2012 26th International Conference on Advanced Information Networking and Applications Workshops

Software Simulation Tool for the Capacity Analysis of WiMAX Base Stations

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Keywords: IEEE 802.16, WiMAX, Traffic Model, Channel Path Loss Model, Link Budget.

Abstract

In this paper it generate a self analysis and verification tool for the field trial data based on the simulation software in the setting of the system parameters for WiMAX base station. Through repeat reviewing and verification of the system specifications for the WiMAX system and the analysis of a series of field trial data to complete an analysis tool that has the attribute that it has been verified through field trail data. With this analysis tool it will provide the service providers a guidance of how to set up its system parameters.

1 Introduction

WiMAX wireless network technique [1-3] is a new generation communication technology to provide a wideband bandwidth and wide coverage service and it anticipates that the introduction of WiMAX system will improve the drawbacks of the traditional wireless networks. In Taiwan it has issued six areas of WiMAX licenses in August 2008, and many base stations are expected to be deployed in the near future. In the base station deployments, it will take a lot of man powers to study the network installation and to consider the traffic flow planning for every base station. However it does not exist any guidance of how to set up the system parameters for each service provider when it is in the process of installing base stations and the selection of system parameters will greatly affect the system performance and the system coverage areas. In the development of capacity analysis software for WiMAX base station it will be proceeded from the following areas, (1) WiMAX traffic model; (2) Channel model; (3) link budget and (4) Calibration Analysis and through the study of these four areas to analyze and simulate the WiMAX base station performance in the actual communication environment.
The organization of this paper is as follows. In Sections 2 it illustrates the various traffic models and their generations in WiMAX base stations, and in Section 3 it specifies the channel models will be used in this paper. In Section 4 it demonstrates of how to use link budget to calculate or design relevant system parameters. In Section 5 it develops the software design and the system structure in the development of WiMAX capacity analysis tool. In Section 6 it considers the theoretical analysis and the calibration process when data variance exists in the simulation results and the actual measured trial data. A conclusion is drawn in Section 7.

2 WiMAX Traffic Model

In the development of WiMAX simulation analysis software it needs to consider is, to determine the data resources for simulation, to accurately generate the state of data source and to generate the network traffic for each data source. The information in the IEEE 802.16m Evaluation Methodology Document [3] has been extracted for developing traffic model, traffic state and traffic volume in the design of the WiMAX simulation analysis tool. Although EMD is developed for the IEEE 802.16m standard, it has been discussed and developed through standard meetings among many network service providers it definitely will provide various traffic trends in the network. Among all possible traffics discussed in the document we will select certain traffics such as VoIP (Voice over Internet Protocol), Video streaming, FTP (File Transfer Protocol), HTTP (Hyper Text Transfer Protocol) etc. to constitute the traffics for this WiMAX traffic generator.

3 Chanel Path Loss Mode

In the signal transmission, the channel interference will affect the receiving signal quality. In this paper we also adopt the channel models as illustrated in IEEE 802.16m Evaluation Methodology Document (EMD) [3-4] such as COST-259, the indoor hot spot etc. [5-6] and we select the COST-231 model [7-8] as our channel model. Other model such as SUI [9-10] is also selected so that different channel models can be selected to reflect the situation when the WiMAX base station is in different radio environment.

4 Link Budget

Link budget evaluation is a well known method for using in initial system planning that needs to be carried out for BS to MS links. Although a link budget can be calculated separately for each link, it is the combination of the links that determines the performance of the system as a whole. The parameters to be used needs to be agreed upon after obtaining consensus. Using the margins in the link budget, the expected signal to noise ratio can be evaluated at given distances. Using these results, the noise limited range can be evaluated for the system.

The link budget template is adopted from ITU-R recommendation M.1225 [13] with additional entries and some modifications to reflect different system operation and characteristics that may be exploited or considered in 802.16m but are not accounted for in the M.1225 document [13]. It must be noted that the link budget should be evaluated separately for control and data channels.

5 The Software Design for the Simulation and Analysis of WiMAX Base Station Capacity

With the traffics mixes selected and their associated traffic models as illustrated in the above sections were adopted and with the selectable parameters that characterize the base station have been determined we have shown in Figure 1 the graphic user interface (GUI) for the designed simulation and analysis software.

