PERFORMANCE STUDIES BETWEEN WIMAX (802.16M) AND LTE ADVANCED FOR 4G

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To my beloved parents, wife, well-wishers Mr. Sugan, Mr. Shanmugam and my dearest friends and course mates (Mr. Zafri, Mr. Ang, Mr. William @ Adam & Mdm. Suhaida).

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ABSTRACT

Wimax - 802.16m and LTE Advanced are working in similarities to compromise ITU IMT advanced which is the base line for the 4G requirement and working with an aim for optimizations for improved interworking and coexistence. The 2.5/2.6GHz frequency spectrum is proposed for the future of Wimax & LTE advanced to 4G. There are total of 9 communication network player candidates and each have a 20MHz block of bandwidth. One is new comer which is Puncak Semangat Sdn Bhd and the rest are existing companies which are Celcom (M) Bhd, DiGi.Com Bhd, Maxis Bhd and U Mobile and four WiMAX players – Asiaspace Sdn Bhd, Packet One Networks Sdn Bhd, REDTone International Bhd and YTL Communications Bhd. The study is to analysis the Wimax - 802.16m and LTE which is documented in Release 8 of the 3GPP specifications advanced for 4G system technical specification and requirement; To understand current technology facility for 802.16m and LTE advanced for 4G system; and to study unacceptable levels of inter-system interference for Wimax and LTE which two different operating systems with differing duplex methods in close proximity to one another. The LTE time division duplex (LTE-TDD) and LTE frequency division duplex (LTE-FDD) are the most practical evolution paths towards 4G technology. In harmonized FDD-FDD and synchronized TDD-TDD coexistence scenarios BS-to-BS interference is not typically a major issue because the case in which a receiver has to operate on a frequency adjacent to an operating transmitter is avoided. However in FDD-TDD scenarios this is not the case. Collocating BS equipment may lead to crippling inter-system interference, with the transmitter of one system blocking the receiver of another. Therefore, when considering FDD-TDD systems a compromise needs to be found that achieves an acceptable tradeoff between BS-to-SS and BS-to-BS interference. The objective of this study is to find out the minimum guard band and minimum distance requirement between Wimax- TDD block as Victim link and LTE – FDD block as Interference link by using SEAMCAT (Spectrum Engineering Advanced Monte-Carlo Analysis Tool) software. Several scenarios between LTE-FDD block and Wimax-FDD block which are BS-to-BS, MS-MS, BS-MS, and MS-BS adjacent-channel interferences and variation of distance between LTE and Wimax devices have been studied. The results obtained provide some figure regarding the minimum guard-band required and minimum distance between LTE-Interferer link and Wimax-Victim lin

