International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 24 (2016) pp. 11894-11900

A New Proposal of Handover Algorithm between Cellular Mobile and Mobile WiMAX Systems

Nasser A. Hamad

Department of Electrical, Electronics and Communications Engineering (EECE)
American University of Ras Al Khaimah, Ras Al Khaimah, UAE.

Abstract

The requirements of instant accessibility of mobile Internet have been increased significantly with various high speed Internet applications. The objective is to access these applications in optimal way to exploit the performance, spectral efficiency, and Quality of Service (QoS). Handover (HO) is a concept which aims to grant stability of connection while crossing diverse networks. A HO scheme between a cellular mobile system and a WiMAX mobile system in physical layer mode is proposed in this paper to provide a collection of high data rates, high mobility, and solving the problem of traffic congestion in cellular mobile network.

Keywords: WiMAX network, cellular mobile network, handover techniques, radio system planning.

INTRODUCTION

WiMAX is considered as an attractive technology to provide high data rates in a mobile environment [1-4]. IEEE 802.11 WiFi is an international standard describing the characteristics of a wireless local area network (WLAN) that provides wireless high-speed internet and network connections with high throughput, on the other hand, the IEEE 802.16 (WiMAX 16) is developed for fixed broadband wireless metropolitan access networks (WMAN) that provides broadband wireless access (BWA) up to 50 km for fixed stations, and 5-15 km for mobile stations [5], IEEE 802.16 supports very high bit rates in both uploading and downloading. Mobile WiMAX combined the issue of mobility and the higher throughput which is the goal of WiMAX in new technology which is IEEE 802.16e Mobile WiMAX standard [6-8].

Aiming at increasing data rates of wireless communication with high performance, OFDM technology is implemented by either Inverse Fast Fourier Transform (IFFT) or Discrete Wavelet Transform (DWT), for more details [cf. 9-11].

Because of user movements, the need to change the channel, serving cell, or system becomes necessary, especially when the coverage or the quality of the communication is deteriorated. In mobile WiMAX networks, there are three different modes for handover mechanism, including hard handover (HHO), macro-diversity handover (MDHO), and fast base station switching (FBSS) [12, 13]. These handover modes are triggered when the signal level between the Mobile Station (MS) and serving Base Station (BS) is too weak.

In a survey given in [14], several HO algorithms are presented, and concentrated on high speed mobile environment, namely, high-speed railways. In our work, the HO is between two different systems supporting heterogeneous data considering the traffic load, signal quality and emerging of a multimode Mobile Terminal (MT). Unlike [15], the HO is initiated based on the MT movements. We assumed perfect synchronization between the two systems all the time, however, inter-WiMAX HO is discussed in [16], wherein the WiMAX system uses two types of ranging, initial ranging used to determine the transmit power of MT to BS terminal, and periodic ranging where the BS continually send time alignment messages to MT as it moves in the radio coverage area.

The performance analysis of the HO between WiMAX and UMTS system is given in [17], where a HO mechanism for moving mobiles and considering the calculation of the lost packets rate to evaluate the performances of the intersystem HO between the two wireless networks UMTS and WiMAX is proposed, their simulation results show that the performances of the HO are satisfactory for a low mobility, however, for high speeds, the performances of the HO fall considerably. In both cases, our results show superior behavior in comparison to their results[1].

This paper is organized as follows: A mobile radio system planning and mobile WiMAX system planning are presented in Section 2 and Section 3, respectively. In section 4, the HO algorithm between cellular mobile system and WiMAX network is presented. We concluded our results in Section 5.

MOBILE RADIO SYSTEM PLANNING

The radio frequency planning process has three major phases. Aiming at clarifying the three phases, we consider specific coverage area called Salf area as a case study, in which we introduce the capacity requirements using macrocells.

A. *Dimensioning*

The first phase defines the essential radio parameters values and technologies. The operator has been allocated only 24 channels (each with 200 kHz) which represent 4.8 MHz of bandwidth. Assuming a population of 2000 subscribers.

[1] To be clarified in the simulation results in the following sections.

