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Evaluation of a Long-Term Evolution Advanced Pro Model with Optimization

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ABSTRACT:
This paper assesses an enhanced LTE-A Pro model that integrates data augmentation techniques including higher Quadrature Amplitude Modulation (256QAM), Carrier Aggregation (CA), and Multiple Input and Multiple Output (MIMO) in order to improve user performance. The model was implemented on the Vienna 5G System Level Simulator using the MATLAB platform. Simulations were performed on the LTE-A and LTE-A Pro models using 8x8MIMO with Component Carriers (CC) aggregation of 5CC (100MHz) to 32CC (640MHz) at 256QAM scheme to attain user throughput. The simulated results showed that the LTE-A model generated 30 Mb/s while the LTE-A Pro model generated 142 Mb/s. Validation of the results revealed that the user throughput of the LTE-A Pro model is 78.8% higher than that of the LTE-A model.

KEYWORDS: Quadrature Amplitude Modulation, Carrier Aggregation, MIMO, LTE-A Pro, and User Throughput

INTRODUCTION

In mobile communication systems, the continuously growing demand for data rate due to the evolution of new technology devices, smartphones capable of displaying high-quality videos or real-time video traffic is a real problem to contend with. The existing technologies of Second Generation (2G), Third Generation (3G), Fourth Generation (4G) of (Long Term Evolution (LTE) and Long Term Evolution Advanced (LTE-A) networks are completely not capable of catering for the dynamic needs of the customers [1]. This focuses on the enhanced version of the LTE-A network known as Long Term Evolution Advanced Pro (LTE-A Pro) also called 4.5G or Pre 5G developed by the Third Generation Partnership project (3GPP) to support higher data rates beyond 3Gbps, increased Bandwidth, increased efficiency and improved latency. This also makes use of both licensed (400 MHz to 3.8 GHz) and unlicensed (5 GHz) spectrum to support up to 32 carriers of 20 MHz each making use of releases 13 and 14 to improve performance required by the International Telecommunications Union (ITU). Despite, the advent of the Fifth Generation (5G) technology currently being studied, it is assumed that 5G mobile networks address the challenges of higher capacity, higher data rate, lower End-to-End latency, massive device connectivity, cost reduction, and consistent quality experience more effective than 4G [2]. However, 4G is the dominant bearer of global cellular data traffic and still carry more than 93% of global cellular data traffic today even with the emergence of 5G. Meanwhile, the performance of 4G networks will be important for the success of the 5G rollout, Worldwide, high-performance 4G networks must not only meet the growing traffic demand but also should provide a solid foundation for 5G deployments [3]. In this paper, the LTE-A Pro model has been adopted to serve as a baseline of 5G performance in achieving 8x8MIMO, 32 carriers of 20 MHz (640 MHz) of CA and 256QAM features and improve user throughput metric.

RELATED WORK

A greedy method to maximize the throughput with Packet Filter (PF) packet scheduling algorithm was proposed in [4]. The method considered link adaptation jointly with Component Carrier (CC) assignment and Resource Block(RB) allocation and checked whether or not the weighted transmission rate of the user with a maximum gain is higher than the currently assigned RB. However, all CCs have an equal number of RB and all users have similar capabilities which are currently unrealistic assumptions compared to the real world. In the work of [5] studied the performance enhancement of heterogeneous networks via dense clusterisation and higher-order modulation. Data traffic was modelled using the bursty FTP traffic model and Simulated on a MATLAB-based System Level Simulator (SLS).The results showed 6% - 9% average throughput gains per UE could be achieved for Small Cell (SC) UEs. There were imperfections at the transmitter and receiver sides leading to a decrease in throughput and performance gains of

in long-term evolution-advanced. The work developed two CC selector's algorithms (All CC selector and Cyclic CC selector) and implemented them using LTE-A downlink system level simulator Relv1-9-Q2-2016 based on 3GPP TS 36.942 (Macrospcopic path loss models) via MATLAB R2016a. Simulation results showed that all component carrier selector outperforms the Cyclic CC selector in term of average cell throughput, average user equipment (UE) throughput and spectral efficiency by 225.16%, 214.35% and 163% respectively. However, only three component carriers (3CC) were considered in the study. In [7] an improved radio resource management with carrier aggregation in LTE-Advanced was developed. The simulations were carried out with other well-known methods to verify the overall performance of the proposed method. The result obtained indicates that the proposed method outperforms the previous methods in the measurement of average user throughput, average cell throughput, fairness index, and spectral efficiency. The limitations of this proposed method were that, in the case of a higher number of users in the cell, average throughput decreased due to the higher congestion and lack of available resources. [8] carried out a data throughput assessment of 4T4R MIMO Technique on LTE Wireless Cellular Networks. The drive test measurement was carried on a captured LTE wireless network of a 4-way Transmit, 4-way Receive (4T4R) multiple-input multiple- output (MIMO) optimization technique and existing 2x2 MIMO to assess the throughput. The results of 4T4R MIMO technique showed that Terminal 1 recorded a maximum achievable downlink and uplink throughput of 47.5 Mbps and
14.2 Mbps respectively against the system baseline 2x2 MIMO of 33.6 Mbps and 10.7 Mbps. Terminal 2, on the other hand, achieved maximum downlink and uplink throughput of 44.0 Mbps and 14.1 Mbps respectively higher than the same baseline 2x2 MIMO. The work was based on field measurement. In order to address the limitations stated in the reviewed researchers, an optimized LTE-A Pro model is developed to overcome the shortcomings of the existing schemes.

