Performance Evaluation of IMT- Advanced Technology

A. Z. Yonis
Communication Engineering Department
College of Electronics Engineering
Ninevah University, Mosul, Iraq

ABSTRACT
In this paper, International Mobile Telecommunications-Advanced (IMT-Advanced) of wireless cellular systems has been a topic of interest for quite a long time. The IMT-advanced in next generation cellular systems is used to achieve the high spectrum efficiency requirement. An efficient scheduling algorithm plays an important role for effective utilization of radio resources, high data rate, and low latency as well as for the entire system performance with various modulation techniques.

Keywords
IMT-Advanced; Modulation; Efficiency; Cyclic prefix (CP) ; Latency, Bit error rate (BER).

1. INTRODUCTION
In the last year or so, significant momentum has started to build around the idea of a fifth generation for telecommunications technology. The research centers projects have started internationally, and new research devoted to 5G technology have begun to develop quickly. International Mobile Telecommunications- Advanced (IMT-A) systems [1] comprise new services and new capabilities, migrating towards an all internet protocol (IP) network. As happened with the IMT-2000 family of standards, it is expected that IMT-Advanced becomes, through a continuous evolution, the dominant technology designed to support new applications, products and services. Moreover, IMT-Advanced systems must support applications for both low and high speed mobility and for different data rates. The main characteristics of IMT-Advanced systems are interconnection capacity with other radio access systems, high quality mobile services and ease of use of applications while maintaining a wide range of services at a reasonable cost and providing a significant improvement in performance and quality of service[2].
The basic framework for IMT-Advanced performance evaluation has been well defined by international telecommunication union radio (ITU-R). These guidelines have been published by ITU-R to perform the assessment of IMT-Advanced technology candidates by external evaluation groups [3]. The framework for the IMT-Advanced requirements and evaluation has started by publishing [1], [2] and [4], respectively, which specify the requirements, evaluation criteria and guidelines for the evaluation process. The remainder of the paper is organized as follows. Section two describes the IMT-Advanced evaluation environments defined by the evaluation guidelines of IMT-Advanced. Section three represents the main characteristics of IMT-Advanced such as (adaptive modulation and coding, multi input multi output (MIMO) capabilities, types of latency and data rate). Simulations and analysis results are provided in Section four. Eventually, Section five concludes the research paper and leads a direction for future research.

2. TECHNOLOGY EVOLUTION OF IMT-ADVANCED
In this research, IMT-Advanced evaluation methodology, system link level simulation, mathematical analysis, and inspection are specified in [5] to be used for performance evaluation, each method for a specific task.

IMT-Advanced framework and objectives are growing demand for mobile services, more data oriented and video applications, new needs and applications in new regions and domains will be the user trends to drive the development of a future radio access network. To that technology trends, such as convergence of services and platforms, and the progress of digital communications and techniques should be added [6]. These increasing traffic expectations require the further development of future mobile and wireless systems. In a few years, IMT-Advanced will theoretically push the peak rate to attain the huge throughput rate of 3 Gbps. IMT-A requirements do not specify a set of services but a structure of services that includes service parameters, service classifications and some examples [7].

IMT-Advanced is still an evolving standard and hence most of the technologies that are to be a part of this standard are yet to be finalized. The work on IMT-Advanced started around the year 2002 where the vision, definition and requirements were charted out. Currently the standard is evolving to accommodate the spectrum allocation requirements as well as reaching out for new radio access technologies. The IMT-Advanced system deployment is expected to be in place by the year 2012 and widely deployed by 2017.

3. IMT-A CHARACTERISTICS
This section highlights the main characteristics of IMT-Advanced technology. Future wireless systems will need to provide reliability to guarantee quality of service to the large number of end users and high peak data rate services with high flexibility. The essential techniques to be included in next generation wireless (NGW) systems include several aspects of advanced radio resource management that have a direct impact on each user's performance, as well as the overall performance of the network [6].

3.1 Adaptive Modulation and Coding
Different modulations quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (QAM) and 64-QAM and coding schemes are available to fit upper layer packet data units into the different physical channels and to make the system capable of being adapted to varying channel conditions.

