NETWORK PLANNING AND QOS SIMULATION SOFTWARE DESIGN FOR 4TH GENERATION BROADBAND WIRELESS TECHNOLOGIES

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Abstract

Mobile network design is complex task that requires evaluation of many parameters that allow service providers to plan optimal network coverage and select mobility management solutions. It's especially relevant for such new technologies as LTE or mobile WiMAX, where ability to simulate network behavior is very important before starting real network implementation. This article presents software that was designed for 4th generation broadband wireless network planning, QoS simulation and analysis. Software consists of three major modules that allow estimating wireless propagation for different modulation techniques, simulating wireless protocols, estimating base station distribution and calculating cumulated data traffic in different types of overlapping wireless sectors. Article analyzes software functionality, operation algorithms, demonstrates possible network planning and simulation scenarios.

1. INTRODUCTION

4Th generation broadband wireless technologies, such as mobile WiMAX and LTE are entering Telco markets, offering newest and most innovative technologies that allow to meet growing demand for mobility and data throughputs. The main goal is to achieve quality similar to wired technologies, enabling seamless use of VoIP, Video and data download services. Despite standards state very high efficiency of 4th generation technologies, it's not easy to achieve it real world environment.

One of the biggest challenges for service providers is to plan and implement such networks, because it requires evolution of many complex solutions, from network planning at the start to QoS modeling at the end. These tasks must be performed at the most possible detail manner in order to achieve best solution optimizing QoS, CAPEX and OPEX.

These major tasks must be performed by network implementation team:

- network equipment selection and base station coverage estimation, enabling services providers to decide what services are possible in certain areas and what equipment is requires to achieve desired data throughputs.
- simulation of wireless protocols that allows to evaluate performance of different services, select solutions for mobility management;
- network coverage planning, that allows to decide what are optimal distances between base stations, minimize zones with overlapping base station coverage and maximize network coverage without gaps and shadow zones.
- Handover overhead estimation, ensuring that designed network will be able to handle multiple users, especially in growing networks.

Automation of these tasks requires very expensive software usually provided by different vendors. It makes network implementation even more complex and time consuming project.

This article provides overview of Authors designed software package that allows service providers to ease network design and implementation tasks. Possible network planning and simulation scenarios are provided. Package consists of three software tools:

- base station (BS) coverage estimation software;
- protocol simulation software;
- network coverage estimation and handover overhead calculation software.

2. BS COVERAGE ESTIMATION

Base station coverage estimation software allows predicting radio signal attenuation in different line of sight and non-line of sight environments. It utilizes four mathematical models that can be used for coverage estimation in urban, suburban and

rural areas: Direct line of sight, Walfish-Ikegami, Walfish-Ikegami geometrical and Stanford University Interim (SUI) models [1]. Software provides descriptions for each model and allows users to select or input required parameters.

Results are provided in graphical and text formats, showing estimated distance for different modulations used with OFDMA multiplexing technique (from QPSK to 64QAM). Higher rate modulations are more sensitive to propagation loss resulting shorter base station coverage radius. This must be taken into account when selecting what data throughput is required for planned services.

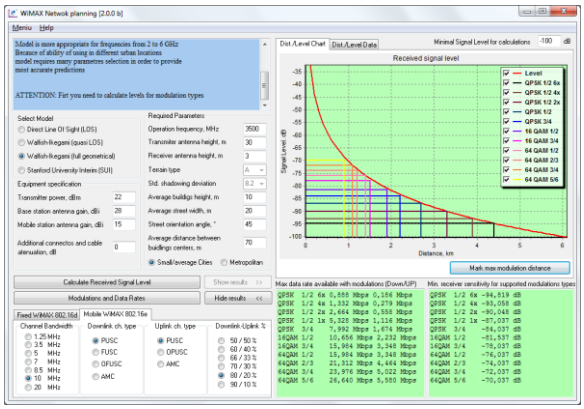
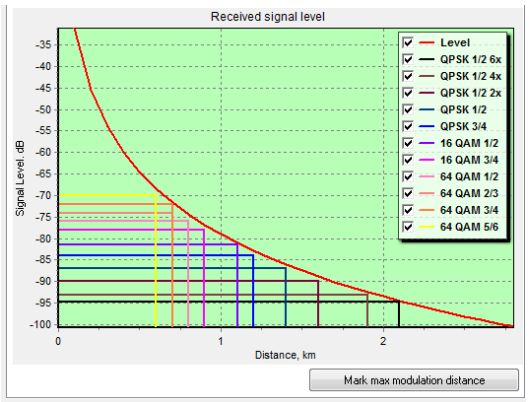


Figure 1. User interface of BS coverage estimation software

In addition to software provides fixed and mobile WiMAX data calculation plugin, which allows selecting channel bandwidth, subcarrier permutation schemes and calculating available data throughput for each modulation.

