna gain reduction factor model. The path-loss model covers three terrain categories: hilly terrain with moderate-to-heavy tree densities (category *A*, to be used with SUI models 5 and 6), mostly flat terrain with light tree densities (category *C*, to be used with SUI models 1 and 2), and terrain with intermediate path loss condition, captured in category *B* (corresponding to SUI models 3 and 4).

5. Conclusion

This paper provided the most important concepts in channel and radio propagation SUI modeling for wireless WIMAX MISO systems. We advocated an intuitive classification into physical models that focus on IEEE802.16d and explain propagation and analytical models that concentrate on the channel impulse response (including antenna properties). For both model types, we reviewed popular examples that are widely used for the design and evaluation of MISO systems. Furthermore, the most important features of a number of channel models proposed in the context of recent wireless standards were summarized. Significantly, more effort is necessary to validate SUI channel models and to determine the applicability of the models in different environments.

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CONFERENCE PRESENTATION

Development of Heterogeneous Cognitive Radio and Wireless Access Network

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***Abstract*—the future of mobile networks is expected to utilize multiple radio access technologies, seamlessly incorporated to form a heterogeneous wireless network. When a new call arrived, the network operator must allocate an access network to the client. However, cognitive network (CN) uses the spectrum temporarily whenever the Primary Network (PN) is off. Thus cooperative sharing between primary and secondary users is important to achieve efficient usage for the available resources. High delivery requirements for mobile users may exceed the capacity of PN resources. To solve this problem, a new scheme for sharing resources between secondary and primary spectrum users is required. The contribution of this paper is to design one pool of cognitive and heterogeneous primary networks that is able to manage the shortage of the primary networks and cognitive resources. In this way, the PN talks to the CN to decide the best action of using a route if the Quality of Service (QoS) weak for certain link. Primary transmitted data is carried by the CN if the secondary routes show more throughputs to the end users. As a result, the PN would be able to gain more resources for other PN's using the CN developed link formulation method. OPNET simulated results show high throughput rates achieved using the CN links compared to a bad primary link in a heterogonous wireless environment. A new aspect of cooperative broadcasting between primary and secondary networks is recommended into research for the next generation networks.**

***Index Terms*—Cognitive radio, Heterogeneous network, Wireless access networks, Cooperative radio, Spectrum sharing.**

I. INTRODUCTION

The world of wireless communications is nowadays facing a serious problem of spectrum shortage. Such problem is not only due to"real" limitations on the available bandwidth, but also (and mainly) to inefficient policies in spectrum management [1]. However, the core technology behind frequency reuse is cognitive radio, for which one of the essential components is channel sensing, the wireless devices can sense the radio spectrum environment within their operating range to detect frequency bands that are not occupied by primary users. In December 2003, FCC issued a notice of proposed rulemaking that identifies cognitive radio as the candidate for implementing negotiated and opportunistic spectrum sharing [2]. Therefore, the key enabling technology of dynamic spectrum access techniques is cognitive radio (CR) technology, which provides the capability to share the wireless channel with licensed users in an opportunistic manner. CR networks are envisioned to provide high bandwidth to mobile users via heterogeneous wireless architectures and dynamic spectrum access techniques. This goal can be realized only through dynamic and efficient spectrum management techniques [3]. Moreover, one possible means of achieving the efficient use of frequency resource is to select one from multiple different communication schemes in some frequency bands which is generally called heterogeneous radio communication; different radio environments may have different radio link quality. The interfacing between secondary and primary networks for efficient spectrum utilization should be considered to obtain the required capability using transmission links [4].

In [5] Chunhua Sun judged that cognitive radio systems, the unlicensed (Cognitive) users are able to access the licensed (primary) spectrum as long as the QoS of the licensed user is guaranteed With the Federal Communications Commission's (FCC) spectrum policy reform, a new metric, called the interference temperature, has been proposed to quantify and manage the interference in a radio environment.

In reference [6], surveyed the integration of WLANs, and MANETs technologies with diverse capabilities and functionalities are an extremely complex task to designing future adaptable heterogeneous networks that provide QoS guarantees to users. Several papers have confidential routing protocols in terms of their behavioural characteristics and applicability. Nevertheless, as Ad hoc On-Demand Distance Vector Routing AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV has great advantage in having less overhead over simple protocols which need to keep the entire route from the source host to the destination host in their messages [7]. Typically, collaboration among unlicensed users to exchange network information is required to achieve cooperative behaviour [8].