The analysis of traffic and coverage data will produce information about the geographical area and the expected capacity (traffic load), assuming that the average call duration 90 sec (*T*), grade of service GoS is 2%, 95% deep indoor coverage (Carrier-to-Interference ratio $C/I > 12$ dB), and the traffic intensity measured in Erlang *A* is given as $A = (n \times T)/3600$, where *n* is the number of calls per hour. In our example, we have $A = 25$ *mE*. Assumed cell pattern is 4/12, thus, the traffic channels per cell = 4 × 8 - 3 (control channel) = 29 traffic channels (TCH) with a 2% GOS implies 21.04 Erlang per cell (Erlang B capacity) [18]. Moreover, the number of subscribers per cell = 21.04 *E*/25 *mE* = 841 subscribers per cell, and if there are 2000 subscribers then the number of cells needed is 2000 / 841 = 2.4 cells. The number of subscribers the site can supply up to 841 × 3 = 2523 user.

The link budget planning analysis provides coverage design thresholds, Effective Isotropically Radiated Power (EIRP) which is needed to balance the path, and Maximum Allowable Path Loss (MAPL). The downlink and uplink link budgets are shown in Table I and Table II, respectively.

Table I: Downlink budget (BTS to MS)

Parameter	Value in dB	Symbol representation
BTS transmitter power	43dB	*A*
Combining loss	3dB	*B*
Feeder loss	2dB	*C*
BTS antenna gain	17dBi	*D*
Total (EIRP)	55dBm	$E = A – B – C + D$
MS receiver sensitivity	-104dBm	*F*
MS antenna gain	0dBi	*G*
Fading margin	6 dB	*H*
In door penetration loss	12dB	*I*
Body loss	3dB	*J*
Minimum reception level	-83dBm	$K= F – G + H + I + J$
MAPL	138dB	$L = E - K$

Table II: Uplink budget (MS to BTS)

Parameter	Value in dB	Symbol representation
MS transmitter power	33dB	*A*
MS antenna gain	0dBi	*B*
Total EIRP	33dBm	$C = A + B$
BTS antenna gain	17dBi	*D*
Feeder loss	2dB	*E*
Diversity gain	3dB	*F*
BTS receiver sensitivity	-107dBi	*G*
Fading margin	6 dB	*H*
In door penetration loss	12dB	*I*
Body loss	3dB	*J*
Minimum reception level	-104dBm	$K= E – D –F + G + H + I + J$
MAPL	137dB	$L = C - K$

The link balance = -1 dB, (downlink budget – uplink budget).

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 24 (2016) pp. 11894-11900

A nominal cell plan can be produced from the data compiled from traffic and coverage analysis. It's a geographical representation of the network; it looks like a cell plans and form the basis for further planning. The area of Salf is 2.5 km^2, by taking the greatest number of sites between coverage and traffic analysis then the number of BS is 3 will distributed over the coverage area using Visio as shown in Figure 1 below.

B. Detailed radio system planning

Radio propagation properties of the actual environment should be taken into consideration in radio system planning. Such planning is implemented based on complex measurement techniques and computer-aided analysis tools for radio propagation studies, planning tool is a software package designed to simplify the process of planning and optimizing a cellular network.

Figure 1: The nominal cell planning of Salf area.

Table III below shows all nominal plan of Salf area including coordinates of each site, antenna direction (the azimuth), the best location. Moreover, it is assumed that antenna beamwidth is 65 degree, antenna height is 21 *m*, and electrical antenna tilt is assumed 3 *m* for each sector.

Table III: Nominal plan parameters of Salf area

CELL	LON(E)	LAT(N)	ANT_DIR
SAL001A	35.18054	32.07779	90
SAL001B	35.18054	32.07779	230
SAL001C	35.18054	32.07779	340
SAL002A	35.175948	32.087936	70
SAL002B	35.175948	32.087936	170
SAL002C	35.175948	32.087936	280
SAL003A	35.185548	32.085349	20
SAL003B	35.185548	32.085349	180
SAL003C	35.185548	32.085349	280

Then using planning tool to determine and predict the percentage coverage of mobile system, then the coverage percent report is 99.98% of 2.5 km^2 of Salf area as shown below in Figure 2.