Calculation examples are provided in Fig. 2, assuming in parameters provided in Table 1.



Max data rate available with modulations (Down/UP)

QPSK 1/2 6x	0,888 Mbps 0,186 Mbps
QPSK 1/2 4x	1,332 Mbps 0,279 Mbps
QPSK 1/2 2x	2,664 Mbps 0,558 Mbps
QPSK 1/2 1x	5,328 Mbps 1,116 Mbps
QPSK 3/4	7,992 Mbps 1,674 Mbps
16QAM 1/2	10,656 Mbps 2,232 Mbps
16QAM 3/4	15,984 Mbps 3,348 Mbps
64QAM 1/2	15,984 Mbps 3,348 Mbps
64QAM 2/3	21,312 Mbps 4,464 Mbps
64QAM 3/4	23,976 Mbps 5,022 Mbps
64QAM 5/6	26,640 Mbps 5,580 Mbps

Min. receiver sensitivity for supported modulations types

QPSK 1/2 6x	-94,819 dB
QPSK 1/2 4x	-93,058 dB
QPSK 1/2 2x	-90,048 dB
QPSK 1/2 1x	-87,037 dB
QPSK 3/4	-84,037 dB
16QAM 1/2	-81,537 dB
16QAM 3/4	-78,037 dB
64QAM 1/2	-76,037 dB
64QAM 2/3	-74,037 dB
64QAM 3/4	-72,037 dB
64QAM 5/6	-70,037 dB

Figure 2. Distance and throughput estimation example

Table 1. Parameters used for calculation

Parameter	Value
Model	SUI-A (Urban environment)
Tx power	23 dBm
BS antenna gain	28 dBi
MS antenna gain	9 dBi
Frequency	3500 MHz
Channel size	10 MHz
Downlink/uplink ratio	80/20%

In this example case scenario we can see that radius of one base station can reach about 2 Km. Taking into account data throughput that is desired by service provider (for example 15 Mbps – 16 QAM) it is required to plan base station coverage not higher than 1,4 Km.

2. SIMULATION OF PROTOCOLS

Protocol simulation software is based on mathematical imitative simulation model which describes each network element as separate aggregate with input and output signals. Each aggregate and signal involves set of parameters and can represent behavior of mobile station, wireless channel, base station and connectivity network. Software user interface visualizes the mathematical model allowing users easily construct their network architecture and enter simulated protocol parameters such as channel latency, error probabilities, etc.

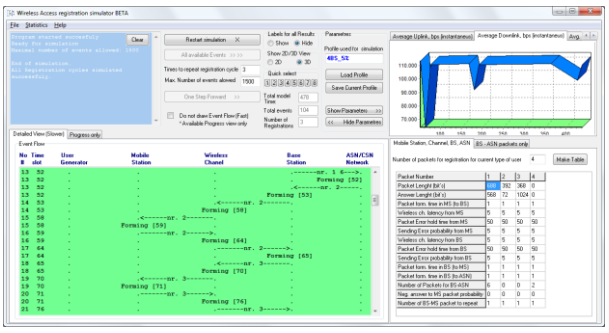


Figure 3. Simulation software GUI

Software allows creating, saving and restoring different simulation profiles for efficient comparison of investigated protocols. Simulation can be performed either step by step, analyzing each packet in time flow diagrams, either as complete simulation for thousands of simulated procedures. Software provides graphical results for different QoS characteristics of each network element – generated traffic, latency, average results, etc.

This article provides mobile WiMAX handover procedure simulation example. Procedure time flow diagram is provided in Fig. 4 [2].