ABSTRAK

Kemajuan Wimax – 802.16m dan LTE bekerja seiras demi berkompromi dengan kemajuan ITU IMT yang menjadi garis asas untuk keperluan 4G dan bekerja dengan tujuan pengoptimuman untuk meningkatkan kerja dalaman dan koeksistensi. Spektrum frekuensi 2.5/2.6GHz dicadangkan untuk masa depan Wimax dan LTE maju ke 4G. Terdapat sejumlah 9 calon bagi rangkaian komunikasi dan masing – masing mempunyai 20MHz blok 'bandwidth'. Puncak Semangat Sdn Bhd adalash pendatang baru dan yang selebihnya adalah Celcom (M) Bhd, DiGi.Com Bhd, Maxis Bhd dan U Mobile dan empat WiMAX calon – Asiaspace Sdn Bhd, Packet One Networks Sdn Bhd, REDTone International Bhd dan YTL Communications Bhd. Kajian ini untuk menganalisis Wimax – 802.16m dan LTE yang didokumentasikan di Realese 8 daripada spesifikasi 3GPP untuk melanjutkan sistem teknikal dan keperluan 4G; Demi memahami kemudahan teknologi terkini untuk 802.16m dan LTE lanjutannya ke sistem 4G; dan meneliti tahap gangguan 'inter – system' yang tidak boleh terima untuk Wimax dan LTE dimana kedua – dua ini adalah sistem yang berlainan dengan cara dupleks yang berbeza dalam jarak dekat diantara satu sama lain. 'LTE time division duplex (LTE – TDD)' dan 'LTE frequency division duplex (LTE – FDD)' adalah jalan evolusi yang paling praktikal menuju teknologi 4G. Dalam FDD – FDD dan synchronise TDD – TDD koeksisten scenario gangguan BS – ke – BS bukannya masalah yang besar kerana kes dimana penerima mesti beoperasi pada frekuensi yang bersebelahan dengan sebuah pemancar dielakkan. Walaubagaimanapun dalam snario FDD – TDD ini tidak berlaku. Kolokasikan peralatan BS boleh menyebabkan gangguan dimana 'inter – system' melumpuh, dengan pemancaran dari salah satu system blok daripada lagi satu penerima. Oleh yang demikian, ketika mempertimbangkan syistem FDD – TDD sato kompromi perlu didapati untuk mencapai satu kesefahaman diantara gangguan BS-ke-SS dan BS-ke-BS. Objektif kajian ini adalah untuk mengetahui minimum 'guard band' dan keperluan jarak yang minimum antara blok Wimax – TDD sebagai 'Victim link' dan blok LTE – FDD sebagai talian interferensi dengan menggunakan SEAMCAT (Spectrum Engineering Advanced Monte-Carlo Analysis Tool) perisian. Beberapa scenario diantara blok LTE – FDD dan blok Wimax- FDD yang BS-ke-BS, MS-MS, BS-MS, dan MS-BS gangguan saluran berdekatan dan variasi jarak antara LTE dan peranti Wimax telahpun dikaji. Keputusan daipada kajian ini memberikan beberapa aspek mengenai keperluan minimum guard band dan jarak minimum diantara LTE – 'Interferer link' dan Wimax – 'Victim link'.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
LTE	Long Term Evaluation
Wimax	Wireless Microwave AXcess (IMT technology developed by IEEE)
IMT	International Mobile Telecommunications
3GPP	3rd Generation Partnership Project
BS	Base Station
CEPT	European Conference of Post and Telecommunications
DL	Down Link
FDD	Frequency Division Duplex
GSM	Global System for Mobile communication
MS	Mobile Station
TDD	Time Division Duplex
UL	Up Link
UMTS	Universal Mobile Telecommunications System

Chapter 1

Introduction

The communication industry has been formulating and producing new standards to efficient deliver high speed broadband mobile access. There were two standards identified as the candidates, IEEE 802.16 (WiMAX) and 3GPP LTE.

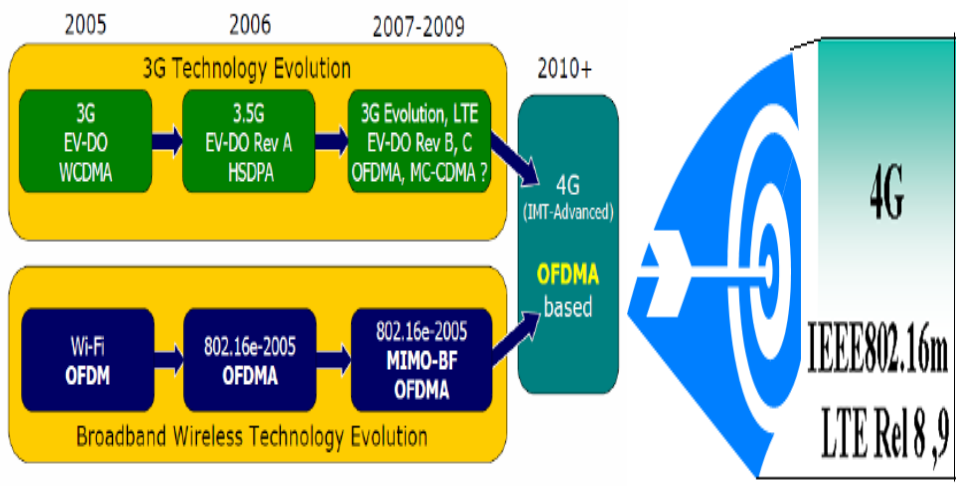

Figure 1: Evoluation Chart of LTE and Wimax[1]