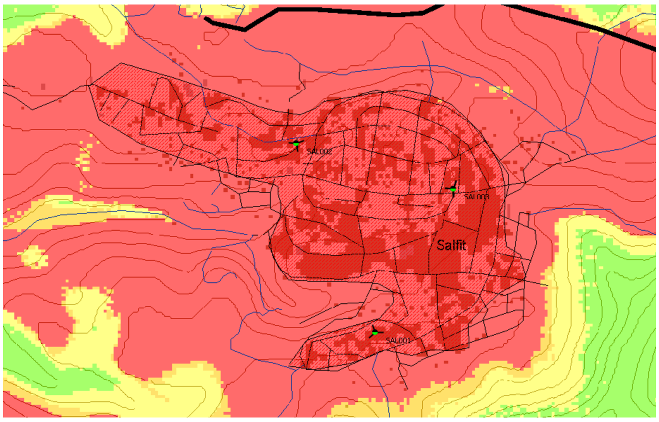

Figure 2: Coverage prediction of cellular mobile system.

The design and planning of the system has to be done so as to reuse the frequencies as often as possible, while keeping the co-channel and adjacent channel interferences within acceptable limits. Since we have 24 frequencies, for example, 4/12 pattern with 4/4/4 transmitter per site then 4 carriers per cell is required. Hence a cluster formed of 4 sites, so the cell reuse pattern is 4/12.

C. Optimization and Monitoring

Unfortunately, neither the number of MS nor their locations are fixed, hence, exact information about the configuration needed for the radio network is hard to predict. Some statistical data is gathered to check whether the radio network has over capacity or congestion. The statistical data based on monitoring results is very important input for the dimensioning phase, thus a starting point for network evolution.

The optimizing process fits the designed radio network to the actual coverage demands and traffic, after the installation, the first step is to verify the coverage. The optimization phase is an adjustment process based on real life changes that were not taken into account in the original radio system planning.

MOBILE WIMAX CELL PLANNING

The WiMAX network architecture can logically be represented by a Network Reference Model (NRM), which identifies key functional entities and reference points. Over which a network interoperability framework is defined. The WiMAX NRM generally consists of Subscriber Station (SS), Access Service Network (ASN), and Connectivity Service Network (CSN).

At high level, the WiMAX NRM differentiates between Network Access Providers (NAPs), Network Service Provider (NSPs), which provides IP connectivity and WiMAX services to WiMAX subscribers according to some negotiated service level agreements (SLAs) with one or more NAPs, and Applications Service Providers (ASP) which provide services such as hypertext transfer protocol (HTTP), video streaming, e-mail, and file downloads, etc. [19].

ASN is comprised of number of BSs connected to an access network, ASN connects to external networks via an access service network gateway (ASN GW), and CSN provides IP connectivity services to WiMAX subscriber and includes servers that support authentication for the devices, users, and specific services. The CSN is also responsible for IP address management, support for roaming between different NSPs, location management between ASNs, and roaming between ASNs.

WiMAX antennas are designed to optimize performance for a given application. Many operators use sector antennas to cover a 360-degree service area rather than use an Omni directional antenna due to the finer performance of sector antennas over an Omni directional antenna.

SS is the industrial term for customer premise equipment (CPE), and it denotes to "mobile CPE" or "portable CPE". Mobile CPE can make a reliable connection while moving as it requires a HO system to avoid interruption or cutting off the connection. Moreover, mobile CPE has some restrictions in its size and the transmitted power whereas portable CPE has a larger size than mobile CPE and its transmitted power is higher than mobile CPE. It doesn't require HO for its connection.

Designing a WiMAX network is a multilayered approach that is executed over time. A network is deployed surrounded by other networks, so the knowledge of all networks in the area is essential because they interfere with each other.

A. Coverage Analysis of Mobile WiMAX

In order to design an accessible WiMAX network, the number of BSs in specific area should be enough to cover that area. This is possible with the planning tool based on an accurate technical model includes technical characteristics of mobile WiMAX together with the desired service specifications.

