IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 5, May 2014, 1-6

SURVEY OF LTE AND LTE ADVANCED SYSTEM

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ABSTRACT

Carrier aggregation (CA) is one of the most important technologies to ensure the success of 4G technologies. Carrier aggregation allows both an efficient use of spectrum already deployed and the required support for the resource allocation in new frequency bands. The Release 8 LTE carrier maximum bandwidth is 20 MHz. This bandwidth can be further extended in LTE-Advanced by carrier aggregation, with which the base stations can transmit multiple LTE carriers, each having bandwidth upto 20 MHz. When no carrier aggregation is used, the user will receive one carrier. When carrier aggregation is used, it is possible to send not only one carrier but multiple carriers to the users, which leads to a higher bit rate. Adding carrier aggregation influences energy efficiency for some modulation schemes. So, the objective is to study energy efficient LTE system in order to reduce power consumption of the system and to increase the energy efficiency and throughput.

KEYWORDS: Carrier Aggregation (CA), Long Term Evolution (LTE), Long Term Evolution Advanced (LTE-A), Heterogeneous LTE and LTE-A, Multiple Input Multiple Output (MIMO)

INTRODUCTION

Long term evolution (LTE) and long term evolution advanced (LTE-A) are the standards for wireless communication. LTE-A (commonly 4G LTE) are the more energy efficient networks as compare to LTE. 3GPP defined LTE of Universal Mobile Telecommunications System (UMTS) cellular technology. It aims to meet the following demands:

- High speed data for mobile phones
- Backward compatibility
- Wide application
- High usability and global roaming
- Demand for higher data rates
- Greater flexibility in frequency allocations

LTE-A Mainly Focus on Three Factors

- Carrier aggregation
- Cell based (like femto, macro etc) stations in a Network
- Extended MIMO support

CARRIER AGGREGATION AND MODULATION

Carrier aggregation is something where multiple carriers of 20 MHz (or less) would be aggregated for the same user equipment (UE). The UE receives carriers at the same time by the use of multiple frequency bands simultaneously. When no carrier aggregation is used, the user will receive one carrier. When carrier aggregation is used, it is possible to send not only one carrier but multiple carriers to the users, which leads to a higher bit rate. Adding carrier aggregation influences energy efficiency for some modulation schemes. With carrier aggregation, we can obtain high bit rates even with a lower modulation scheme or bandwidth.

A higher modulation scheme or coding rate results in lower energy efficiency and leads to a shorter range for a higher bit rate. The reduction in range is greater than the increase in bit rate, leading to a lower energy efficiency as the power consumption and number of served users remains the same. We can obtain higher bit rates even for higher energy efficiency using carrier aggregation. For example, using a macrocell base station with 1/2 QPSK modulation, energy efficiency (EE) = 0.4 (km2 • Mbps)/W for LTE while 2.1 (km2 • Mbps)/W when aggregating five 5-MHz component carriers. It is the impact of carrier aggregation which does not influence the obtained ranges and number of served users. Carrier aggregation has very little impact on base station power consumptions.

IMPACT OF DIFFERENT MODULATION ON CARRIER AGGREGATION

One of the most important blocks of LTE-Advanced is the modulation technique because it affects the level of throughput, energy efficiency and the accuracy of the system. The effect of modulation is represented by the used technique and code rate. The code rate is directly proportional to throughput of system modulated using QPSK and the best code rate for the system with 2x2 MIMO is 2/3. The maximum code rate can be used with 16QAM is 3/4 with 2x2 MIMO which gives the best throughput. On the other hand, 64-QAM has high throughput as compared to BPSK and QPSK. 64QAM gives the best performance for LTE-Advanced and makes the system has high throughput if the used code rate is 5/6. It implies that higher modulation scheme gives the best throughput. But on the other hand it has few disadvantage which is given below.