The WiMAX (IEEE 802.16 standard) comes from IEEE family of protocols and provides the wireless access from the Local Area Network (typically based on the IEEE 802.11 standard) to Metropolitan Area Networks (MAN) and to Wide Area Networks (WAN). While it improved and starts uses a new physical layer radio access technology called OFDMA (Orthogonal Frequency Division Multiple Access) for uplink and downlink. Versions of 802.16-2004 focused on fixed and nomadic access, and then later version 802.16-2005, an extended to 802.16-2004 with many new features and functionalities needed to support enhanced QoS and high mobility broadband services at speeds greater than 120 Km/h. The 802.16-2004 is also called 802.16d and is referred to as fixed WiMAX while the 802.16-2005 is referred to as 802.16e, so called as Mobile WiMAX. The Mobile WiMAX uses an all IP backbone with uplink and downlink peak data rate capabilities of up to 75 Mbps and its dependable on the antenna configuration and modulation,

practicable to 10 Mbps within a 10 Km radius. The earliest WiMAX was approved with the TDMA TDD and FDD with line of sight (LOS) propagation across the 10 to 66 GHz frequency range which was later expanded to include operation in the 2 to 11GHz range with non line of sight (NLOS) capability using the robust OFDMA PHY layer with sub-channelization allowing dynamic allocation of time and frequency resources to multiple users.

The 802.16m (Mobile WiMAX Release 2) Task-force is currently working on the next-generation systems with an aim for optimizations for improved interworking and coexistence with other access technologies such as 3G cellular systems, WiFi and Bluetooth and enhance the peak rates to 4G standards set by the ITU under 'IMT-Advanced' which calls for data rates of 100 Mbps for high mobility and 1 Gbps for fixed/nomadic wireless access.

The LTE, on the other hand evolves from the Third-generation technology which is based on WCDMA and defines the long term evolution of the 3GPP UMTS/HSPA cellular technology. The specifications of these efforts are formally known as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN), commonly referred to by the 3GPP project LTE. The first version of LTE is documented in Release 8 of the 3GPP specifications. It defines a new physical layer radio access technology based on Orthogonal Frequency Division Multiple Access (OFDMA) for the downlink, similar in concept to the PHY layer of Mobile WiMAX, and uses SC-FDMA (single Carrier Frequency Division Multiple Access) for the uplink. LTE supports high performance mobile access functional up to 350Km/h. Peak data rates range from 100 to 326.4Mbps on the downlink and 50 to 86.4 Mbps on the uplink and it's dependable on the antenna configuration and modulation depth. The LTE also targets to achieve the data rates set by the 4G 'IMT-Advanced' standard. The development of LTE interface is linked closely with the 3GPP system architecture evolution (SAE) which defines the overall system architecture and Evolved Packet Core (EPC). The LTE also aimed to provide an all IP backbone with reduction in cost per bit for better service provisioning, flexibility

in use of new and existing frequency bands, simple network architecture with open interfaces, and lower power consumption.

1.1 Background

In Malaysia the current frequency spectrum allocation adopted base on the IMT. The below figure shows the IMT spectrum bands and their current usage in Malaysia:

No	Spectrum Bands	Identified for IMT	Current usages in Malaysia
1	450-470 MHz	WRC 2007	CDMA450 + telemetry
2	790-960 MHz	WRC 2007	790-806 MHz (broadcasting & government use)
		WRC 2000	806-821 MHz / 851-866 MHz (DTRS / ATRS)
			821-824 MHz / 866-869 MHz (BWA)
			825-835 MHz / 870-880 MHz (FWA)
			880-915 MHz / 925-960 MHz (GSM900)
			869-870 MHz (newly proposed RFID), 919-923 MHz (RFID)
3	1710-1885 MHz	WRC 2000	1710-1785 MHz / 1805-1880 MHz (GSM1800)
			1790-1800 MHz (BWA)
4	1885-2025 MHz	WARC 92	1885-1900 MHz (DECT)
	2110-2200 MHz		1900-1915 MHz (TDD)
			1920-1980 MHz / 2110-2170 MHz (FDD) and 1915-1920 MHz, 2010-2025 MHz (TDD) (3G WCDMA / HSDPA)
5	2300-2400 MHz	WRC 2007	BWA (WiMAX - TDD)
6	2500-2690 MHz	WRC 2007	BWA (to be vacated)

Figure 2: IMT Spectrum Band for Current Usage In Malaysia[16]

Wireless communication service provider in Malaysia are listed as Maxis, Digi, Celcom, U-Mobile which were categorized as LTE technology drivers while Asiaspace Dotcom, Bizsurf (YTL, XOHM), MIB communication (Green Packet, P1), and Redtone categorized as Wimax technology drivers. The below figure and table show their current spectrum band usage in Malaysia.

