Overview of Power Optimization in LTE Network

Vaibhav Gaikwad,
Dept. of E&TC,
D.Y.Patil College of Engg,
Akurdi, Pune

Trupti Wagh
Dept. of E&TC,
D.Y.Patil College of Engg,
Akurdi, Pune

ABSTRACT
Power in any cellular network is a key degree of freedom in management of connectivity, energy factors, speed etc. As the Network evolved, a new-generation technology for mobile communication was specially created to fulfill the need of bandwidth ravenous user's viz. LTE, WCDMA, UMTS, but this technology demand more power. So Power control in uplink and downlink has been major concern in cellular network (LTE) because of limited resources in user equipment (UE). So save power at different level of network are discussed.

General Terms
LTE (Long term evolution), SIMO (Single input multiple output), DTX (Discontinuous transmission), DRX (Discontinuous reception), eNB (evolve node)

Keywords
Power saving, LTE, DRX, EARTH and DTX

1. INTRODUCTION
Long Term Evolution (LTE), a new-generation technology for mobile communication was specially created to fulfil the need of bandwidth ravenous users. With aims to entitle users with a new smartphone experience, providing higher data-rates and lower latencies that could transform the overall industry into a new wireless ecosystem of smartphone devices and applications. LTE render remarkable improvements over older cellular communication standards like GPRS, EDGE and WCDMA, and because of this outstanding improvement it is called as 4G (fourth generation) technology. LTE architecture is based on Internet Protocol (IP) distinct from other cellular Internet protocols, the 4G-LTE supports browsing Web sites, VoIP and other IP-based services as well. LTE was proposed to achieve theoretically download rate of 300Mbps or more based on experimental trials. In practical the rates vary on actual network bandwidth accessible to an individual LTE subscriber sharing the service provider's network (ISP) with other customers is significantly less [10]. Most of the commercially established LTE networks are optimized for USB data dongles where the power consumption is not a crucial concern. With the inception of LTE, power consumption has become a major problem to the end user using smartphones and tablets and other handheld LTE device. So power efficiency can be increased at Network architecture and protocol level, OFDM access, SC-FDMA and MIMO diversity.

Different method that has becoming popular is Discontinuous reception [13], Discontinuous transmission [1],[2],[4], Green communication and Power Management through MIMO [3].

This paper has been divided in three main sections LTE architecture, Different Power efficient technique and Conclusion.

2. LTE ARCHITECTURE

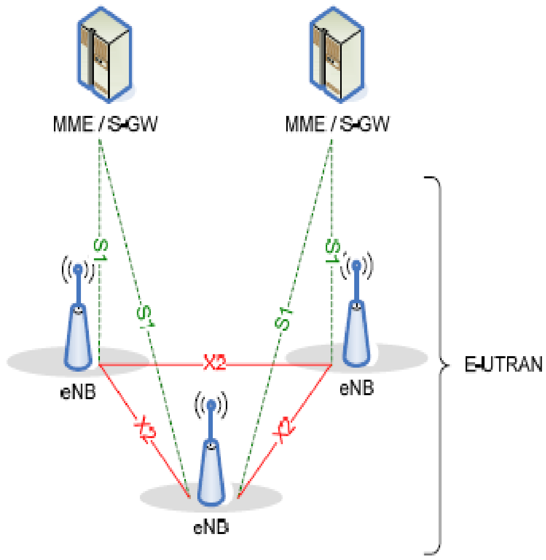

Figure 1: LTE Utran Architecture

Figure 1 depicts the essential design of LTE. The radio network architecture projected by the 3GPP LTE consists of evolved NodeB (eNodeB). The eNodeB provides a link between the user instrumentality and core network. As shown in Figure 1, eNodeB is connected to the core network via the S1 interface, and every eNodeB is interconnected via the X2 interface. The eNodeB is responsible for the bulk of the radio resource management (RRM) functions like packet programing. Both mobility management entity (MME) and serving gateway (S-GW) are a part of the core networks. The MME is responsible for paging and user instrumentality (UE/UI) quality in idle mode inside the network, whereas the S-GW node is responsible for routing user information packets and handling alternative user requests, as an example handover. LTE uses orthogonal frequency division multiple access (OFDMA) as a radio interface. OFDMA divides the bandwidth into subcarriers and assigns them to the users depending on the present demand of service. Every subcarrier carries information at low rate, however exploitation of multiple subcarriers at once to produce high information rates.