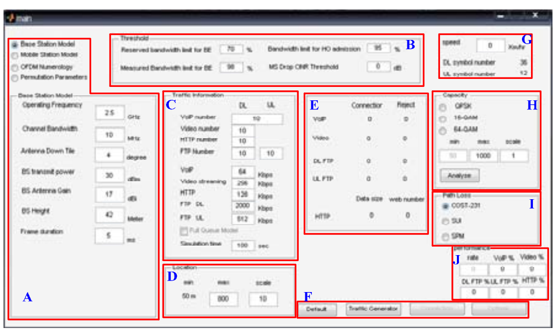


Figure 1: GUI of the Software for the Simulation and Analysis of WiMAX Base Station Capacity

It consists of ten parts of the simulation and analysis software; each part has its own function and is illustrated in the following:

A. The set up of Link Budget parameters [11]: the set up of these parameters are as illustrated in Section 3.

B. The set up of limited ranges of certain parameters of the base station as in the following:

1.Reserved bandwidth limit for BE service admission

2.Measured Bandwidth limit for BE service admission

3.Bandwidth limit for HO admission:

It uses in the admission control for the MS request; it will reject the MS request if the BS accepts this MS request its resulting load will exceed this limit.

4.MS drop CINR Threshold [dB]

When the BS detects the uplink CINR and its level is below this threshold for a certain period of time and realizes that the signal can not meet the minimum requirement for normal operation; the BS will release this MS.

C.The set up of WiMAX traffic model parameters: the parameters characterize the traffic models are discussed in Section 2.

D.The set up of the coverage range of the WiMAX base station.

E.The total connection/rejection traffic after completes the simulation of the WiMAX capacity simulation tool.

F.The run stage in the execution of the WiMAX capacity simulation tool.

G.The set up of user's speed and the number of symbols will be tested in the uplink and downlink transmission.

H.The set up of modulation parameters

I.Chanel Path Loss Mode [5-10, 12]: the channel path loss model is as discussed in Section 3.

J.The performance of each traffic model of the WiMAX base station considered.

In this paper the simulation mechanism of the simulation and analysis tool will start to simulate from up to down blocks and output the results as soon as the system parameters are set and entered. Every parameter in the module in this simulation tool is set and follows by the specification of IEEE 802.16m, the output simulation results are deemed to be accepted for reference and even can be verified with the field trial data to test whether their results are close. After field trials and the simulation results are verified, the WiMAX telecommunication service providers are considering obtaining the optimized parameters for their base stations. It is assumed that the hardware installations of the base station are fixed, then in this situation the service provider will consider the possibility to increase its number of customers or increase its system capacity; then this simulation tool developed will also provide this optimization function. The optimization process has the functional blocks as shown in Figure 2; this function will repeatedly adjust the parameters of the base station that are 'improper' or 'un-optimized' at the previous simulation stages and through various simulations till it reach an optimized result.

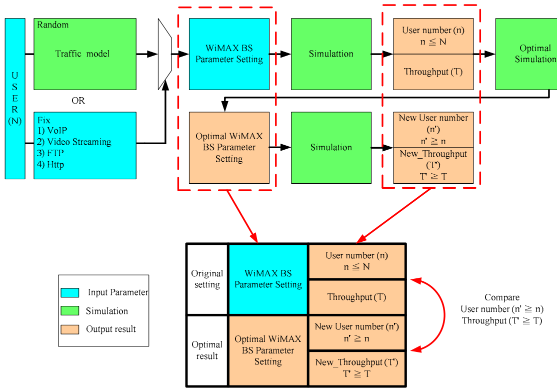


Figure 2 The Functional Block Diagram in the Optimizing Operation of the Simulation Tool for WiMAX Base Station Capacity

6 Calibration Analysis

In the early simulation stage it is the stage to set up the parameters values to be used for the simulation, this is the academic study stage and it is usually unable to apply the simulation results directly into the actual measurement environment. In order to solve and find the possible difference between the simulation data and the actual measured data we run through many tests of cross-comparison between the simulation data and the actual measured data to evaluate and find the difference between the simulation and the actual measured data and this difference value can be adopted as the calibration reference value.

By using the designed simulation tool it has the simulation results as shown in Figure 3. This is the data resulting from the theoretical simulation; from this figure it can easily derive the signal covering range and its transmission capacity. However when we work through the measurement data taken from tested WiMAX base station it has the measured signal strength and traffic capacity as shown in Figure 4 and Figure 5 respectively. We also have the measurement results tabulated in Table 1. From this measurement table and the field trial data, the difference between the theoretical derivation and the actual measurement is around 8.5 times and it also has 8.5 times difference in the traffic throughput. We consequently use the actual field measured data as the reference to deduct and modify the data generating from the simulation tool, it has the final calibrated simulation results as shown in Figure 6 and Figure 7.