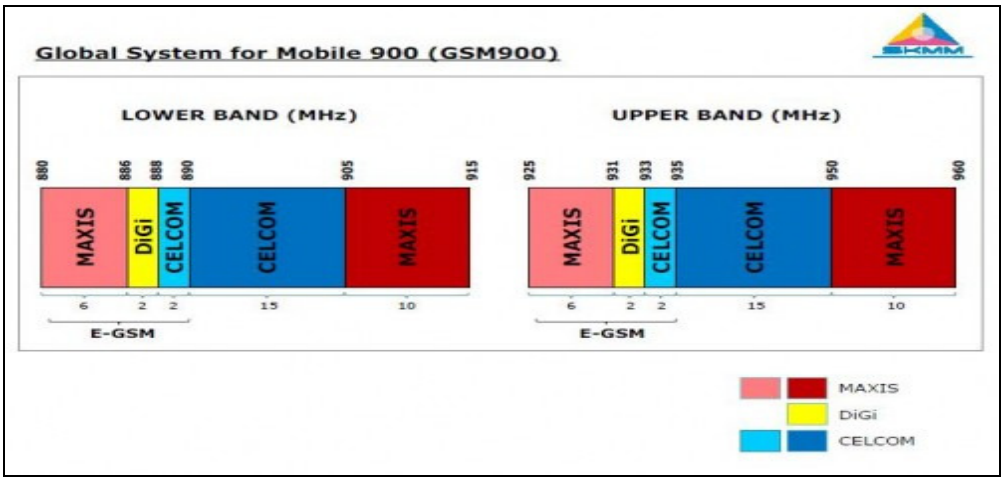

Figure 3: GSM900 Frequency Spectrum[16]

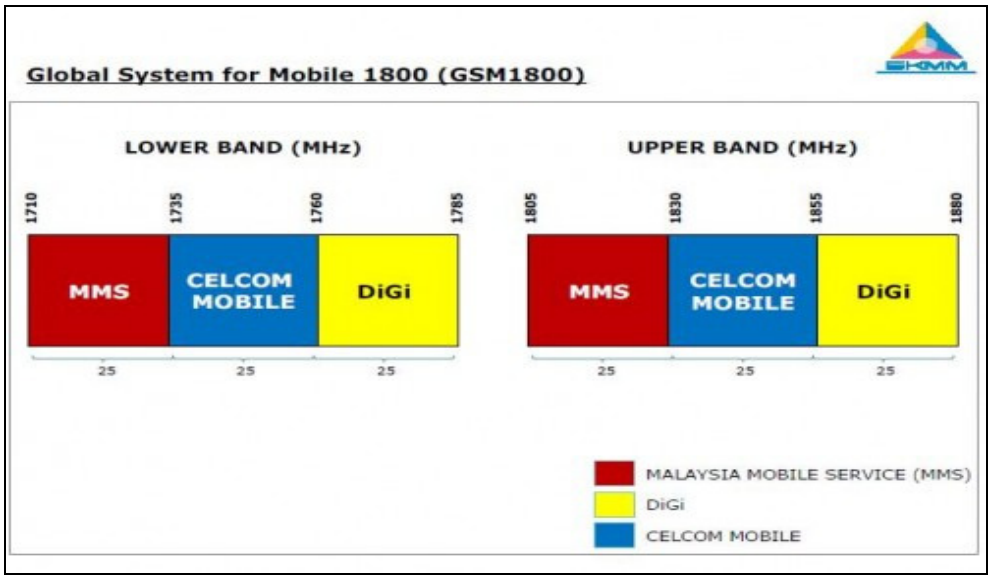

Figure 4: GSM1800 Frequency Spectrum[16]