3. DIFFERENT POWER EFFICIENT TECHNIQUE

3.1 MISO-OFDM SYSTEM

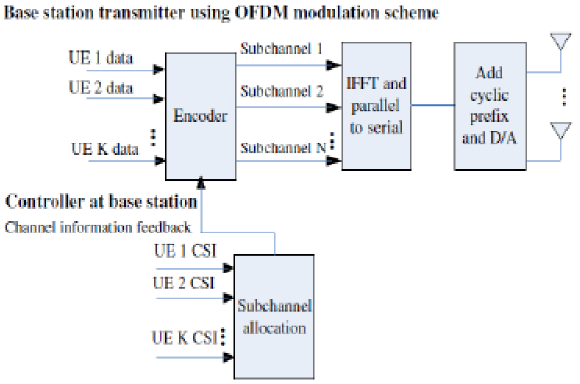

Figure 2: MISO-OFDM system model

Multi Input Single Output (MISO) or Multi Input Multi Output (MIMO) and Orthogonal frequency division Multiplex is mainly found in LTE systems. However power saving leads to degrade Quality of service such as system throughput and delay. MISO-OFDM communication system is illustrated in Figure 2 In Fig. 2. The evolve Node is integrated with multiple antennas and every user terminal just is integrated with one antenna. There are K users and a evolve Node distributed into a MISO-OFDM communication system. In this communication system, all orthogonal N subcarriers are regrouped into N or less N sub channels by the OFDM scheme. The total bandwidth of communication system is assumed as B. Every chosen user is allocated a sub channel for transmitting data. User scheduling algorithm accounting for the QoS of sub channels is employed. Received signal can be given as Hk is channel vector, no is Gaussian noise and Pn is power allocation of nth sub channel [3].

$$P_{\min} - P_{total} \geq P_{\min} - C_{\min}$$

$$\sum_{n=1}^{N} P_n = P_{total} P_n = \frac{\|H_{k,n}\|_F^2}{(\|H\|_F^2)_{\min}} P_{\min} - P_{total} \qquad (1)$$

$$C_{\min} = \frac{B}{N} \log_2 [1 + \frac{P_{\min} \zeta_{\min}}{N_o} (\|H\|_F^2)]$$

$$Y_{k,n} = \sqrt{\frac{pn}{M_t}} H_{k,n} S_k + n_o \qquad (2)$$

But even MISO-OFDM doesn't have any significant impact User Equipment power saving factor.

3.2 Discontinuous Transmission (DTX)

Discontinuous transmission (DTX) is employed for reduction of energy utilization in a radio base station yhat is evolve node (eNB). LTE can save near about 61% of the energy in a realistic traffic scenario [13] [8], by turning off the eNB base station. The Cell Base Station (eNB) monitors for traffic statistic, if it is found that no traffic is there then the Cell go in sleep mode which is also called as DTX mode. Assuming that the cell can enter in sleep mode with zero time delay while going back from a sleep mode to the active transmission mode requires a certain delay and a certain amount of energy which both depend on the sleep state. In the longest sleep state the power use can be arbitrarily close to zero Watt. However to wake up from this low power mode may require some 10-20 seconds or more. In a more short sleep mode, only some well selected parts of the cell hardware may be inactivated and the activation process is much faster, however, at the expense of somewhat reduced power savings [13]. The DTX algorithm depends on mirco cycle of DTX, Short DTX traffic and DTR cell power, where micro DTX and Short DTX is duration of switching off BS.

Before going in DTX mode the Cell BS (eNB) send a ping to UE so that user can also go in inactive mode but it has to monitor the channel. In DTX there is a lot of chances that QoS get degraded and Power On transient loss also a measure concern.