However, in a cognitive radio network with cooperative unlicensed users, optimization or supportive can be useful to obtain an optimal and fair solution for distributed dynamic spectrum access. On the other hand, collaborative behavior of the unlicensed users is able to exchange network information with each other. In this case of cooperation among unlicensed users, a protocol will be essential for exchanging network information.

In contrast to previous works, this paper proposes a developed solution for the problems of primary user's end-to-end link formulation in heterogeneous wireless environment. When the primary user can not insure the QoS for a certain link, it will negotiate with the cognitive network the probability to formulate new link using the CN.

Therefore, both cognitive and primary networks must have the necessary communications to share their resources. The contribution of this paper is to simulate the efficiency of the new established link between the primary and the cognitive networks. Compassion is given between the traditional link performance and the designed scenarios. New coexistence management between the licensed and the unlicensed bands is given through this proposal.

The rest of this paper is arranged as follows: a briefly description for the heterogeneous wireless networks is proposed in Section II. The capabilities of the cognitive network are explained in Section III. The setup for the simulated heterogonous network is explained in Section IV. Simulations results are reviewed in Section V. Conclusions are presented in Section VI.

II. Heterogeneous Cognitive Network

The coexistence of many types of primary and cognitive networks creates heterogeneous networks as shown in figure1. This heterogeneously wireless environment is using plurality of connectivity alternatives from multifarious wireless access technologies to handle requests from primary end-users. The main modification in this designed scheme is that CN offers leased services to PN by allowing smooth transferring of data between licensed users using the unlicensed bands.

This ease in interoperability of signals between the PN and the CN assumes high levels of collaborative cognition for the expected actions between the two systems. Therefore, the primary network should be able to understand exactly the suitable times and locations for requesting services from the cognitive systems. One expected solution is that the CN ask the PN for spectrum availability as long as services are being charged from the PN. Otherwise, the PN should send help request to the CN and wait for reply to start transmission. This requires a permanent connection between the primary and secondary systems to perform such scenarios. This permanent primary to cognitive network linking was proposed in [9].

As seen from the scenario in figure 1, the cognitive radios are following the distributed management. In this scenario, all the base stations from various networks are able to communicate with each other and share the available resources. Additionally, requests from CN end users can be delivered through a combination of links established over primary and secondary networks. This flexibility in spectrum trade for a variety of operators and diversity of vender's base stations is impacted by the time delays during route formulations between different technologies and spectrum channels. These delays are critical factors to evaluate the success of the proposed management between networks especially in a very dynamic wireless environment where the service interruption loss is increased

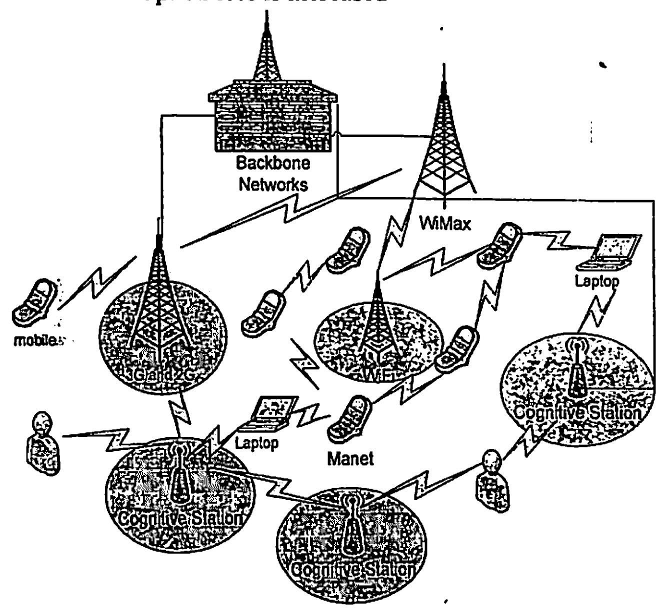

Figure.1 Heterogeneous Network

III. Future Heterogeneous Wireless Access Networks and Cognitive Radio

Future generation wireless networks should offer to mobile users the best connectivity to services anywhere at any time. Consequently, future wireless systems will be accepted to have the following key attributes to enable a high performance seamless user experience equivalent to a wire-line [8, 10, and 11]:

- High transmutation rate: new wireless applications and service, e.g. video and file transfer, require higher data rate to reduce the data transmission time and support a number of users. Many advance techniques in the physical layer have been developed to increase the data rate without increasing spectrum bandwidth and transmit power requirement.
- Optimized connectivity: the user is always connected to the most efficient access network, for instance, microcellular, wireless LAN) in terms of network resource usage, to cater to the specific QoS and mobility requirements.
- QoS support: various type of traffic, e.g. voice video, and data, will be supported by the next generation wireless system. Service differentiation and QoS support are required to prioritize different types of traffic according to the performance access the available spectrum.
- Integration of different wireless access technologies: Next generation wireless networks will use the IP technology to glue the different wireless access

technologies to a converged wireless system .in this converged network , multi interface mobile units will be common. With multiple radio interfaces, a mobile should be able to connect to different wireless networks using different access technologies simultaneously. For example, a mobile can connect to a WLAN through the IEE 802.11-based radio interface. However, when this mobile moves out of range of the WLAN, it can connect to a cellular network (e.g. using a 3G air interface) or a WiMAX network to resume the communication session. Such a heterogeneous wireless access network provides two major advantages: it enhances the data transmission rate since multiple data streams can be transmitted concurrently, and it enables seamless mobility through providing wireless connectivity anytime and anywhere.

IV. Ability of Cognitive Network

Although there are many scenarios for the coexistence between primary and secondary networks, it is mandatory to achieve a certain level of cooperation to prevent any interference resulted from the computation between the cognitive and primary networks or between the cognitive networks. This situation becomes even more complicated in a heterogonous wireless environment composed of many types of networks: primary and secondary. Thus, cooperative schemes are necessary to guarantee seamless communications and to achieve optimal spectrum access. The IEEE 802.11 networks perform the listen to talk operations in transmissions. Therefore, they are the best available standers to simulate the future CN with zero interfences. However, it is very important to understand the differences between the traditional networks and the cognitive capabilities as they have been reviewed in [12]:

A. Location Spectrum Sensing

A cognitive radio can sense spectrum and detect "spectrum holes" which are those frequency bands not used by the licensed users or having limited interference with them.

B. Spectrum Sharing

A cognitive radio could incorporate a mechanism that would enable sharing of spectrum under the terms of an agreement between a licensee and a third party. Parties may eventually be able to negotiate for spectrum use on an ad hoc or real-time basis, without the need for prior agreements between all parties.

C. Location Identification

The ability to determine its location and the location of other transmitters, and then select the appropriate operating parameters such as the power and frequency allowed at its location. In bands such as those used for satellite downlinks that are receive-only and do not transmit a signal, location technology may be an appropriate method of avoiding interference because sensing technology would not be able to identify the locations of nearby receivers.

D. Network Discovery

For a cognitive radio terminal to determine the best way to communicate, it shall first discover available networks around it. These networks are reachable either via directed one hop communication or via multi-hop relay nodes. The ability to discovery one hop or multi-hop away access networks is important.

V. Heterogeneous Broadcast

Cognitive radios are being intended that opportunistically utilize spectrum across a broad range of frequency bands, by this means providing for a large set of frequency- divide channels. The situation of vacant channels in such dynamic spectrum access networks perhaps heterogeneous, for instance, diverse channels may support diverse data rates, broadcast ranges, and delay characteristics as well. In addition, the set of obtainable channels itself may possibly adjust with time, depending on traffic imposed by the primary user. A packet transmitted by a node when successfully to reaches a maximum distance on destination may be called transmission rate. The exact area over which a transmission can be received could have a complex outline that depends on channel propagation features. Furthermore, Federal Communications Commission (FCC) may identify different maximum transmission range for different channels. As a result, various channels support various transmission ranges .Due to homogeneous channels, the accessible multi-channel multi-radio MCMR networks often assume with the purpose of a node can reach a common locate of stations in the same area on any of its channels [13]. While, for heterogeneous CR networks, a node can communicate with near stations nodes, depending on the channel used, and therefore, a node is able to communicate with heterogeneous set of stations using various channels.

VI. Heterogeneous Network Setup

In this section, an overview is presented for a heterogeneous architecture of cognitive network working cooperatively with a primary network. To set such a collaborate behavior, Ad-hoc On-demand Distance Vector (AODV) is used as the routing protocol for the designed heterogonous network. According to reference [14] we consider WiFi as cognitive network as well as mobile ad hoc network (MANET) is used as primary networks. Three cognitive mobile stations are used to provide the alternative link as shown in figure 2, and four primary stations are deployed in the service area.