3.2 MIMO Capabilities
IMT-Advanced present single user SU/MIMO and multi-user MU/MIMO capabilities as a means to enhance cell and user equipment (UE) performance. Cell spectral efficiency (CSE) and cell-edge UE spectral efficiency can be improved using MIMO. Moreover, user equipment data rate and user equipment coverage can be enhanced with MIMO.

3.3 Latency
IMT-Advanced will support improved performance with respect to use of spectrum, latency to support delay sensitive systems and the performance on the edge of a cell [3].

3.3.1 Control plane latency

Control plane (C-Plane) latency is typically measured as the transition time from different connection modes, such as from idle to active state. A transition time (excluding downlink paging delay and wire line network signaling delay) of less than 100 ms shall be achievable from idle state to an active state in such a way that the user plane is established [3].

3.3.2 User plane latency

The user plane latency is defined as the one-way transit time between an service data unit (SDU) packet being available at the internet protocol layer in the user terminal/base station and the availability of this packet protocol data unit (PDU) at internet protocol layer in the base station /user terminal. User plane packet delay includes delay introduced by associated protocols and control signaling assuming the user terminal is in the active state. IMT-Advanced systems shall be able to achieve a user plane latency of less than 10 ms in unloaded conditions for small internet protocol packets for both downlink and uplink.

3.4 High Data Rate

The proposed capabilities of these IMT-Advanced systems are service demands in multi-user environments with target data rates of up to approximately 3 Gbps for low mobility such as nomadic/local wireless access and up to approximately 100 Mbps for high mobility such as mobile access, which enables the favorable conditions to develop the multimedia based services and envisaged to handle a wide range of supported data rates according to economic. To support this wide variety of services, IMT-Advanced has different frequency band and radio interfaces in order to access large number of mobile users for new nomadic local area wireless access [8].

4. SYSTEM PERFORMANCE WITH VARIOUS MODULATION TECHNIQUES

The international telecommunication union radio defined the requirements for the IMT-A such that the system should be able to have to 100 Mbps data rate support for high mobility [4] and up to 3 Gbps peak data rate for low mobility case; compatibility of services within IMT and with fixed networks; capability of interworking with other radio access systems; peak spectral efficiency, ranging from 0.015 bits/s/Hz up to 0.1 bits/s/Hz ranging up to 15 bits/s/Hz and cell edge user spectral efficiency; latency requirements for control plane to achieve 100 ms transition time between idle and active state; flexibility to allow cost efficient support of wide range of service and applications and bandwidth scalability up to 100 MHz, and respectively to enable 10 ms user plane latency. In this research, usage of cyclic prefix to reduce the multipath distortion.

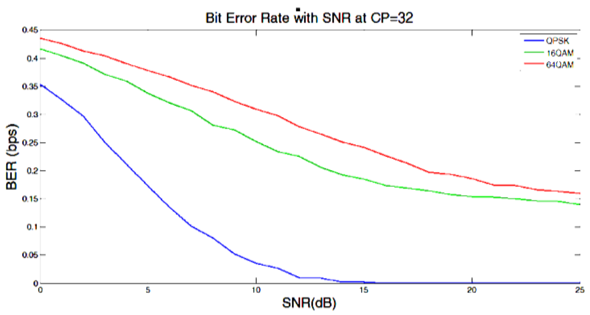

Fig. 1. BER with SNR at CP=32

Results in the simulation of the proposed system confirms that when the length of the cyclic prefix is increased the bit error rate will reduce. The following Figures show the effect of increasing the cyclic prefix length on different types of modulation techniques.

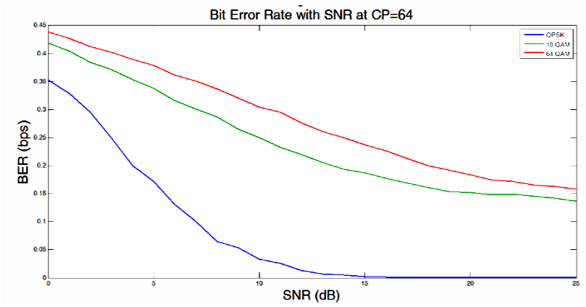

Fig. 2. BER with SNR at CP=64

The Figures 1 to 3 show that there is a large improvement of the values of the bit error rate (BER) when increasing the cyclic prefix of the samples which reduce the effect of the ISI that resulted from the multipath effect.