The BS receiver feeder cable depends on the feeder type and length. For a coaxial feeder cable model (7/8") diameter, losses are 32 dB, and 55 dB at 1000 MHz, and 2000 MHz, respectively. Losses are nominally taken 3 dB when the cable length and diameter are known. The actual cable losses may be substituted in the link budget along with an additional margin of 0.5 dB for connector losses. For deep indoor, CPE station parameters are shown in Table IV.

Table IV: Base station parameters

Parameter	Mobile CPE
UL transmitter power	27dBm
UL transmitter antenna gain	2dBi
Other UL transmitter gain	0dB
DL receiver antenna gain	2dBi
Other DL receiver gain	0dB
DL receiver noise figure	6dB

For forward link communication, BS simulates isotropically radiated power EIRP and can be calculated as,

$$EIRP = (DL\ T_X\ Power) - (feeder\ losses + connector\ losses + jumper\ losses) + (DL\ T_X\ antenna\ gain + other\ DL\ T_X\ gain) \quad (1)$$

While for reverse link communication, EIRP can be calculated as,

$$EIRP = (UL\ TX\ power) - (body\ loss) + (UL\ TX\ antenna\ gain + other\ UL\ TX\ gain\ or\ Diversity\ gain) \quad (2)$$

The receiver sensitivity includes thermal noise, receiver SNR, noise figure, and the implementation loss. The receiver sensitivity is given as,

$$Receiver\ sensitivity\ (RS) = Thermal\ noise + RX\ SNR + RX\ noise\ figure - implementation\ losses \quad (3)$$

To calculate the link budget, we have to consider several margins, such as fade margin, interference margin and building penetration loss (BPL) factor. Slow fading margin is equal to 10 dB. Interference margin happens due to Co-Channel Interference (CCI) in frequency reuse deployments. It is equal to 2 dB at the downlink and 3 dB at the uplink. Buildings obstruct the transmitted electromagnetic signals and BPL for suburban equal 15 dB.

For downlink communication link budget calculations MAPL is specified as

$$MAPL = EIRP + CPE\ DL\ Rx\ antenna\ gain + CPE\ other\ DL\ Rx\ gain - Rx\ sensitivity - Lognormal\ fading\ margin - Head / Bodyloss - Interference\ margin - Building\ penetration\ loss \quad (4)$$

For the uplink communication, MAPL is specified as

$$MAPL = EIRP + BS\ UL\ Rx\ antenna\ gain + BS\ other\ DL\ Rx\ gain - Rx\ sensitivity - Lognormal\ fading\ margin - Fast\ fading\ margin - Interference\ margin - Building\ penetration\ loss + UL\ Subchanneling\ gain \quad (5)$$

The most important issues in the design implementation and operation of land mobile system, is the knowledge of the received signal and its fluctuations. Propagation models take into account the type of the environment and the materials. Cost-231 Hata Model [18] which is extended path loss model. WiMAX forum recommends using this model for system simulation and network planning of macrocellular systems in both urban and suburban areas for mobility application. The median path loss for Cost-231 Hata Model is given by

$$PL = 46.3 + 33.9\log_{10} f - 13.82\log_{10} h_b + \left(44.9 - 6.55\log_{10} h_b\right)\log_{10} d + C_F + a(h_m) \quad (6)$$

where, f = 3500 MHz and the MS antenna-correction factor is given by

$$a(h_m) = \left(1.11\log_{10} f - 0.7\right)h_m - \left(1.56\log f - 0.8\right). \quad (7)$$

Then the path loss is given by

$$PL = 46.3 + 33.9\log_{10} 3500 - 13.82\log_{10} 30 + \left(44.9 - 6.55\log_{10} 30\right)\log_{10} d + C_F - 0.02 \quad (8)$$

From the above equation the diameter (d) of the cell equal $d = 0.44km$ and $R = 0.22km$. For suburban areas the correction factor CF is 0 dB, the WiMAX forum recommends adding 10 dB fade margin to the medium path loss to account for shadowing. Assuming a hexagonal cell shape, and considering mobile WiMAX uses cellular network structure, then the number of sites is calculated as [18],

$$A = \frac{3}{2}\sqrt{3} \times R^2$$

$$A = 2.6 \times \left(0.22^2\right) = .125km^2$$

$$numberofcells = \frac{Area_{Salf}}{Area_{Cell}} = \frac{2.5km^2}{.125km^2} = 20cells$$

$$numberofsites = \frac{20}{3} = 7 \quad (9)$$

The range of the cell site depends upon the transmitter power, Antenna size, direction, and height, and geographical position of the cell site. Delivering number of sites and sectors required to cover a region is the final objective of planning tool.