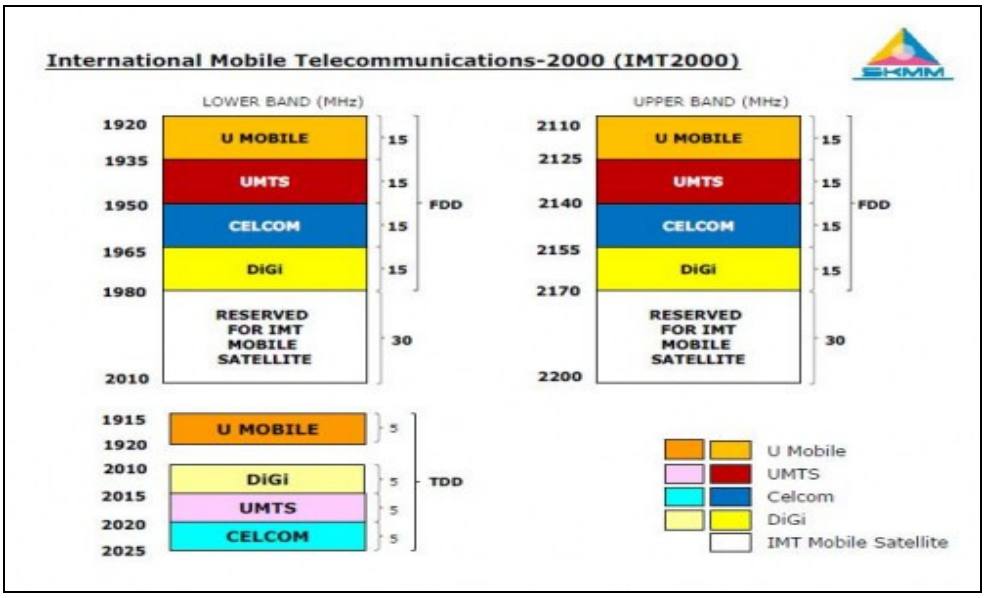

Figure 5: IMT-2000 Frequency Spectrum[16]

Service Provider	Spectrum Band	Area of Operation
Asiaspace Dotcom	2300-2330MHz	Peninsular Malaysia
Bizsurf (YTL, XOHM)	2330-2360MHz	Peninsular Malaysia
MIB communication (Green Packet, P1)	2360-2390MHz	Peninsular Malaysia
Redtone – CNX Broadband	2375-2400MHz	Sabah and Sarawak

Table 1: Current Malaysia Service Provider, Spectrum Band, and Operating Area[16]

The Malaysian Communications and Multimedia Commission (MCMC) announced news that the wireless players each will have a 20 Mhz block of the

2.5/2.6GHz spectrum. In future advanced to 4G technology Wimax-806.16m and LTE advanced technology driver will be operating on the 2.5/2.6GHz spectrum.

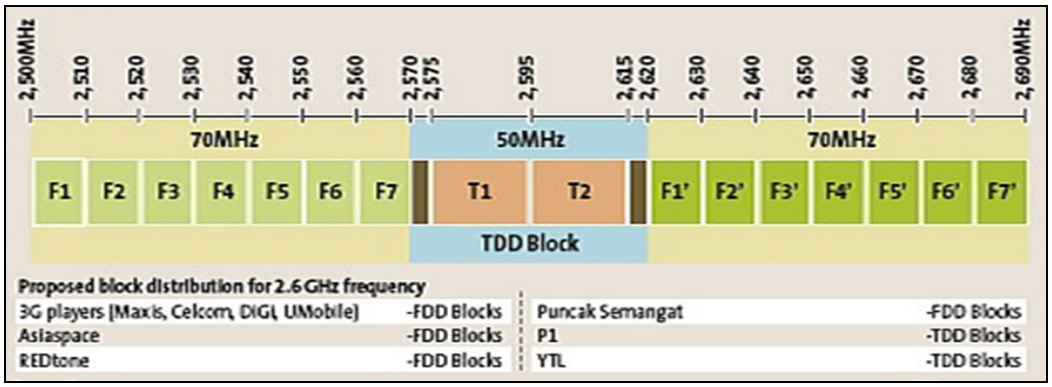

Figure 6: Malaysia Future Proposed Spectrum Band for LTE & Wimax Candidate[16]

The proposed wireless player candidates are total of nine and each have a 20MHz block of 2.5/2.6GHz spectrum. One is new comer which is Puncak Semangat Sdn Bhd and the rest are existing companies which are Celcom (M) Bhd, DiGi.Com Bhd, Maxis Bhd and U Mobile and four WiMAX players – Asiaspace Sdn Bhd, Packet One Networks Sdn Bhd, REDTone International Bhd and YTL Communications Bhd.

1.2 Problem Statement

The LTE time division duplex (LTE-TDD) and LTE frequency division duplex (LTE-FDD) are the most practical evolution paths towards 4G technology.

