Interference Analysis of WiMAX and DVB-T Systems

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Abstract- **With the increasing development of wireless systems, frequency utilization is limited by the problem of insufficient spectrum. More portion of the spectrum is needed to cope with the increasing demand of the 3G and 4G technologies. On the other hand, analogue TV is shifting to digital and after this switch-over there is some part of the spectrum that free. Thus, the objective of this research is to investigate the interference of the coexistence on DVB-T and WiMAX systems. We design an interference analysis to find out realistic distance between the DVB-T transmitter and WiMAX receiver. We consider a scenario where the DVB-T transmitter is located together with a WiMAX system in very close proximity. We evaluate and analyze the performance due to the separation distances between the two systems in terms of transmission power, capacity and the signal strength. Simulations results have shown that at 40 km distance, there is no interference between the transmission.**

Keywords- 3G, analogue TV DVB-T, WiMAX, SEAMCAT, ERO

I. INTRODUCTION

Recent advances in technology design have led to rapid development and deployment of wireless communication systems resulting into a congested radio spectrum. However, it has been estimated that 70 % of licensed spectrum in some countries is not utilized efficiently across time and space [1]. Since different operators in adjacent bands might choose to use different systems, the coexistence of different systems is becoming one of the most challenging issues. When transmitters and receivers are operating simultaneously in adjacent spectrum and in the same area, the transmitters may cause significant interference to the receiving systems. So it's important to know the effect of interference between systems in such environments [2]. Currently universal TV broadcasting systems are switching from analogue to digital hence improving quality of TV broadcasting and the efficient usage of the spectrum. Consequently a significant amount of precious spectrum will be available in the UHF bands as an "interleaved spectrum" or TV White Spaces (TVWS) [3]. Since these are in known geographical locations, they can be expanded for DVB-T or other secondary such as mobile networks [4]. The devices which are used in TVWS are called White Space Devices (WSDs).

II. BACKGROUND

A. WiMAX systems

WiMAX (Worldwide Interoperability for Microwave Access) is based on the IEEE 802.16 standard has been developed for higher data rate applications especially in mobile environment. As a mobile broadband wireless access technology, it can realize enhanced network capacity requirements and various services as well as provide more novel experiences for users [5]. It is a standard for providing last mile wireless broadband access as an alternative to wired broadband such as cable and DSL. There are three variants that WiMAX 802.16e can offer: fixed, nomadic and mobile. Fixed WiMAX serves users at one location or stationary users at different places, nomadic WiMAX allow users to get connected in a portable way and mobile WiMAX which supports easy hand-off between base stations just like mobile phones. The latter is thus highly suitable for users on the move [6]. The air interface of mobile standard is licensed for using 2.3 GHz, 2.5 GHz, 3.3 GHz and 3.5 GHz frequency bands (IEEE, 2005). However, the allocation of these frequency bands are varying from one country to another or one geographical region to another for example the band 2.3 GHz are reserved for fixed or mobile version in Malaysia.

B. Interference in WiMAX systems

In the initial working group release, the standard supports 5 and 10 MHz bandwidth allocations for each radio frequency channel. The available channel bandwidth is made up of subcarriers each of which can be modulated individually with information. WiMAX uses Orthogonal Frequency Division Multiple Access (OFDMA) to assign sub-carriers to different users. The number of sub-carriers available for assignment in the UL and DL are function of the channel bandwidth, the frame size and the UL/DL ratio. In mobile WiMAX, the smallest unit of frequency-allocation available is a slot which contains 48 data sub-carriers. The sub-carriers comprising a slot can be made up of adjacent sub-carriers or can be allocated in a distributed fashion throughout the available carrier space. In general, distributed carrier allocations perform better in mobile environment while adjacent sub-carriers are better suited for fixed link. The number of slots assigned to a particular user per frame is a function of their data needs.

C. DVB-T system

Digital Video Broadcasting (DVB) is a set of internationally accepted open standards for digital television developed by DVB Project. This system is much more than a simple replacement for existing analogue transmission. DVB is a transmission scheme based on moving pictures expert group MPEG-2 video compression. DVB provides superior picture quality with the opportunity to view pictures in standard format or wide screen (16:9) format along with mono, stereo and surround sound. DVB-T for terrestrial network is the traditional broadcast networks used to delivery digital TV to the consumer. In the ETSI 300 744 standard, the DVB-T system is defined as the functional block of equipment performing the adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer to the terrestrial channel characteristics [7].