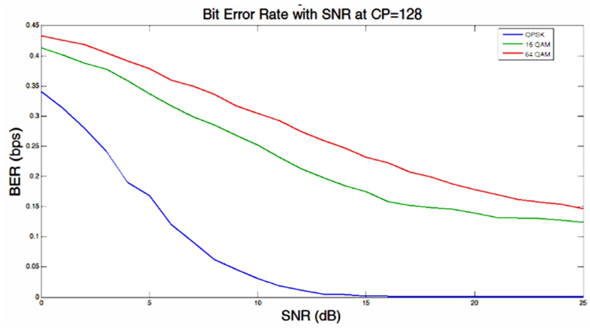

Fig. 3. BER with SNR at CP=128

This effect is studied for a various types of modulation technique such as QPSK, 16QAM and 64QAM which is used as the modulation technique in the downlink of the system.

Also as shown from the Fig. 4, Fig. 5 and Fig. 6, it is observed that QPSK modulation has less bit error rate as compared to the other modulation techniques. It is followed, in order by 16QAM and 64QAM. In the other hand, 64QAM require a highest signal to noise ratio (SNR) followed, in order by 16QAM and QPSK modulation technique.

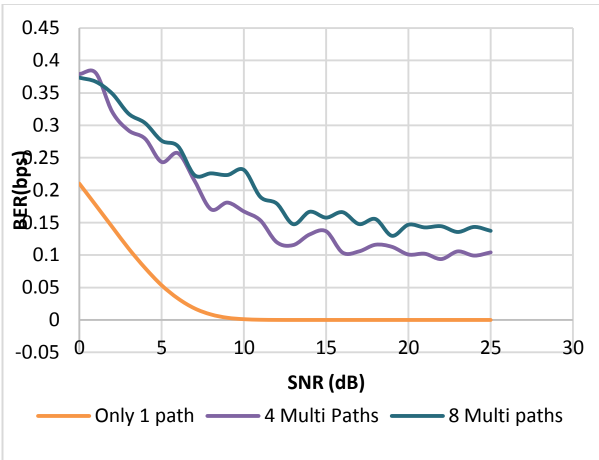

Fig. 4. Effects of multi path on QPSK/ IMT-Advanced system

Where Fig. 4 shows the effi of the least square channel estimation to the multipath fading channel and Additive White Gaussian Noise (AWGN) in the QPSK modulation.

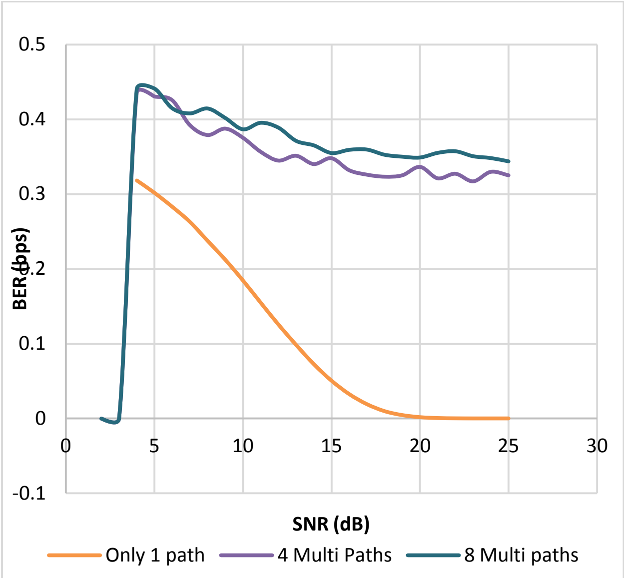

Fig. 5. Effects of multi path on 16 QAM IMT-Advanced system

Fig. 5 shows the effects of the least square channel estimation to the multipath fading channel and Additive White Gaussian Noise in the 16 QAM modulation.