Drawback of Using Higher Modulation Scheme

There is also disadvantage of using higher modulation scheme everywhere, the drawback is that it is more vulnerable to noise and interference in the channel. Lower modulation schemes are less susceptible to noise and interference in the channel. A higher modulation scheme or coding rate results in lower energy efficiency (EE) because a higher modulation scheme and coding rate lead to a shorter range for a higher bit rate.

HETEROGENEOUS LTE AND LTE-A

Heterogeneous networks are the combination of any of micro, macro, pico and femtocell- based stations in one network. Small cells are a good alternative to network densification as they achieve higher network capacities with good energy efficiency. To have further improvement in the efficiency of the resulting heterogeneous networks, we can propose a sleep mode which would switch off some of the cells when the traffic is low and quantify the resulting increase in efficiency. The hybrid macro and femto approach is about 65 times more efficient in terms of total consumed power than the macrocell approach and about 1,400 times more efficient in terms of radiated power.

The bit rate determines which base station type is most energy efficient (EE). For the bit rates higher than that of 20 Mbps, the macrocell base stations are the most energy efficient (*EE* = 7.5 (km2 • Mbps)/W versus 4.5 (km2 • Mbps)/W for 25 Mbps) due to their longer range and higher number of users served (despite its higher power consumption). When used below 20 Mbps, there is no unambiguous (clear) answer. In some cases, the macrocell base stations are most energy efficient (like, for 5 Mbps), while in the other cases, the femtocell base stations are most energy efficient (for example, when used for 13 Mbps).

Femtocells in Heterogeneous LTE

A femtocell base station (BS) is a BS having low transmit power, installed by a subscriber in homes or SOHO (small office/home office) to provide access to a closed or open group of users as configured by the subscriber and/or the access provider. The macrocell throughput degradation will increase with increasing femtocell deployment density, where the degradation will reach up to 8% when 80 femtocells are dropped within one macrocell. At the same time, the femtocell solution can significantly improve energy efficiency in terms of some commonly used energy consumption metrics. Clearly there is a tradeoff between energy efficiency and system throughput (or spectral efficiency) in deploying femtocells. In order to overcome this hybrid use of femtocells is necessary with other small cells.

Femtocells Can be Operated in Two Modes Depending on Their Requirements

- Open access
- Closed access

Open access means femtocell will allocate resources to all users within its range, it overcomes the problem of interference while closed access allocates resources only to specific users. Closed access mode provides a level a security so that only authenticated users can have access to it. For a given SINR, capacity of open access femtocell is greater than that of the closed access mode and for closed access mode the capacity decreases with increasing correlation between the actual and interfering signal.

MIMO AND ENERGY EFFICIENCY

Multiple input multiple output (MIMO) means the more the transmitting and receiving antennas. MIMO increases the energy efficiency (EE). In case of single input single output (SISO), there is only one transmitting and one receiving antenna. For the macrocell base station, EE increases upto 433 percent when used with 8×8 MIMO. Base stations power consumption (watts) becomes 2 times higher, while Range (kms) becomes 3 times higher, resulting in an EE which comes out to be 5 times higher. When used with the femtocell base station EE increases up to 454.6 percent (or 5.5 times). It is used for spatial diversity.

The results for spatial multiplexing using 1/3 QPSK and a 5-MHz channel have also been calculated. Again, more transmitting and receiving antennas results in higher EE. For the macrocell base station, a maximum increase of 304.8 percent (or about 4 times) comes out due to 8 times higher bit rate, but the power consumption increases only upto 2 times. For a femtocell base station, the EE gain is a maximum of 131.3 percent (or 2.5 times). The highest EE gain is obtained using MIMO for spatial diversity

Energy Efficiency in Terms of Carrier Aggregation

Table 1

Network	Base Station	Carrier Aggregation	Coding Rate	Energy Efficiency (Km^2 Mbps)/W
LTE	Macrocell	(1×5)MHZ	1/2 QPSK	0.4
LTE-A	Macrocell	(2×5)MHZ	2/3QPSK	0.5
LTE-A	Macrocell	(2×5)MHZ	2/3 64QAM	0.2
LTE-A	Macrocell	(5×5)MHZ	1/2 QPSK	2.1