B. Detailed Radio Planning Using Planning Tool

In order to cover Salf area with Mobile WiMAX indoor coverage, we need to increase the number of sites. It appears that the coverage prediction of Mobile WiMAX working at 3.5 GHz is less than cellular mobile system and the coverage report is 49% of Salf area. To cover the remaining area after using the three sites, we need to add more sites to compensate the less in coverage, the number of sites we need is 7 sites to cover all area of Salf city, and the coverage report now is 99.6%, as shown in Figure 3.

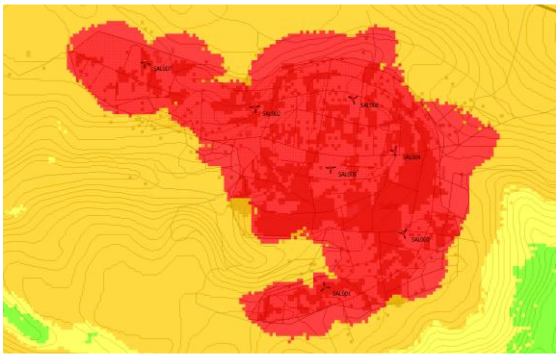

Figure 3: Mobile WiMAX coverage prediction of 7 sites.

Frequency reuse can be implemented by using the so-called segmentation in WiMAX to maximize spectral efficiency, where the whole subchannels are grouped into segments that are used for different sectors, thus avoiding interferences. Each sector has smaller number of subchannels, which means the capacity of each sector might be degraded.

The sub-channel reuse pattern can be configured so that users with sufficient CINR (Carrier Interference Noise Ratio) operate with all sub-channels available, while for the edge users, each cell or sector operates on the zone with a fraction of sub-channels available. This is the basis of fractional frequency reuse FFR in mobile WiMAX. FFR is an efficient method to balance the tradeoff between different frequency reuse patterns [20].

HO BETWEEN MOBILE AND WIMAX NETWORKS

In the coverage prediction of Mobile system and Mobile WiMAX, 3 sites are enough to cover the whole area with Mobile system with 99.98% indoor coverage, whereas seven mobile WiMAX sites showed enough to cover the area with 97.6% indoor coverage. Our objective is to integrate the two systems in order to increase the spectrum efficiency and capacity of the Mobile system. Accordingly, if three sites of the Mobile system employ WiMAX antennas in addition to other four sites are used, then Salf area will be covered by the two systems.

A. Handover between Two Systems (*Simulation Results*)

The main objective is to prove the capability of HO between cellular mobile and mobile WiMAX systems, as cellular system support the mobility for users and mobile WiMAX is designed mainly to support superior data rate, hence, the integration between the two systems will achieve the aforementioned objective, namely, the mobility and high data rates.

We implement new Graphical User Interface GUI using Matlab in order to prove the HO capability between the two systems. Aiming at simplifying the simulation, we assume that the transmitted signal is subjected to an AWGN channel.

Figure 4 shows the normal interface of the GUI program, in which a select menu to select one of five inputs of communication systems, text, image, voice, video, and web. Assuming four mobiles, two of them are cellular mobiles and the others are WiMAX mobiles. At the left of the GUI, data type, distance between the mobile station and the sites, and the results of calculating BER.