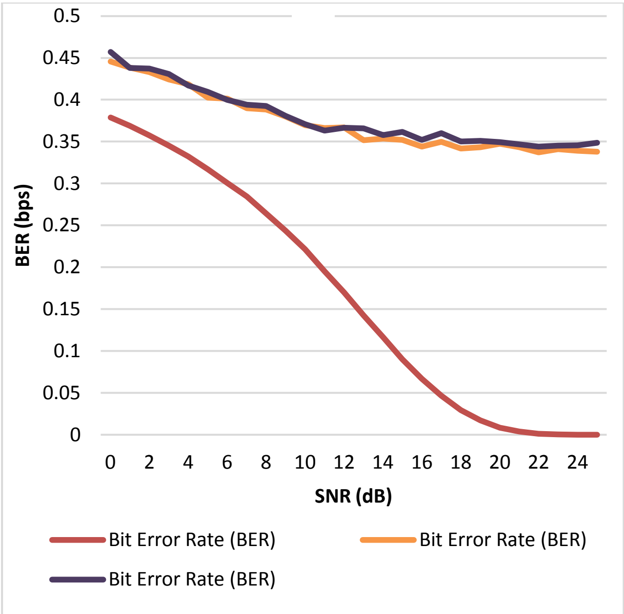

Fig. 6. Effects of multi path on 64 QAM IMT-Advanced system

While Fig. 6 contains the effects of the least square channel estimation to the multipath fading channel and Additive White Gaussian Noise (AWGN) in the 64 QAM modulation.

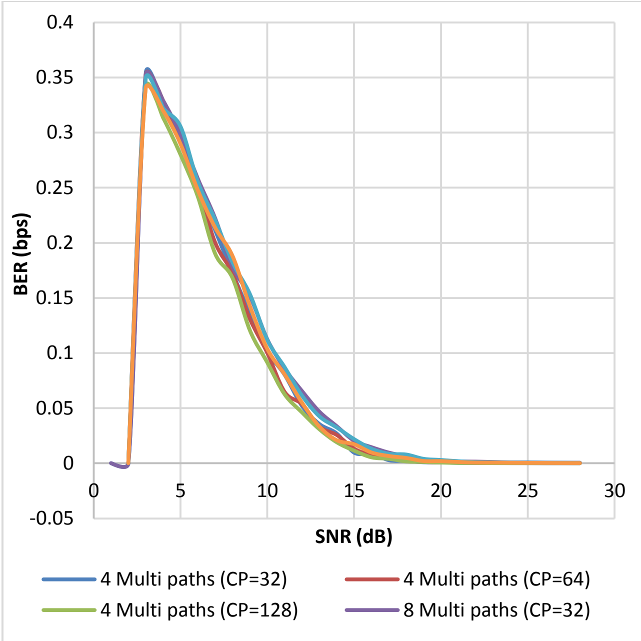

Fig. 7. Effect of Cyclic Prefix on QPSK/ IMT-Advanced system

In Fig. 7 shows the effects of the increasing the length of the Cyclic Prefix in QPSK modulation.

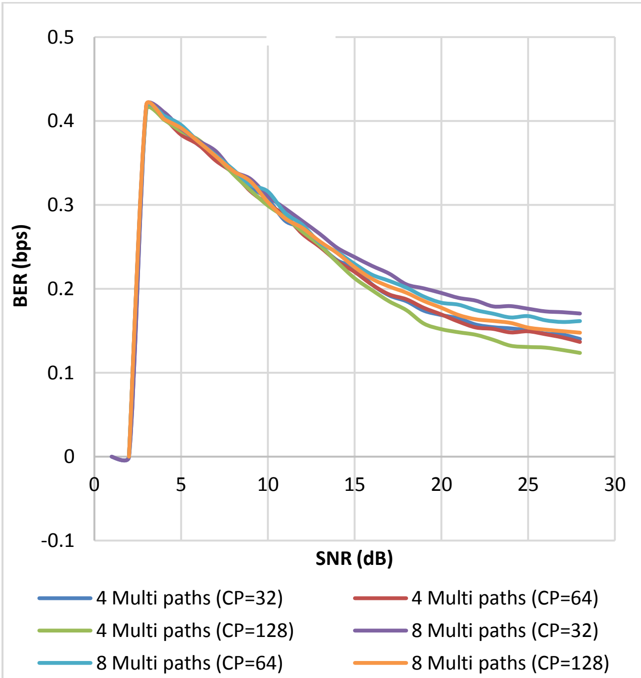

Fig. 8. Effect of Cyclic Prefix on 16QAM/ IMT-Advanced system

The effects of the increasing the length of the cyclic prefix in 16QAM modulation shows in Fig. 8 .