III. METHODOLOGY

DVB-T broadcasting system is set as the victim from the interference of WiMAX sytems where both are assigned at 2.3 GHz frequency band. We consider two different received signals as described as follows: dRSS is the signal transmitted by the Wanted transmitter (Wt) or transmitter of the primary system (DVB-T transmitter) to the Vr. iRSS is the signal transmitted by the Interfering transmitter (It) or secondary system (WiMAX transmitter) and received by the Vr. Figure 1 shows the flowchart of the SEAMCAT simulation process.

A. Flowchart

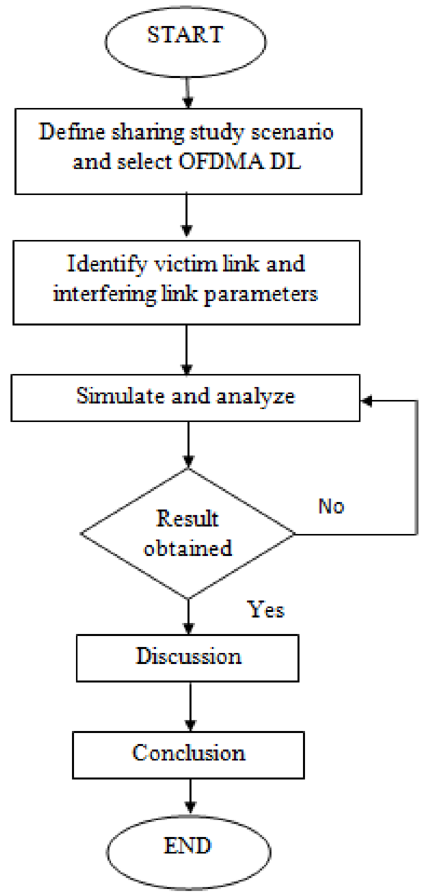


Figure 1: Flowchart of SEAMCAT simulation

B. Simulation model

The statistical methodology used as the basic for SEAMCAT is known as the Monte Carlo technique. The victim receiver (Vr) is connected to a wanted transmitter (Wt) and operates amongst a population of interferer transmitter (It). This interferer may belong to the same system, different system or a mixture of both. The interferers are randomly distributed around the victim in a manner decided by the user and are linked to a wanted receiver (Wr).

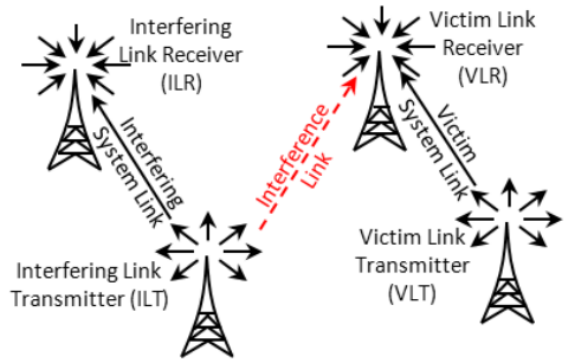
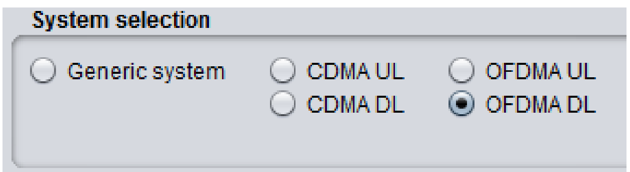


Figure 2: Main Elements of SEAMCAT Interference Scenario

C. OFDMA system



The parameters of the DVB-T system and WiMAX are shown in Table 1 and Table 2 respectively. Two antennas are set in vertically position in the free space propagation model.