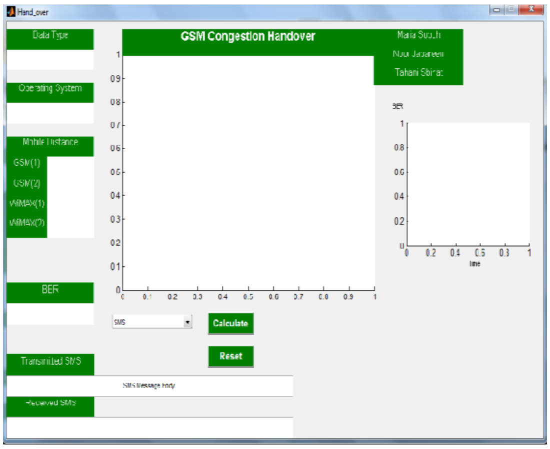

Figure 4: The normal view of the graphical user interface (GUI)

As examples, we will consider transmitting two types of transmitting information, namely, SMS and voice signals.

1. When transmitting SMS signal

While the MS is moving, the massage received at the receiver side with a certain BER shown in the left bottom of the GUI. The mobile continues sending massages as long as the BER of the received signal below a predetermined threshold value. The HO is initiated to the Mobile WiMAX system when the BER becomes above $BER_{threshold}$. The BER performance of the two systems appears in the right side of Figure 5, noticeable drop of BER when the mobile operates in the Mobile WiMAX system.

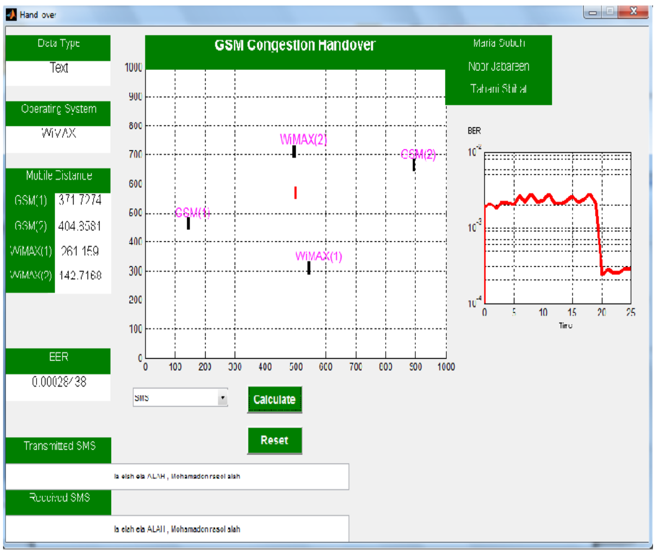

Figure 5: HO between two systems when transmitting SMS signal

2. When transmitting voice signal

Similarly, Figure 6 shows the BER performance in HO scenario between the cellular mobile and the mobile WiMax systems. The system performance is greatly enhanced after carrying out the HO between the two systems.

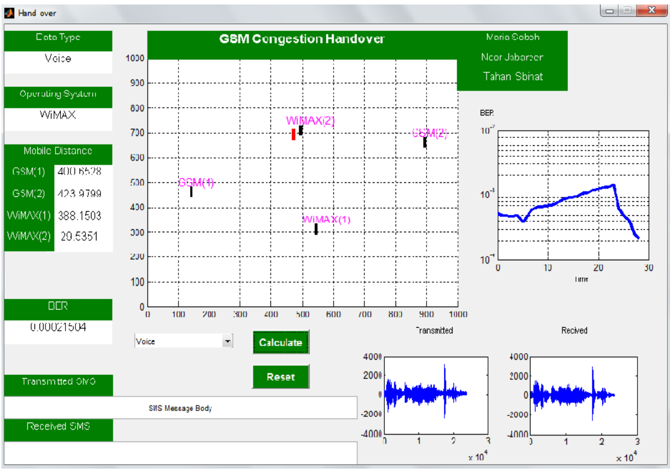

Figure 6: HO between two systems when transmitting voice signal

CONCLUSION AND FUTURE WORKS

In Our project, we proposed a HO algorithm between a cellular mobile and WiMax mobile systems, the model and BER performance before and after carrying out the HO is calculated and shown in simulation results. We introduced a case study in Salf area with numerical and practical applications in both systems, namely, in Mobile WiMAX where we design a new link budget with several parameters to distribute the sites in the city. Simulation results prove that there is integration and HO between the two systems in physical layer mode.

In our research, we consider only the physical layer mode, it will be more interesting to consider also the MAC layer mode. In our analysis, we consider an Additive White Gaussian (AWG) channel. It will be interesting to consider more practical channels such as multipath fading channel.