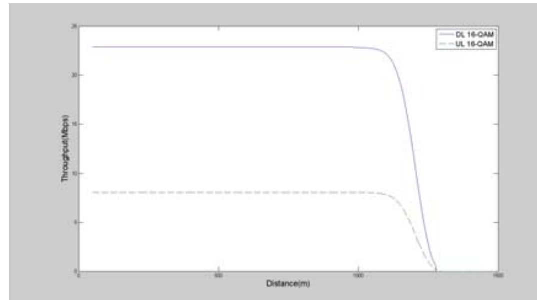


Figure 3 Transmission Efficiency Before Calibration (16 QAM)

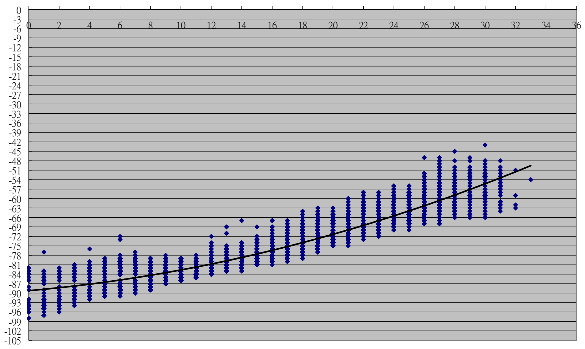


Figure 4 RSSI vs. CINR

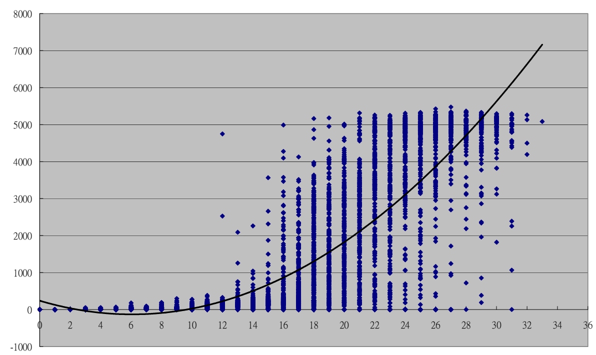


Figure 5 Throughput vs. CINR

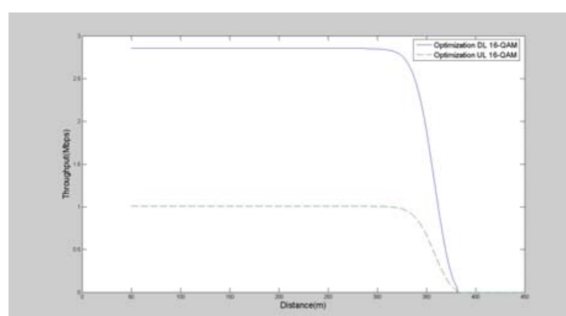
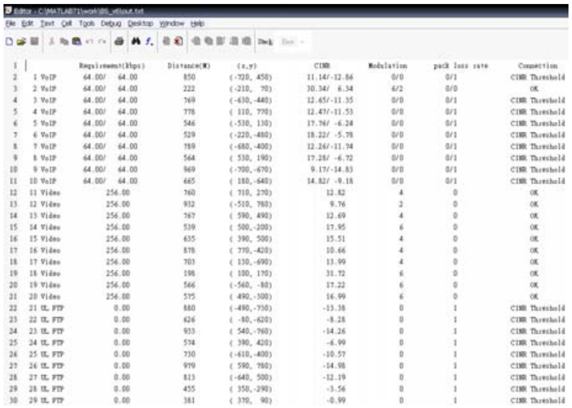


Figure 6 The Transmission Efficiency after Calibration (16 QAM)