Table 1: Parameters for DVB-T system

Parameters	Value
Frequency band	2300 MHz
Transmit power	46.0 dBm
System Bandwidth	10 MHz
SINR minimum	-1000 dB
Max subcarriers per base station	51
Number of subcarriers per mobile	17
Handover margin	3 dB
Minimum Coupling Loss	70 dB
Receiver Noise Figure	4 dB
Bandwidth of Resource Block	180 kHz
Number of external interferers	57
Number of active users	3
Antenna height	30 m
Antenna Peak Gain	15.0 dBi
Channel model	Free space
Cell-radius	0.433 km

Table 2: Parameters for WiMAX

Parameter	Value
Frequency	2300 MHz
System Bandwidth	10 MHz
Cell radius	4.33 km
Antenna Height	30 m
Antenna Peak Gain	15 dBi
Antenna Pattern	Omni-directional
Output Power	46 dBm
Propagation Model	Free space

The victim transmitter (Vt) is always positioned at the origin of the simulation area. The victim receiver (Vr) and interfering link (It) are then positioned relative to the victim transmitter (Vt) according to appropriate user defined statistical rules. The results have been corresponding to 5km until 50km distances between DVB-T RX and WiMAX TX channels. The interfering transmitter (It) is placed at fix location 5 km to the right to the reference cell.

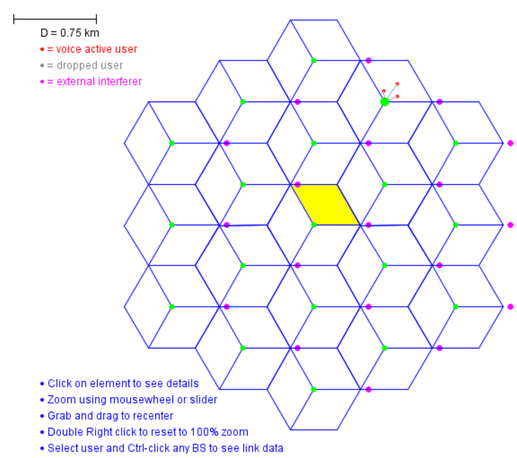


Figure 3: Illustrates Cellular Structure of Interfering Link System

Figure 3 illustrates the cellular structure of the interfering link system from SEAMCAT simulation. The red points are voice active user for victim receiver while the green points refer to the victim transmitter. Purple points correspond to the sample of external interferer at certain distances. The following figure illustrates the interference scenario where the mobile WiMAX 9-cell pattern interferes with the DVB-T RX located randomly towards the DVB-T coverage area of a radius of 0.433 km where is most susceptible to interference.

III. RESULT AND DISCUSSION

In this section we present the results from the Monte Carlo simulation for four performance metrics which are iRSS, SINR, interfered bit rate and external interference.

A. iRSS signal

The iRSS signal is defined as the signal transmitted by the Interfering Transmitter (It) and received by the Victim Receiver (Vr). Figure 4 shows the iRSS unwanted and iRSS blocking for specific distance. The signal strength is much lower due to increasing the distance.

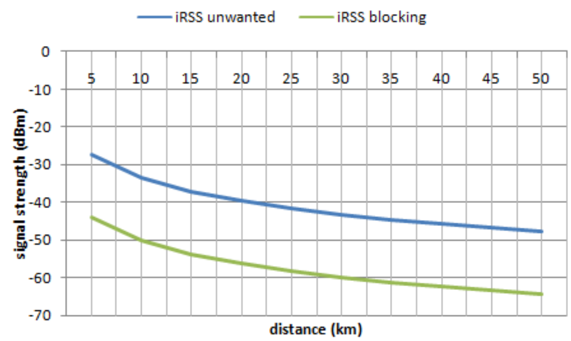
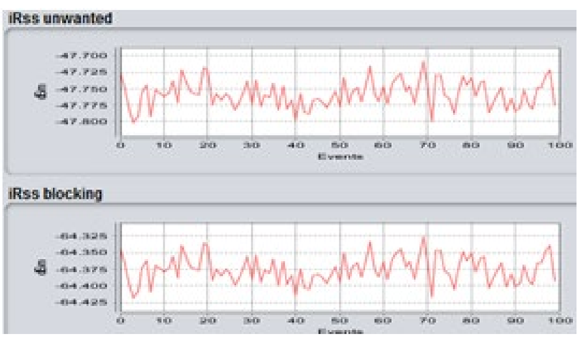


Figure 4: iRSS signal



Example iRSS signal for 100 event at a specific distance

B. SINR Victim system

Signal-to-interference-noise ratio (SINR) is used to measure the clarity of a signal. It is calculated by dividing the power of the wanted signal to the power of the unwanted signal, which consists of interference and noise. Figure 5 shows the SINR victim system which is lower as the distance is increased. This is because the farther the distance , the interference to the victim system is much lesser.