In harmonized FDD-FDD and synchronized TDD-TDD coexistence scenarios BS-to-BS interference is not typically a major issue because the case in which a receiver has to operate on a frequency adjacent to an operating transmitter is avoided. However in FDD-TDD scenarios this is not the case.

Collocating BS equipment may lead to crippling inter-system interference, with the transmitter of one system blocking the receiver of another. Therefore, when considering FDD-TDD systems a compromise needs to be found that achieves an acceptable tradeoff between BS-to-SS and BS-to-BS interference.

1.3 Objective

To study the minimum guard band and minimum distance requirement between Wimax- TDD block as Victim link and LTE – FDD block as Interference link by using SEAMCAT (Interference Analysis Software Tool).

1.4 Scope

To analysis the Wimax - 802.16m and LTE which is documented in Release 8 of the 3GPP specifications advanced for 4G system technical specification and requirement.

To understand current technology facility for 802.16m and LTE advanced for 4G system.

To study unacceptable levels of inter-system interference for Wimax and LTE which two different operating systems with differing duplex methods in close proximity to one another.

1.5 Methodology

An organised, documented set of procedures and guidelines are very necessary for a research designation analysis. Methodology of this project include a diagramming notation of the procedure; a step-by-step approach for carrying out the research procedure begins from first part of determines related works or study carried out from other party (literature review) and requires technical specification and application approximation; second part or the next step is on theoretical and numerical analysis as a supported captures an objective (ideally quantified) set of criteria for determining whether the results of the procedure are of acceptable quality; third step is the system design tool, which determination of usage of tool such as software/ hardware and relevant resource of application material; fourth step is the main picture of the overall designed system performance configuration judgement criteria which are result of created scenario and expected result discussion; and at last the conclusion and recommendation of implementation idea.

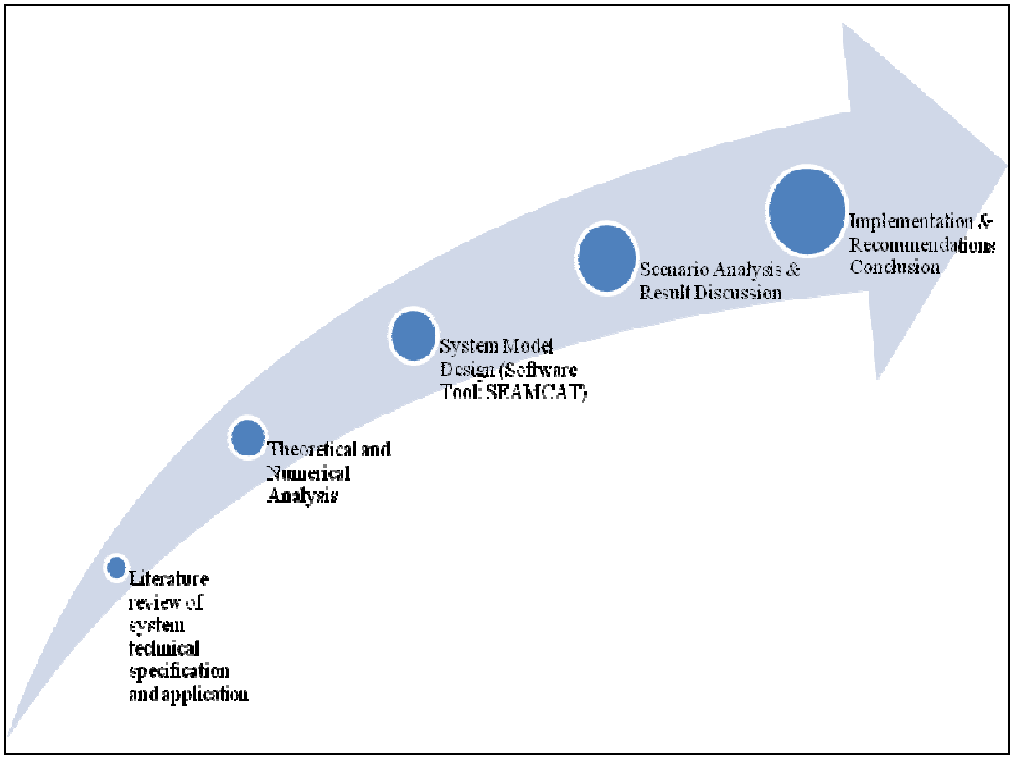

Figure 7: Methodology of Project Work

1.5.1 Literature review

A literature review can be a precursor in the introduction of a research paper, or it can be an entire paper in itself, often the first stage of large research projects, allowing the assessor to ascertain that the research is on the correct path.