Energy Efficiency in Terms of MIMO

Table 2

(A) Spatial Diversity		
Base Station	**MIMO**	**Energy Efficiency**
Macrocell	(8×8)	Increases to 433%
Femtocell	(8×8)	Increases to 454.6%

Table 3

(B) Spatial Multiplexing				
Multiplexing	**Channel**	**MIMO**	**Base Station**	**Energy Efficiency**
1/3 QPSK	5 MHZ	(8×8)	Macrocell	Increases to 304.8%
1/3 QPSK	5 MHZ	(8×8)	Femtocell	Increases to 131.3%

RELATED STUDY

Fengming Cao and Zhong Fan [1] proposed some of the benefits and challenges of deploying femtocells in cellular networks. In this paper, the focus is on the tradeoff between energy efficiency and the system performances. Taking realistic LTE system parameters in account, it is shown that femtocells can improve the energy efficiency of the network. However, this comes with a price – performance degradation due to interference, which is severe in dense scenarios. Therefore, femtocell solutions are “green”, but also “noisy”. Interference mitigation mechanisms such as mobility management, power control and the resource allocations are then discussed.

Luis Cucala, Oscar Moreno [2] discussed about the new generation of the cellular technologies and the current trends towards the small cells or femtocells, which offers an improved spectral efficiency per area, also it offers an opportunity to improve the energy efficiency, which is measured as the power consumption needed to provide a certain throughput in a given area. In this paper, two network aggregated throughput, performance indicators and energy efficiency, have been analyzed and compared in the two network architectures; a deployment based on outdoor macro base stations, for the provisions of indoor and outdoor coverage, and a deployment in which some of the indoor traffic is supported by the femtocells. Performance simulations and energy calculations showed that the introducing a femtocell layer, complementing a macrocell layer is an excellent leap forward in energy efficiency and system performance, when compared with current indoor coverage which is based on the outdoor macro and micro base stations. Also, this paper presented a study on how much could be reduced the mobile network energy requirements of macrocell deployments in high density urban deployments, with low traffic conditions, based upon the application of two Self Organizing Networks (SON) techniques for selective disconnection, energy saving and power reduction of eNodeBs and HeNBs.

L. Saker, S. E. Elayoubi [3] studied the impact of small cells on the energy consumption and capacity of an LTE-Advanced network in a heterogeneous setting where macro cells coexist with outdoor femtocells and picocells. They analyzed the Erlang-like capacity in such an environment and showed the gains obtained from offloading traffic from macro cells to small cells. Energy efficiency is used throughout this study, brought together the network performance and its overall power consumption. Results showed that small cells are a good alternative to network densification as they can achieve higher network capacities with a good energy efficiency. To further improve the efficiency of the resulting heterogeneous network, they proposed a sleep mode that switches off some picocells when the traffic is low and quantify the resulting increase in efficiency

M. F. L. Abdullah, A. Z. Yonis [4] discussed that the Carrier aggregation (CA) is one of the most important technologies to ensure the success of 4G technologies. This paper presented a new Long Term Evolution-Advanced (LTE-Advanced) depending on CA technology; the new system has better performance as compare to LTE. The system supports wider bandwidth upto 120 MHz and provides a higher level of throughput. Here, Carrier Aggregated (CA) LTE-Advanced is designed for 2x2 Multiple Input Multiple Output (MIMO) and different modulation techniques such as: Quadrature Phase Shift Keying (QPSK) and 64Quadrature amplitude modulation (64QAM) has been used. The results and comparison proved that the maximum throughput is based on assuming 64QAM modulation, maximum bandwidth is 120 MHz 5/6 code rates.