REFERENCES

[1] M. Gerami, "A Survey on WiMax", International Journal of Computer Science and Information Security, Vol. 8, 2010.
[2] Zerihun Abate, WiMax RF Systems Engineering, Artech house, MA, 2009.
[3] Dharma P. Agrawal, and Qing-An Zeng, Introduction to Wireless and Mobile Systems, 4th edition, CENGAGE Learning, USA, 2016
[4] P. Datta, and S. Kaushal, "Exploration and Comparison of different 4G Technologies Implementations: A Survey", Proceedings of 2014 RAECS UIET, Panjab University Chandigarh, 6-8 March, 2014.
[5] IEEE Standard for Local and Metropolitan Area Networks. Part 1: Air Interface for Fixed Broadband

Wireless Access Systems. New York, USA: s. n., October 1, 2004.
[6] Y. Li and G. L. Stiiber, Orthogonal Frequency Division Multiplexing for Wireless Communications, Springer-Verlag, 2006.
[7] Seok Y. Tang, Peter Muller, and Hamid R. Sharif, WiMax Security and Quality of Service, An End-to-End Perspective, John-Wiley & Sons Ltd, 2011.
[8] Martin Sauter, From GSM to LTE, An Introduction to Mobile Networks and Mobile Broadband, 1st edition, John-Wiley & Sons Ltd, 2011.
[9] Nasser A. Hamad, "OFDM Performance Measurements in WiMax Physical Layer Network", International Journal of Applied Engineering Research ISSN 0973-4562 Vol. 10, No. 24, pp 44393-44398, 2015.
[10] G. Gowri, G. Uma Maheswari, E. Vishnupriya, S. Prabha, D. Meenakshi, N. R. Raajan, "Performance Analysis of DWT-OFDM and FFT-OFDM systems", International Journal of Engineering and Technology, Vol. 5, No. 2, Apr-May, 2013.
[11] Naagesh S. Bhat, "FPGA based DWT-IDWT implementation of OFDM on UWB Systems", International Journal of Applied Information Systems, Vol. 2, No.7, May 2012.
[12] J. Korhonen, Introduction to 3G mobile communications, Artech House Publishers; 2nd edition, 2003.
[13] J. G. Andrews, A. Ghosh, and R. Muhamed, Fundamentals to WIMAX Understanding Broadband Wireless Networking, Prentice-Hall, 2007.
[14] Y. Zhou, and B. Ai, "Handover schemes and algorithms of high-speed mobile environment: A survey", Computer Communications, Vol. 47, pp. 1-15, Jul. 2014,
[15] S. Mojtaba, S. Khorsan, and S. Yarahamadian, "A New Handoff Management System for Heterogeneous wireless Access Networks", Inter. Journal of Communication Systems, Vol. 27, No. 7, pp. 1020-1033, July 2014.
[16] F. T. Al-Saedi, and W. A. Maddallah, "Evaluation of Handover Process in WiMAX Networks", IJCSET, Vol. 2, No. 1, pp. 831-838, Jan. 2012.
[17] A. Djemai, M. Hadjila, and M. Feham, "Performance Analysis of the Interconnection between WiMAX and UMTS Using MIH Services in MIPv6", International Journal of Computer Science and Network Security IJCSNS, Vol.11 No.8, Aug. 2011.
[18] Theodore S. Rappaport, "Wireless Communications: Principles and Practice", 2nd edition, Pearson Education, 2010.
[19] P. Iyer, N. Natarajan, M. Venkatachalam, A. Bedekar, E. Gonen, K. Etemad, and P. Taaghol, "All-IP Network Architecture for Mobile WiMAX", IEEE Mobile WiMAX Symposium, Page 95, 2007.
[20] Jau-Yang Chang, Hsing-Lung Chen, and Chun-Yu Lin, "A resource reservation scheme with hybrid dynamic grouping for multimedia mobile wireless communications networks", 5th International symposium on Wireless Personal Multimedia Communications, Vol. 3, Taipei, Taiwan, 27-30 Oct., 2002.