	Requirement(Kbps)	Distance(M)	(x,y)	CINR	Modulation	path loss rate	Connection
1 VoIP	64.00/ 64.00	850	(-720, 450)	11.14/-12.86	0/0	0/1	CINR Threshold
2 VoIP	64.00/ 64.00	222	(-210, 70)	30.34/ 6.34	6/2	0/0	OK
3 VoIP	64.00/ 64.00	769	(-630,-440)	12.65/-11.35	0/0	0/1	CINR Threshold
4 VoIP	64.00/ 64.00	778	(110, 770)	12.47/-11.53	0/0	0/1	CINR Threshold
5 VoIP	64.00/ 64.00	546	(-530, 130)	17.76/ -6.24	0/0	0/1	CINR Threshold
6 VoIP	64.00/ 64.00	529	(-220,-480)	18.22/ -5.78	0/0	0/1	CINR Threshold
7 VoIP	64.00/ 64.00	789	(-680,-400)	12.26/-11.74	0/0	0/1	CINR Threshold
8 VoIP	64.00/ 64.00	564	(530, 190)	17.28/ -6.72	0/0	0/1	CINR Threshold
9 VoIP	64.00/ 64.00	969	(-700,-670)	9.17/-14.83	0/0	0/1	CINR Threshold
10 VoIP	64.00/ 64.00	665	(180,-640)	14.82/ -9.18	0/0	0/1	CINR Threshold
11 Video	256.00	760	(710, 270)	12.82	4	0	OK
12 Video	256.00	932	(-510, 780)	9.76	2	0	OK
13 Video	256.00	767	(590, 490)	12.69	4	0	OK
14 Video	256.00	539	(500,-200)	17.95	6	0	OK
15 Video	256.00	635	(390, 500)	15.51	4	0	OK
16 Video	256.00	878	(770,-420)	10.66	4	0	OK
17 Video	256.00	703	(130,-690)	13.99	4	0	OK
18 Video	256.00	198	(100, 170)	31.72	6	0	OK
19 Video	256.00	566	(-560, -80)	17.22	6	0	OK
20 Video	256.00	575	(490,-300)	16.99	6	0	OK
21 UL FTP	0.00	880	(-490,-730)	-13.38	0	1	CINR Threshold
22 UL FTP	0.00	626	(-80,-620)	-8.28	0	1	CINR Threshold
23 UL FTP	0.00	933	(540,-760)	-14.26	0	1	CINR Threshold
24 UL FTP	0.00	574	(390, 420)	-6.99	0	1	CINR Threshold
25 UL FTP	0.00	730	(-610,-400)	-10.57	0	1	CINR Threshold
26 UL FTP	0.00	979	(590, 780)	-14.98	0	1	CINR Threshold
27 UL FTP	0.00	813	(-640, 500)	-12.19	0	1	CINR Threshold
28 UL FTP	0.00	455	(350,-290)	-3.56	0	1	CINR Threshold
29 UL FTP	0.00	381	(370, 90)	-0.99	0	1	CINR Threshold

Figure 7 Report Profile of the Simulation Result

Table 1 WiMAX Field Trial Data at Fixed Location

Transmitted Type	IxChariot Throughput Scrip
Speed	Static
Traffic	Light Traffic
Weather	Cloudy
Distance	100-200m
FEC Coding & Modulation Type	DL/UL: 16 QAM 3/4 16 QAM 3/4
DL Throughput	2.5 Mbps
UL Throughput	0.7-0.8 Mbps

7 Conclusion

In this paper we developed a software simulation tool for the capacity analysis of WiMAX base stations through the review of the system specifications and the field trials and analysis of WiMAX system. The most critical issue in the parameters set up is the calibration mechanism; this calibration mechanism is based on the actual field trial data collected at the receiver end and the collection and test of these data need the cooperation from the WiMAX service providers. After analysis of these test data it will generate a ‘convergent reference error’ between the simulation and the actual field data and then the data generated from the simulation data will be valuable for reference and practicability since they can be calibrated to reflect the possible actual data. Of course in actual field trails the system throughput will exhibit unstable situation due to the channel fading effect; this is an unavoidable situation can be reduced by taking many trials and eliminate those ‘extreme data’ to generate the average trial data. In the mobility test, it will also generate unstable system throughput due to the channel fading and the mobile speed can not be kept constant during the test period, we have experienced many tests with unreasonable data but eventually we select from many data that seem to be reasonable and able be referenced and use these data to calibrate the simulation results to complete this simulation tool for estimating the base station capacity. Through this valuable cooperation experience with service providers, this resulting simulation tool can be used as a valuable reference for other service providers in the setting of their base stations parameters.

8 Acknowledgements

This study is partially support from the National Science Council, ROC under contracts NSC 100-2221-E-002 -136 -

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