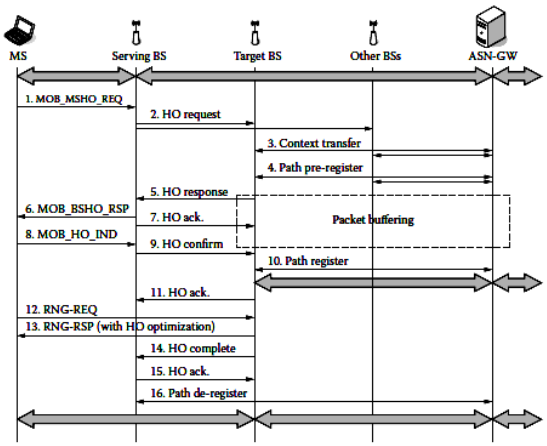


Figure 4. Handover time flow diagram

Diagram represents registration procedure and packets used for performing handover procedure. Describing each packet in simulation software was based on mobile WiMAX standard [1].

Simulation results are provided in Table 2. Values represent results when mobile station is in coverage from 2 to 4 base stations.

Table 2. Mobile WiMAX handover simulation results

QoS Characteristics	Result
Handover latency	from 92 to 180 ms
Uplink generated data load	from 2.5 to 7 kbps
Downlink generated data load	from 3 to 9.5 kbps

As we can see registration procedure of one user is acceptable from latency point of view and does not create high data traffic, but when implementing network it must be taken into account, because network consists of many mobile stations and in overlapping network zones where could be continuous handover activity.

3. NETWORK COVERAGE EVALUATION

Network coverage evaluation software utilizes results of BS coverage estimation and protocol simulation. Software suggests optimal distance between base stations, provides graphical representation of base station coverage and calculates areas between all types of overlapping sectors. It allows specifying number of mobile stations in each area type and inputting traffic load.

Calculation examples are provided in Figure 6, assuming that there are 25-75 mobile stations per sector, 2% wireless channel error probability, 50% of mobile station performs handover at sector edge. It results in up to 130 kbps for downlink and up to 120 kbps for uplink generated traffic. When lowest rate modulation QPSK1/2x6 is used (it's most probable at sector edges) handover procedure can consume up to 18% and 41% sector capacity for downlink and uplink respectively. Therefore it's important to foresee what user expansion is expected in the future and initially implement required overhead.

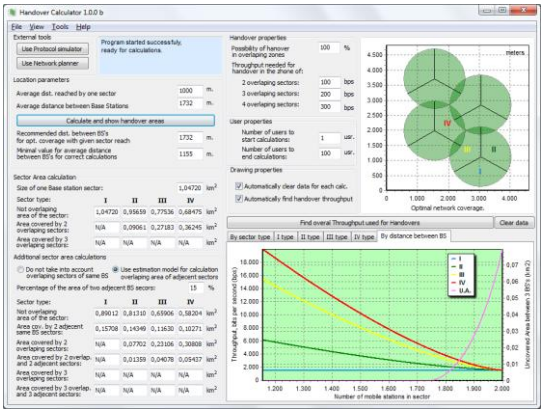


Figure 5. Network coverage evaluation software GUI

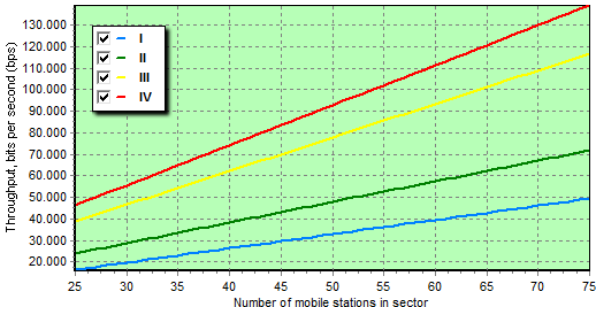


Figure 6. Handover data load dependencies from number of users by sector type

7. CONCLUSIONS

Software that is designed and presented by Authors allows automating network implementation and service simulation tasks for 4th generation wireless technologies. Software can be used as efficient tool for network providers or for educational purposes.

Example results presented in this paper show that multiple and complex tasks must be solved in order to achieve optimal network performance and even such regular procedure as handover can affect QoS. Automated software allows foreseeing and avoiding such of network behavior by choosing higher capacity equipment, selecting more efficient mobility management solutions or increasing BS density.

References

[1] IEEE 802.16 Broadband Wireless Access Working Group. "Channel Models for Fixed Wireless Applications", 2001, 36 p.

[2] IEEE. „IEEE Standard for Local and Metropolitan area networks / Part 16: Air Interface for Broadband Wireless Access Systems" - New York, 2009. - 864 p.