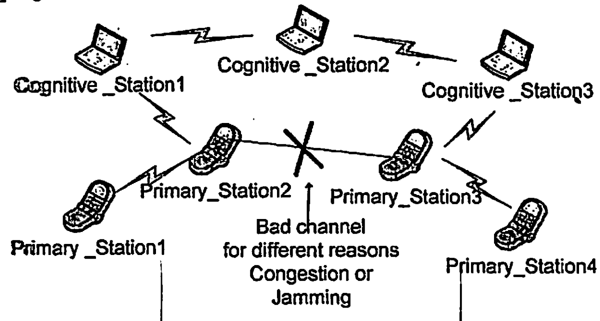

Figure2 Cooperative spectrum of heterogeneous primary and secondary

The main assumption in this proposal is that one of the primary links is not running well according to the requested QoS. This was chosen in the simulated scenario to be the link between primary _ station 2 and primary_ station 3. However, the channel is bad under different reasons for the declination in the services across this link for instance high level of congestion, jamming and bad data flow in services. Therefore, the primary network send request signal to the cognitive_station1 which are a number of primary users in the same region, who are willing to provide their rich spectrum for secondary user. As a result, new link is established from primary_station 2 to cognitive_station 1. Then data packets are forwarded from the CN to the next primary station or even to the destination. In this case, Secondary users can access these spectrum gaps opportunistically, meaning exploit the spectrum of the primary users only when it is not currently used by primary user's information to cognitive _station2 and cognitive_station3 respectively, before flow the data to the primary_station4.

VII. SIMULATION SETUP

We evaluated our scenario in a heterogeneous network system performance by using OPNET modular network to create a heterogeneous environment as shown in figure3. However, System performance includes the network throughput i.e. the amount of data delivered in all the way through the network, and end-to-end packet traffic. In result described below the cognitive network environment out performance better than non-heterogeneous.

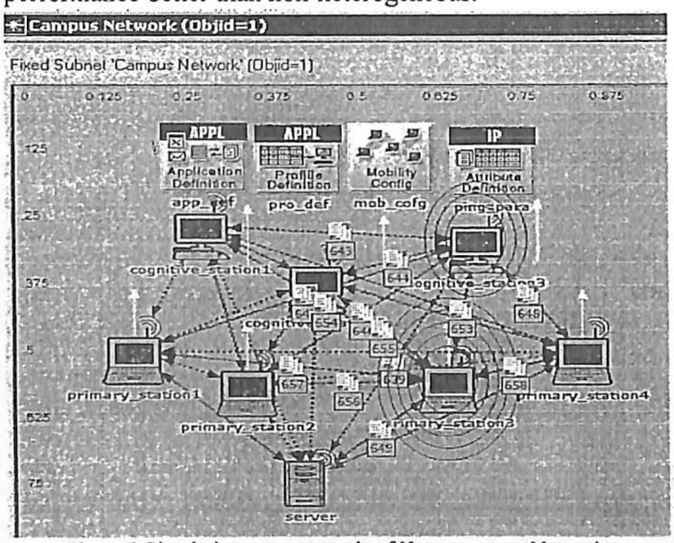

Figure 3 Simulation setup example of Heterogeneous Network

The simulation setup is as the follows. There are 3 cognitive nodes and 4 primary nodes in the network. We run the simulation twice once four primary nodes (non-heterogeneous) unaided and then three cognitive nodes with four primary nodes (heterogeneous cognitive) and we compare the results.

VIII. SIMULATION OPNET RESULT

A. Results at the End of the link

The performance of cognitive heterogeneous is investigated in terms of throughput. Figure 4 gives information about the amount of throughput for both the heterogeneous and non-heterogeneous network at the end of the link. The figure shows that heterogeneous cognitive throughput was around 1100 bits/sec at the first time which is higher than non-heterogeneous and then decline rapidly to approximately 200 bits/sec. On the other hand, non-heterogeneous throughput was around 400 bits/sec before dropping to around 50 bits/sec and remains stable. Overall, the cognitive heterogeneous throughput is considerably higher than the non-heterogeneous.

Moreover, figures 5 to 7 show queue size, Delay, Load of cognitive heterogeneous and non- heterogeneous. As we know in the simulation results, the cognitive has better performance with increasing queue size and load. The delays of two cases are comparable and they are all of the order in a second. Each case suffers delay degradation when the loaded packet traffic increases.