1.5.2 Theoretical and Numerical Analysis

Numerical analysis is the study of approximation techniques for clarification in mathematical technique. This project included mathematical assumption to model the wireless network performance analysis.

1.5.3 System model design – SEAMCAT software tool

The wireless communication model will be designed using SEAMCAT is a software tool permits statistical modeling of different radio interference scenarios for performing sharing and compatibility studies between radio communications systems in the same or adjacent frequency bands

1.5.4 Scenario Analysis & Result Discussion

The project is to study and analysis few conditional scenario due to its involve not only one partition of analysis but from wireless communication station till user end. It's could be involve different path of scenario consideration. The obtained result will be discussed clearly for justification.

1.5.5 Conclusion & Implement Recommendation

The final stage of project, it's compulsory to conclude final judgement accordingly to meet research specification from literature review and theoretical analysis. Proposal or idea recommendation of implementation requires for future work.

1.6 Content of the Thesis

This thesis report included of literature review which consist of theory study and relevant works from other parties clarification in chapter 2; In chapter 3 methodology of SEAMCAT software tool interface definition and requirement details were illustrated and tabled technical parameter of Wimax-802.16m & LTE – Release 8 which used for scenario analysis interference of MS - LTE to MS - Wimax, BS - LTE to BS - Wimax, MS- LTE to BS - Wimax, and BS - LTE to MS – Wimax; Chapter 4 is the part of study of all stated scenario and discussions of obtained result; while Chapter 5 is the final element of the thesis which narrow the point of conclusion in summary form and perspective of future works.

References

[1] LTE and WiMAX Comparison, Tejas Bhandare, Santa Clara University, December 2008

[2] WiMAX(TM) Ecosystem Backs IEEE 802.16m for IMT-Advanced and Future Proof Roadmap, Press Release, 6 Oct 2009. WiMAX Forum

[3] LTE Benefit, LTE PRODUCT DESIGN, MAY 14, 2009

[4] Interference Analysis of Guard Band and Geographical Separation between DVB-T and E-UTRA in Digital Dividend UHF Band, Denny, Dadang and Djamhari from Departemen Elektro FTUI, Kampus UI, Depok 16424, Indonesia.

[5] POSITIONING PAPER: Driving 4G: WiMAX & LTE, Motorola.

[6] DRAFT ECC REPORT ON COMPATIBILITY STUDIES BETWEEN RDSS AND OTHER SERVICES IN THE BAND 2483.5-2500 MHz, Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT)

[7] IMT Advanced, INTERNATIONAL TELECOMMUNICATION UNION, Document 8F/IEEE-3-E, 15 March 2007.

[8] SEAMCAT Handbook, January 2010, European Communication office.

[9] CPM Report on technical,operational and regulatory/procedural matters to be considered by the 2007 World Radiocommunication Conference, (Geneva, 2007).

[10] Report from CEPT to the European Commission in response to the Mandate; Compatibility study for LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands)

[11] INTERNATIONAL TELECOMMUNICATION UNION Document 8F/1330-E 19 June 2007 RADIOCOMMUNICATION STUDY GROUPS

[12] Migration fromWiMAX Release 1 to WiMAX Release 2 August 2010

[13] WiMAX Forum® Air Interface Specifications WiMAX Forum® Mobile Radio Specification WMF-T23-005-R015v04 WiMAX Forum® Approved (2010-09-07)

[14] Service Recommendations to Support Technology Neutral Allocations FDD/TDD Coexistence 10 April 2007

[15] 3GPP TS 36.101 V8.1.0 (2008-03) & TS 36.104 V8.1.0 (2008-3) Technical Specification.

[16] TECHNICAL STANDARDS FOR INTERNATIONAL MOBILE TELECOMMUNICATION (IMT) MTSFB 001 : 2010 © Copyright 2010 Malaysian Technical Standards Forum Bhd.

[17] Technology white paper Mobile Wimax Physical Network Best Server Modelling

[18] The 11th international symposium on wireless personal multimedia communication (WPMC 2008) Deployment of the mobile Wimax in Urban environment