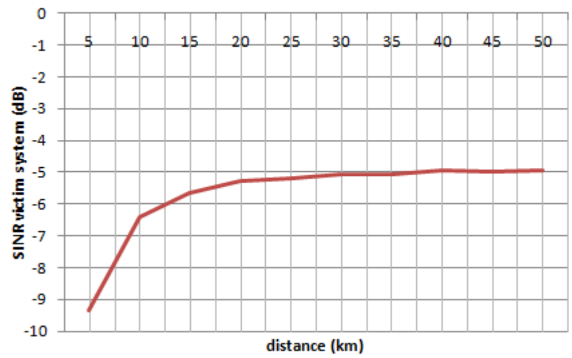


Figure 5: SINR, Victim system

C. Average Interfered Bit Rate System

Bit rate describes the rate at which bits are transferred from one location to another; it measures how much data is transmitted in a given amount of time. Figure 6 shows average bit rate systems. It is observed that, there is no interference between DVB-T and WiMAX at approximately 40 km distance. This is when the receiver of is getting the average throughput as being delivered by the transmitter.

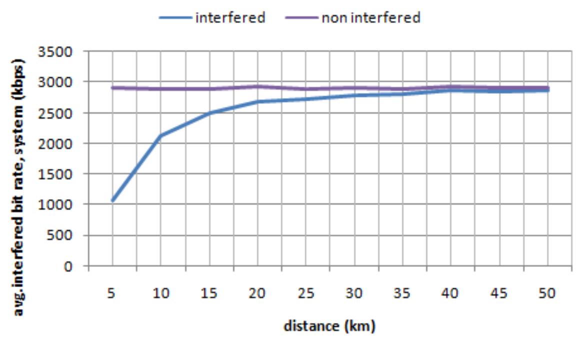


Figure 6: Avg. Interfered Bit rate system

D. External interference, blocking and unwanted (all victims, all interferers)

External interference is caused by other wireless appliances operating in the same frequency range of the network of interest using other radio technologies. Both external interference shows decreased when the distance is increased as shown in figure 9.

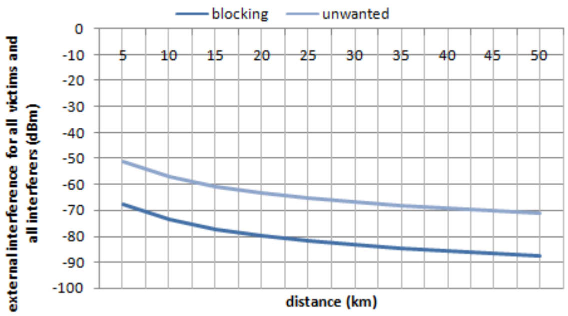


Figure 9: External interference blocking and unwanted for all victims and all interferers

IV. CONCLUSION

In this paper, the interference effect and coexistence of DVB-T system with mobile WiMAX has been analyzed. We provided a brief description of the main parameters causing interference. Results have been investigated by the analytical and simulation studies. A SEAMCAT tool based on Monte Carlo simulation is used to evaluate the interference by implementing a realistic interference scenario between DVB-T and WiMAX networks. The distance between the terminals is the factor that caused the interference in WiMAX network. Analysis of the results has been demonstrated showing the effect on the iRSS unwanted and blocking, average interfered bit rate systems and non average interfered bit rate systems and SINR victim system.

V. FUTURE WORK

Future work includes the implementation of the interference analysis employing Adjacent Channel Interference Ratio (ACIR) to determine the suitable value of guard band between both systems. A guard band is necessary to separate adjacent or similar frequency bands so that both can transmit simultaneously without interfering each other.

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