3.3 Discontinuous Reception (DRX)

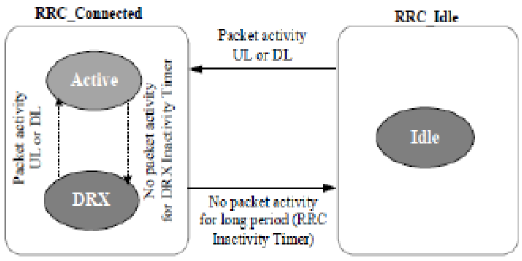

Figure 3: LTE mode

LTE has two Radio Resource Control (RRC) states, RRC CONNECTED and RRC IDLE [10,17], as shown in Figure 3. At RRC CONNECTED state, User Equipment (UE) can be in one of the three modes: Continuous Reception, Short DRX, and Long DRX. The transition from one state to another depends on the traffic activity. Network runs an inactivity timer referred as RRC Inactivity timer to push the device to Idle mode. When there is no packet activity for a long duration (equal to RRC Inactivity Timer), UE is moved to Idle state from Connected state. RRC Inactivity timer is reset with any uplink or downlink data activity. In LTE, UE may be configured with a DRX mechanism by radio resource control (RRC) in both Connected and Idle states [14]. However, the functionality and configuration parameters of DRX are different in these LTE states. Since data traffic mainly take place in connected state. DRX can be configured by RRC on per UE basis to control UE's Physical DL Control Channel (PDCCH) monitoring activity in order to save UE's battery power. Network runs an inactivity timer called DRX Inactivity timer for the connected UEs to push them to DRX mode. When there is no packet activity for duration of DRX Inactivity timer, UE stays in connected state but moves to DRX mode. DRX inactivity timer is also reset with any uplink or downlink data activity. RRC Inactivity timer is used to move the UEs to Idle and DRX Inactivity timer is used to move the UEs into DRX mode while still staying in Connected. In current LTE deployments, RRC Inactivity timer is larger than DRX Inactivity timer.

The parameters on which the DRX Algorithm depends are DRX cycle, DRX inactivity timer, DRX retransmission timer. Other includes parameter long cycle and short cycle is duration of switching off UE.

3.4 Other Methodology

Other method are likely cognitive radio which is beneficial for leveraging intricate trade-offs among energy efficiency, performance and practicality [1]. Secondly Distance-Aware Base Station Sleeping Algorithm which use the knowledge of the distance between the User Equipment's (UEs) and their associated BS[4]. Thirdly network controlled uplink transmission power parameters [5], [6], [8], [9], [11] and also control has been made in downlink with continuous traffic and non-real time traffic even in sensitive and non-sensitive with QoS.

4. CONCLUSION

An LTE is one of the most popular technology among user because of improved system capacity and coverage, High peak data rates, Low latency, and Multi-antenna support. But the problem which LTE suffers is from high power utilization which is overcome by DRX and DTX with proper power allocation in OFDMA. However, DTX, DRX, Scheduling algorithm and MIMO-OFDMA power allocation doesn't make any significant impact on "Network" individually but if few of these methods are combine viz DRX and DTX can make a greater impact on eNB BS side and also end user (UE).

Considering an DRX in UE make an best suited option for power utilization but for proper QoS and efficient trade-off between latency and energy consumption need to done. Furthermore there need to find solution for low power consumption in User equipment as the battery constraint is limited. Whereas the power utilization of evolve node is concern there is still need of research work apart from sleep scheduling or DTX.

5. REFERENCES

[1] Gürkan Gür and Fatih Alagöz, "Green Wireless Communications via Cognitive Dimension: An Overview," IEEE Network, vol. 22, no. 2, pp. 50– 56, Mar. 2011.

[2] XiaofeiWang ,Athanasios V Vasilakos • Min Chen Yunhao Liu Ted Taekyoung Kwon, "A Survey of Green Mobile Networks: Opportunities and Challenges," Mobile Network Application: Springer, vol. 17, no. 1, pp. 4– 20, Arpil. 2012.