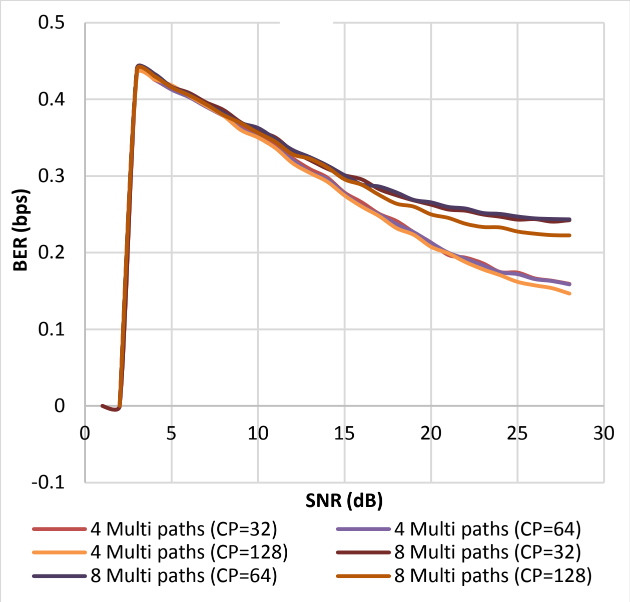

Fig. 9. Effect of Cyclic Prefix on 64QAM/ IMT-Advanced system

It's clear that Fig. 9 shows the effects of the increasing the length of the cyclic prefix in 64QAM modulation.

When the length of the cyclic prefix is increased from 16 to 64 for the same usage data and the same value of the signal to noise ratio, the values of the bit error rate is reduced (improved) from 0.1740 to 0.1613 in QPSK modulation as shown in the Fig. 4 and Fig. 7, and reduced from 0.1820 to 0.1791 in 16QAM modulation as shown in the Fig. 5 and Fig. 8, and reduced from 0.1901 to 0.1884 in 64QAM modulation as shown the Fig. 6 and Fig. 9. The proposed system improves the BER values of the practical circuits used in IMT-Advanced system.

5. CONCLUSION

IMT-Advanced systems are mobile broadband communication systems that include new capabilities that go significantly beyond those of the IMT-2000 family of systems. The article has analyzed the performance evaluation of IMT-Advanced system, the analysis has focused on the important features involved in the downlink like the modulation technique, modulation index and the effect of cyclic prefix over AWGN fading channel. The results of the proposed system show the improvement of BER when cyclic prefix is increased. This improvement is obtained with various modulation techniques such as 2 bits and 4 bits. In order to develop this work, the system can be carried out in new radio technology in handover area. The researchers are focusing on developing various technologies to reach the ultimate requirements of IMT-Advanced.

6. ACKNOWLEDGMENTS

The Author is grateful to the Ninevah university, Faculty of communication engineering for providing the facilities in carrying out this study.

7. REFERENCES

[1] "Guidelines for evaluation of radio interface technologies for IMT-advanced," Geneva, Switzerland, Tech. Rep. ITU-R M.2135-1, Dec. 2009.

[2] G. D. Roche, A. A. Glazunov and B. Allen, "LTE-Advanced and Next Generation Wireless Networks Channel Modelling and Propagation", Wiley book, pp.5-6, 2013.

[3] "Requirements related to technical performance for IMT-Advanced radio interface(s)", Report ITU-R M.2134, 2008.

[4] "Evaluation criteria and submission templates for the development of IMT-Advanced", Report ITU-R M.2133 Requirements

[5] K. Safjan, V. D'Amico, D. Biiltmann, D. Martin-Sacristan, A. Saadani, and H. Schoneich, "Assessing 3GPP LTE-Advanced as IMT-Advanced Technology: The WINNER+ Evaluation Group Approach," Communications Magazine, IEEE, vol. 49, no. 2, pp. 92-100, 2011.

[6] A. Osseiran, J. F. Monserrat, W. Mohr, "Mobile and Wireless Communications for IMT-Advanced and Beyond", 2011.

[7] UIT-R, "Framework for services supported by IMT", UIT, Recommendation M.1822, 2007.

[8] Y. Park, F. Adachi, "Enhanced Radio Access Technologies for Next Generation Mobile Communication", book springer,2007, pp. 34-35.