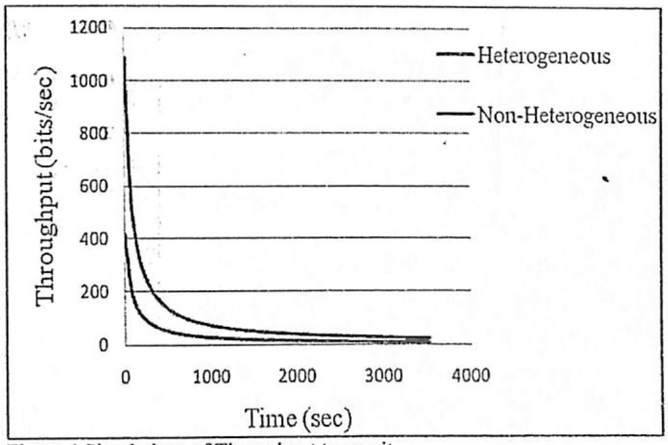

Figure 4 Simulations of Throughput transmit

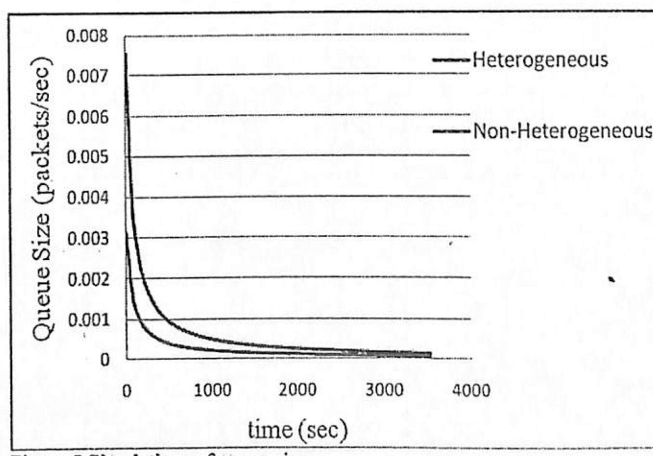

Figure 5 Simulations of queue size

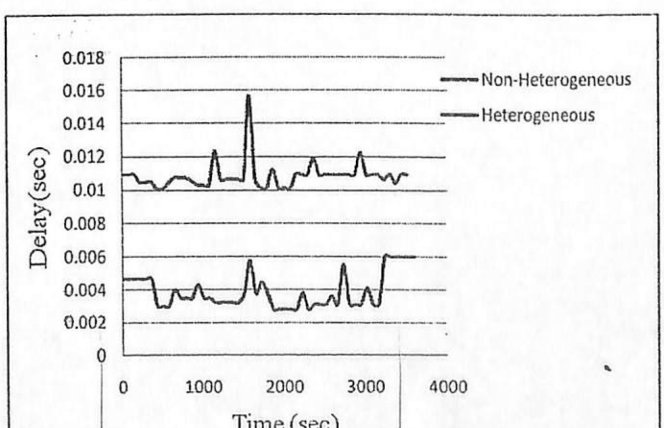

Figure 6 Simulations of Delay

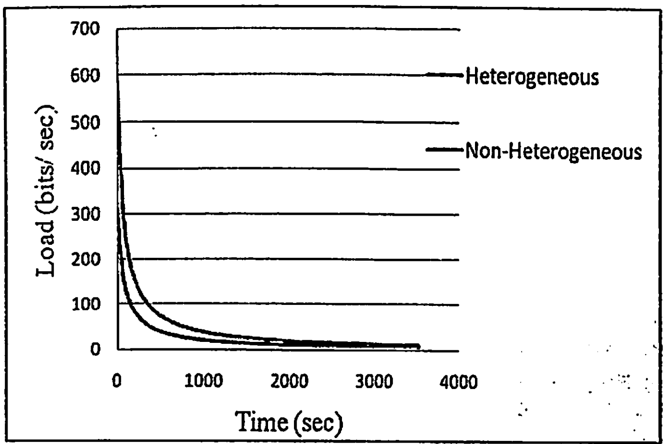

Figure 7 Simulations of Load

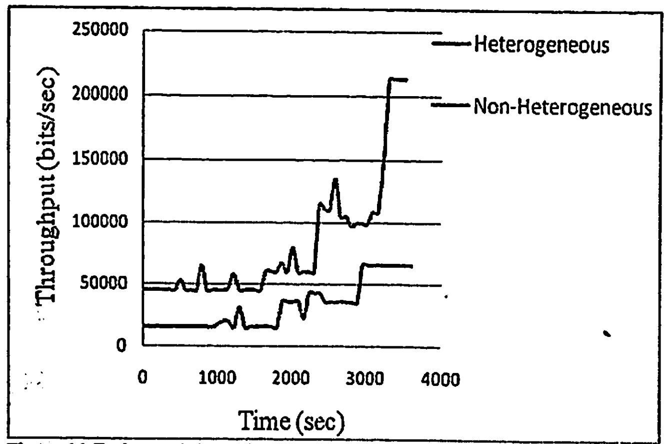

Figure 11 End to end throughput

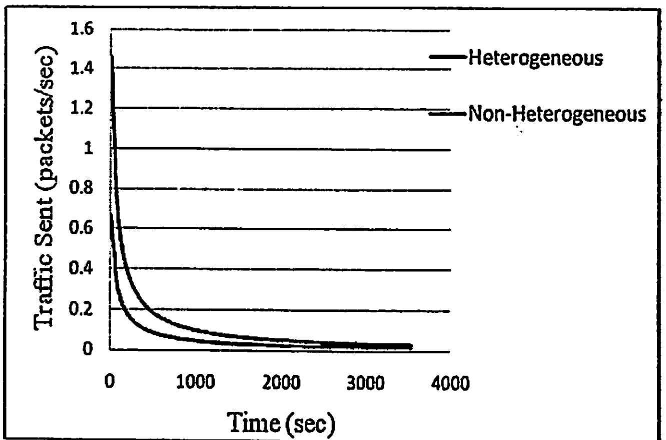

Figure 8 Simulations of traffic sent

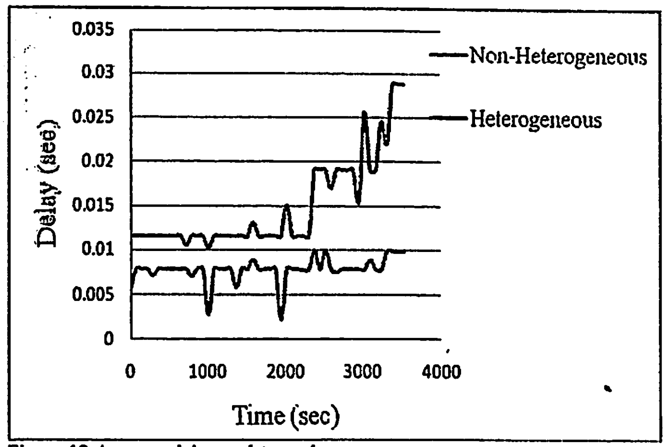

Figure 12 Average delay end-to-ends

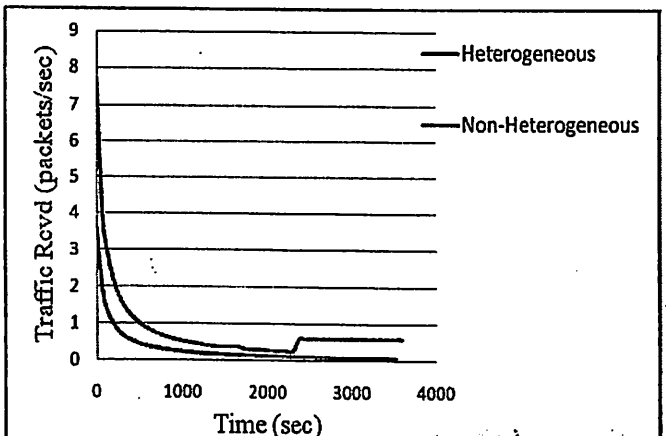

Figure 9 Simulations of traffic received

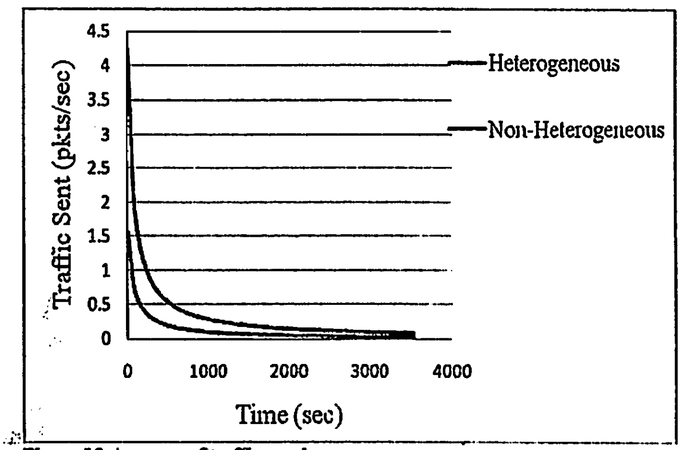

Figure 13 Average of traffic send

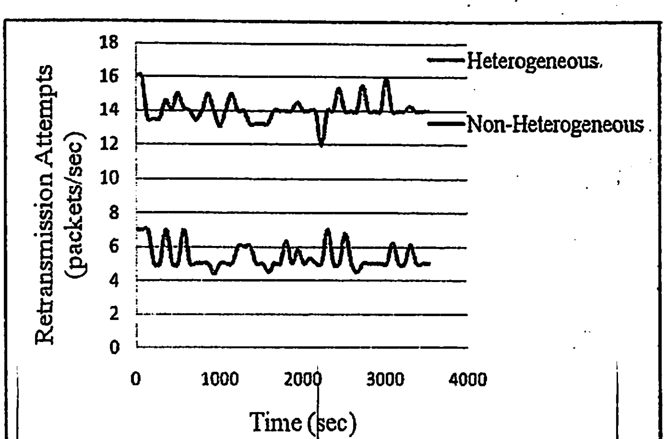

Figure 10 Simulations of retransmission attempts

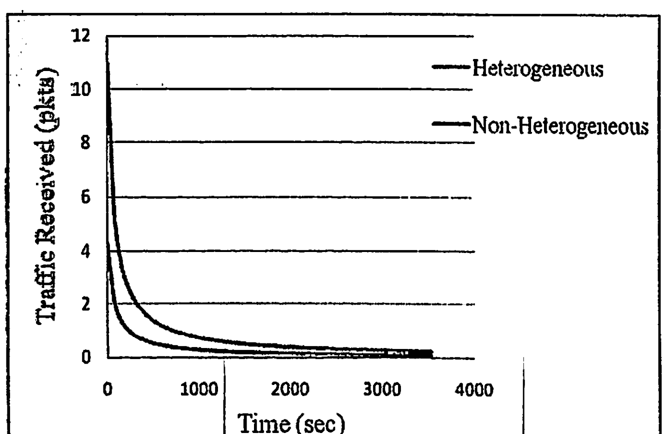

Figure 14 Average of traffic received

Figure 8 and 9 plot traffic routing of both cases. We can clearly see that the path selected by cognitive heterogeneous will be high traffic because the number of nodes is higher than other case. However, cognitive traffic required bandwidth more than non-heterogeneous. Figure 10 reports the average time spent at the end of the system by secondary and primary packets retransmission attempts to the average service time when varying the traffic intensity of the primary and secondary station. As shown in the figure, cognitive radio starting retransmissions is 16 packets per second and then fluctuates, it seem set to continue. However, the retransmissions of primary station are lower bandwidth only about of 7 packets per second.