[3] Xiaohu Ge & Jinzhong Hu & Cheng-Xiang Wang & Chan-Hyun Youn & Jing Zhang & Xi Yang, "Energy Efficiency Analysis of MISO-OFDM Communication Systems Considering Power and Capacity Constraints," Mobile Network Applicatuon: Springer, vol. 17, no. 1, pp. 29– 35, Feb. 2011

[4] Mads Lauridsen, Anders Riis Jensen, and Preben Mogensen, Luis Alonso1, and Christos Verikoukis, ""Green" Distance-Aware Base Station Sleeping Algorithm in LTE-Advanced," IEEE Precedings on Communications (ICC), pp. 1347– 1351, Jun. 2012

[5] Alexandra Bousia1,Angelos Antonopoulos, Luis Alonso, and Christos Verikoukis, "Reducing LTE Uplink Transmission Energy by Allocating Resources," Proceedings IEEE VTS Vehicular Technology Conference., pp. 1– 5, Sept. 2011

[6] Oliver Blume, Harald Eckhardt, Siegfried Klein, Edgar Kuehn, and Wieslawa M. Wajda, "Energy Savings in Mobile Networks Based on Adaptation to Traffic Statistics," Wiley Periodicals, Inc: Bell Labs Technical Journal,no.2 pp. 77-94, Jun. 2010.

[7] Bjoern Dusza, Christoph Ide and Christian Wietfeld, "Measuring the Impact of the Mobile Radio Channel on the Energy Efficiency of LTE User Equipment," 21st International Conference on Computer Communication Networks, pp. 1– 5, 2012

[8] Vincenzo Mancuso a, Sara Alouf b, "Analysis of power saving with continuous connectivity," ELSEVIER: Computer Networks, Vol. 56 pp. 2481– 2493, 2012.

[9] Chunyi Peng, Suk-Bok Lee, Songwu Lu, Haiyun Lu, Hewu Li, "Traffic-Driven Power Saving in Operational 3G Cellular Networks," ACM :MobiCom'11, PP. 19–23, 2011.

[10] Junxian Huang1 Feng Qian1 Alexandre Gerber Z. Morley Mao1 Subhabrata Sen2 Oliver Spatscheck2, "A Close Examination of Performance and Power Characteristics of 4G LTE Networks," ACM : MobiSys'12,PP. 25–29, 2012.

[11] Anders R. Jensen, Mads Lauridsen, Preben Mogensen, Troels B. Sørensen and Per Jensen, "LTE UE Power Consumption Model For System Level Energy and Performance Optimization," Precedings of IEEE Vehicular Technology Conference (VTC Fall), pp. 1-7, 2012.

[12] Sizhong Chen and Tong Zhang, "Low Power Soft-Output Signal Detector Design for Wireless MIMO Communication Systems," ACM: ISLPED'07, 27–29, 2007.

[13] Pål Frenger, Peter Moberg, Jens Malmodin, Ylva Jading , and István Gódor, et al "Reducing Energy Consumption in LTE with Cell DTX," Proceedings IEEE VTS Vehicular Technology Conference., pp. 1– 5, May. 2011.

[14] Ayman Elnashar and Mohamed A. El-Saidny, "Extending the Battery Life of Smartphones and Tablets," IEEE vehicular technology magazine JUNE 2014.

[15] Ali T. Koc, Member, IEEE, Satish C. Jha, Member, IEEE, Rath Vannithamby, Senior Member, IEEE, and Murat Torlak, Senior Member, IEEE, "Device Power Saving and Latency Optimization in LTE-A Networks Through DRX Configuration," IEEE Transaction Wireless Communications, vol. 13, no. 5, MAY 2014.

[16] S. C. Jha, A. T. Koc, and R. Vannithamby, "Optimization of discontinuous reception (DRX) for mobile internet applications over LTE," in Proceeding IEEE Vehicular Technology Conference (VTC'12-Fall), pp. 1–5, Sept 2012.

[17] S.-R. Yang and Y.-B. Lin, "Modeling UMTS discontinuous reception mechanism," IEEE Transaction Wireless Communications, vol. 4, no. 1, pp. 312– 319, Jan. 2005.

[18] S.-R. Yang, S.-Y. Yan, and H.-N. Hung, "Modeling UMTS power saving with bursty packet data traffic," IEEE Transaction Mobile Computing, vol. 6, no. 12, pp. 1398–1409, Dec. 2007.

[19] S. Yang, M. Yoo, and Y. Shin, "Adaptive discontinuous reception mechanism for power saving in UMTS," IEEE Communication Letter, vol. 11, no. 1, pp. 40–42, Jan. 2007