Shivram S Arunachalam, Kishore Kumar Sekhar[5] investigated the performance of open access and closed access femtocells (HeNB) in the presence of a co-channel interference (CCI) from a nearby microcell base station (eNB). The analysis is presented for a downlink (DL) Long term Evolution (LTE) channel model in a heterogeneous network where there is no co-operation involved between eNB and HeNB. They further considered that the primary common pilot symbol (P-CPICH) is at least 20hdB higher at the user equipment (UE) to which it is connected in order to differentiate the useful signals from the interference. Performance study indicates that a significant variation in bit error rate (BER) is observed when HeNB transmit power is varied and approximately 4dB gain in SNR is achievable when the eNB MUE link distance reduces from 700m to 500.

Imran Ashraf, Federico Boccardi [6] discussed about the small cell base stations (BSs) that form an overlay layer on the existing macrocell network which offer tremendous potential in terms of satisfying high data rate traffic requirements and enables breakthrough services. Small cell deployments can pose negative energy-efficiency implications when not equipped with advanced power saving mechanisms. In this work, they addresses this issue and propose algorithms that instill the small cell BS with the ability to invoke a low-power *sleep* mode when not required to serve any user traffic. More specifically, they presents three different strategies for sleep mode enactment for small cells, which relay on core network driven, small cell driven, and user equipment (UE) driven approaches. Based upon a mixture of voice and data traffic model, the algorithms provides approximately 13–56% energy savings in the network relative to the absence of the sleep modes, coupled with the additional capacity incentives.

Margot Deruyck, Wout Joseph, Bart Lannoo [7] compared the design of Long-Term Evolution (LTE) networks to energy-efficient LTE-Advanced networks. LTE-Advanced introduces three new functions — heterogeneous networks carrier aggregation (CA) and extended multiple-input, multiple-output (MIMO) support. They developed a power consumption model for LTE and LTE-Advanced macrocell and femtocell base stations, along with the measurement of energy efficiency. They proposed that LTE-A carrier aggregation and MIMO improves networks's energy efficiency up to 400 to 450 percent, respectively.

CONCLUSIONS

In this paper, analysis of two systems that is, LTE and LTE-A has been done. It has been studied that introducing a femtocell layer, complementing a macrocell layer is an excellent leap forward in energy efficiency and system performance. This paper presented a new Long Term Evolution-Advanced (LTE-Advanced) depending on CA technology; the new system has better performance as compare to LTE. We have studied the power consumption model for LTE and LTE-Advanced macrocell and femtocell base stations, along with the measurement of energy efficiency. LTE-A carrier aggregation and MIMO improves networks's energy efficiency.

REFERENCES

1. Fengming Cao and Zhong Fan, "The trade off between energy efficiency and system performance of femtocell deployment", 2010 IEEE, pp.315-319
2. L. M. del Apio et al., "Energy Efficiency and Performance in Mobile Networks Deployments with Femtocells," Proc. IEEE Int'l Symp. Personal Indoor and Mobile Radio Comm., IEEE, 2011, pp. 107–111
3. L. Saker, S. E. Elayoubi et al, "Energy efficiency and capacity of heterogeneous network deployment in LTE-Advanced" European Wireless 2012, April 18-20, 2012
4. M. F. L. Abdullah, A. Z. Yonis, "Impact of Modulation Techniques on Aggregated LTE Advanced", Proceeding of the 2013 IEEE International Conference on Space Science and Communication (Icon Space), 1-3 July 2013, pp.267-271.
5. Shivram S Arunachalam, Kishore Kumar Sekhar, "Performance of Closed access and Open access Femtocells in a Heterogeneous LTE Microcellular Environment" Intrl Conf. on Communication and Signal Processing, April 3-5, 2013 IEEE, pp.787-790
6. Imran Ashraf, Federico Boccardi, "Power Savings in Small Cell Deployments via Sleep Mode Techniques", 2010 IEEE, pp.307-311
7. Margot Deruyck, Wout Joseph et al, "Designing Energy-Efficient Wireless Access Networks: LTE and LTE-Advanced", September/October 2013, pp.39-45