Over all the retransmission ability for both of primary and secondary are fluctuating all the time.

Finally, note that the capacity benefits from cognitive heterogeneous in the transmitter side to send information to the primary end station is highly significant. In other words, overhead send information from the cognitive to the primary improves throughput and performance of network significantly.

B. *Results over all Networks*

In this section, we present the average performance of the network like throughput, delay, and traffic routing. Figure 11 shows the differences in average throughput between the primary and cognitive stations over the link. Clearly, the cognitive throughput for the cognitive link is much higher than the primary link for the detected path. That is actually the desired goal of this proposal. Furthermore, end-to-end average delay result is illustrated in figure12. Again, the comparison is given between heterogeneous and non-heterogeneous; clarify the performance of cognitive heterogeneous better than other one. It is also realistic that the delay difference becomes larger; implying that the high capacity of cognitive radio offer connections to carry the traffic, also the improved traffic transmission thus contributes to the reduction of packet latency and pick up of network throughput.

Finally, figure 13 and 14 shows the average behavior of routing for all system when varying the traffic of the cognitive heterogeneous and non-heterogeneous. As clear from the figures, the optimal payload for secondary user transmissions decreases when increasing the primary traffic. The total time spent in the system by secondary packets increases when increasing the traffic intensity of both primary and secondary station.

IX. Conclusion

Heterogeneous wireless interconnections of cognitive and primary networks are predicted to be part of future wireless networks. This collaborative coexistence between CN and PR systems is likely not just for avoiding interference but also to share resources. In this way, high throughput demands for futuristic primary mobile end users, for instance HDTV and VoIP users may needs resources more than what is available for the primary networks. On the other hand, the weakness of QoS of a certain primary links may push the PN to ask the formulation of new links over the CN. Hence, the primary network may lease the CN to send data to a certain primary stations or users. This paper has proposed architecture for such scenario and has focused on the heterogeneous design for a combined relay selection and optimal influence allocation of the PN and CN systems. Opnet simulated results proved the competence of the proposed solution in comparison to continuing the use of the primary bad links. Results demonstrate that cooperation between cognitive and primary systems can perform well with respect to both throughput and traffic routing. As we have shown through simulations, the proposed heterogeneous network and cognitive radio is able to choose the most suitable connectivity alternative for users in hard situation. With regards to our future work we plan to undertake the presented idea to other QoS parameters, such as packet loss, jitter in heterogeneous scenarios.