MODEL METHODOLOGY

The LTE-A Pro model of Figure1 was implemented on a 5G system-level simulator using MATLAB 2020a and simulated. The simulation of the LTE-A model was carried out applying 8x8MIMO with 5CC to 32CC of CA at 256QAM to obtain user throughput as performance metric. The simulation parameters are showed in Table 1.

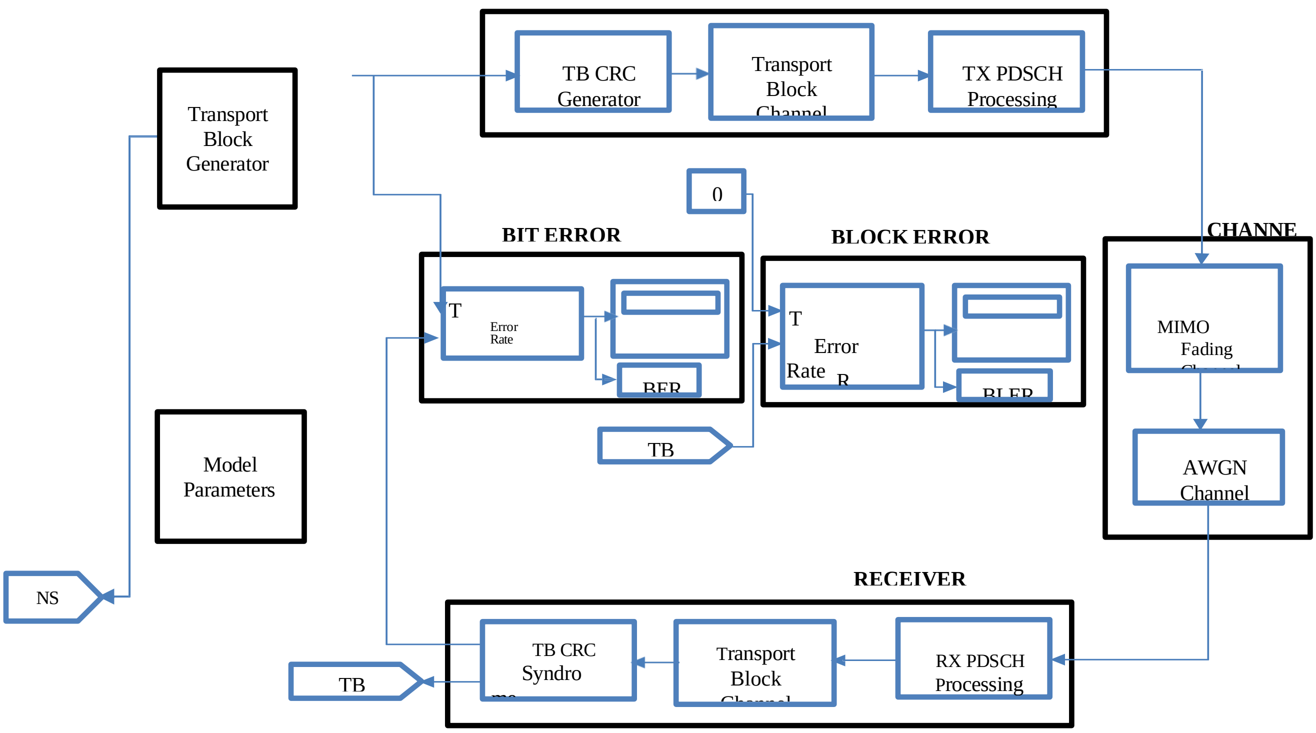

Figure 1: Block Diagram of LTE-A Pro Model

Table 1: Simulation Network Parameters of LTE-A Pro Model

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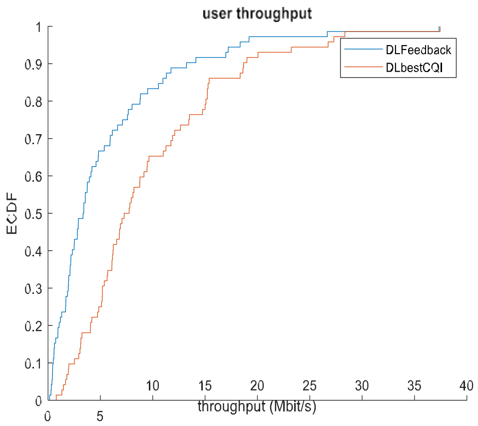
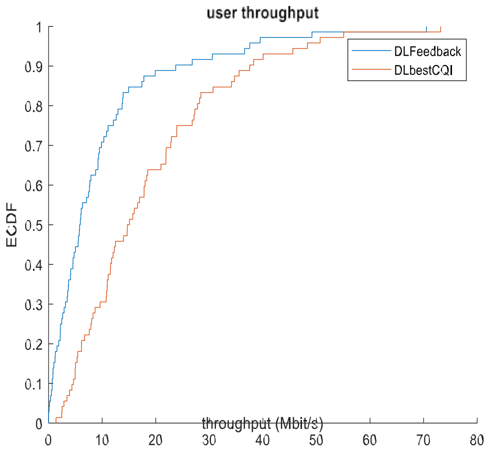
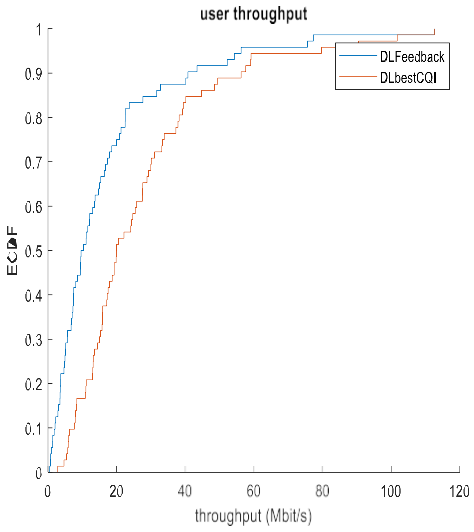
Parameters	Setting/Description
CA deployment	Macro-Pico cells
Carrier frequency	2400 MHz - 2600 MHz
CC Bandwidth	20 MHz -100 MHz
Network configuration	3sites, 3 sectors/site
Scheduling algorithm	Proportional Fair (PF)
eNodeB_distances	500 m
Transmit power	40 dBm
Scenario	Urban (constant UEs per cell)
User speed	5 km/hours
Simulation Time	10 TTI
Modulation Technique	256 QAM
Diversity	DL=2x2 MIMO, 4x4 MIMO & 8x8 MIMO
Duplex Mode	FDD
OFDMA Symbol	Normal Symbol
TTI	1ms
Number of Tx/Rx antenna	2/2 , 4/4 & 8/8
Transmission modes used	TxD, CLSM & TM9

I. SIMULATION RESULTS

The simulation results of the LTE-A Pro model were obtained for User throughput of Downlink (DL) feedback (DLfeedback) and Downlink best Channel Quality Indicator (CQI) (DLbestCQI)). The simulation results of the model applying 8x8MIMO with various Component Carriers of 5CC (100 MHz), 10CC (200 MHz), 20CC (400MHz) and 30CC (640 MHz) at 256QAM scheme were obtained and plotted. The plots of the Empirical Cumulative Distribution Function (ECDF) against throughput (Mb/s) for the determination of user throughput (DLfeedback and DLbestCQI) are depicted in Figures (2 - 5) and discussed as follows. In Figure 2, the ECDF plot of the user throughput of DLfeedback and DL best CQI against throughput(Mbits/s) , user throughput increases and converge at the maximum throughput of 30Mb/s and remains constant at ECDF of 1, although user throughput of DLfeedback has better user throughput to that of DLbestCQI. In Figure 3, user throughput increases and converges at the maximum throughput of 55Mb/s and remains constant at ECDF of 1, although user throughput of DLfeedback is better compared to that of user throughput DLbest CQI. In Figure 4 also user throughput increases and converges at the maximum throughput of 100 Mb/s and still remains constant at ECDF of 1, although user throughput of DLfeedback is better performance to that of user throughput DLbestCQI. In Figure 5, user throughput also increases and converges at the maximum throughput of 140Mb/s and still remains constant at ECDF of 1, although user throughput of DLfeedback is of better output to that of user throughput DLbestCQI.







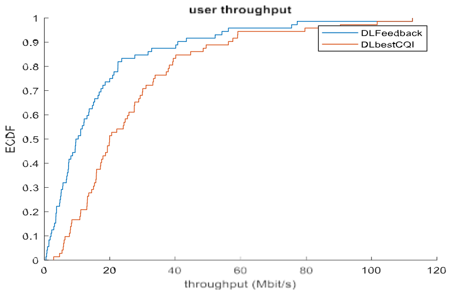


Figure 4: 8x8MIMO with 20CC (400 MHz) **Figure 5: 8x8MIMO with 30CC (640 MHz)**

CONCLUSION AND FUTURE WORK

At 32CC (640 MHz), the simulated user throughput result of the LTE-A Pro model was 142 Mb/s, which was 82% greater than the LTE-A model of 8x8MIMO at 5CC (100 MHz) of 30 Mb/s. Data rate improvement on 5G features beyond 8x8 MIMO, 32CC, and 256QAM heterogeneous networks might be the subject of future research using additional small cells such as relays and Remote Radio Heads (RRH). Additionally, any appropriate analytical technique using 5G characteristics, such as the multi-dimensional Markov chain, may be used to create an analytical model.

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