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FUNDAMENTAL RESEARCH GRANT SCHEME FINAL REPORT ASSESMENT FORM

Borang Penilaian Laporan Akhir Skim Geran Penyelidikan Fundamental

A.	**TITLE OF RESEARCH:** *Tajuk penyelidikan:*		Novel Architecture Of Dual Band Rfid Passive Tag With Malaysian Microchip (Mmchip)
B.	**PERSONAL PARTICULARS OF RESEARCHER** / *Maklumat Penyelidik:*		
	(i)	**Name of Research Leader:** *Nama Ketua Penyelidik:*	D. Widad Ismail
	(ii)	**School/Institute/Centre/Unit:** *Pusat Pengajian /Institut/Pusat/Unit:*	Pusat Pengajian Kejuruteraan Elektrik & Elektronik
	(iii)	**Phone No. (Office):** *No. Tel. (Pejabat):*	04-5946090
	(iv)	**Hand Phone No:** *No. Telefon Bimbit:*	
	(v)	**Fax. No:** *No. Faks:*	

C.	**SUMMARY OF ASSESSMENT** *(Tick (√) the appropriate box. Also, provide additional comments in Section F)*	Inadequate 1	Inadequate 2	Acceptable 3	Very Good 4	Very Good 5
1.	Achievement of Project Objectives			√		
2.	Quality of Output			√		
3.	Quality of Organisational outcomes			√		
4.	Quality of sectoral/national impacts			√		
5.	Technology Transfer / Commercialization Potential					
6.	Quality and Intensity of Collaboration					
7.	Overall Financial Expenditure			√		
8.	Overall Assessment of Benefits			√		

D.	**ACTION TO BE TAKEN** *(Tick (√) the appropriate boxes)*
☑	**Project file to be closed.** *(For financial and administration purposes)*
☐	**Project to be Reviewed Once Additional Information Has Been Obtained by the Project Leader** *(Please see section E)*
☐	**Forward to Innovation Office for Consideration:** ☐ **Patent** ☐ **Commercialisation** ☐ **Technology Transfer** ☐ **Others** *(Please specify):* ______________
☐	**Forward to Division of Industry & Community Network (DICN)**
☐	**Others** *(Please specify):* ______________ *(E.g.: Formations of teams or cluster etc.)*

E. **Areas requiring additional information** [Please tick appropriate box. Also provide additional details in Section F]

☐ Sumary for the report

☐ Objectives achievement

☐ Benefit s of the project

☐ Technology transfer/commercialisation approach

☐ Assessment of the project structure

☐ Research approach

☐ Project Schedule

☐ Project costs

☐ Additional project funding obtained

☐ Remarks

F. **Additional information to be provided by the Project Leader** [Please provide details of the specific information being requested from the project Leader in the areas identified in Section E]

G.	**Comments Regarding Assessment** [Please provide below an explanation of any assessment made in Section C showing a rating below "acceptable"]
H	**Overall Comments:** ok **Name of Panel:** Prof Bassim H. Hameed **Signature:** ________ **Date:** 14/3/2011
I	**Endorsement & Comments/Suggestions of Research Dean:** **Signature:** ____________________ **Date:** ________

Final Project Output Summary

	Achievement Percentage			
Project progress according to milestones achieved up to this period	25%	50%	75%	100%
				✓

No.	Title	Achievement
1	**Research Publications**	*Research Findings* **i- Number of articles/manuscripts/books** ISI Journal : 1 International Journal : 4 National Journal : 8 /
		ii- Paper presentations International : 1 National : /
		iii- Others (Please specify) :
2	**Numbers of PhD & Master (by research) Students**	*Human Capital Development*
3	**Intellectual Property**	/

	Malaysian	Non-Malaysian
PhD Student:	1 on going	
M. Sc. Student:	2 on going / 1 completed	
Undergraduate Final Year Project:	4 on going	

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Pusat Pengajian Kejuruteraan Elektrik dan Elektronik

School of Electrical and Electronics Engineering

Tarikh: 11 Februari 2011

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LAPORAN AKHIR GERAN PENYELIDIKAN FRGS (1/2010)

Tajuk Projek: **NOVEL ARCHITECTURE OF DUAL BAND RFID PASSIVE TAG WITH MALAYSIAN MICROCHIP (MMChip)**

No. Akaun: **203.PELECT.6071187**

Merujuk kepada perkara diatas dengan ini disertakan 2 salinan laporan akhir projek beserta penyata akaun terkini geran untuk tujuan rekod universiti.

Sekian, terima kasih.

Yang menjalankan tugas,

Dr. Widad Ismail
Ketua Projek