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Active Queue Management in Long Term Evolution All IP Networks

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***Abstract*—Cellular communication has been experiencing an exponential growth since inception in users and demand for data access with high speed also is increasing. Long Term Evolution (LTE) is designed to support wireless communication for voice and non-voice data on a single air interface to meet the demand of users. The flat Evolved Packet Core as supported plethora of diverse applications. Differentiated Services (DiffServ) is one of the important features in current modern and complex networks. DiffServ with rapid change in network environment results in congestion. To mitigate congestion end to end or network induced, Active Queue Management (AQM) with DiffServ framework conceptual model for LTE to address Congestion Control is proposed in this paper.**

***Index Terms*— Long Term Evolution, Congestion Control, Active Queue Management, Differentiated Service.**

I. INTRODUCTION

The fast growing Internet industry needs a communication standard that efficiently delivers high-speed broadband mobile access in a single air interface, with low cost feasibility to operators and end users with ubiquitous possibilities to connect to Internet. Mobile communication is becoming one among basic needs today [1]. New communication system standardization process should enhance availability, reliability, interoperability and security. All these new governing standards gave rise to a new next generation wireless broadband technology called Long Term Evolution (LTE), a product from 3GPP (Third Generation Partnership Project) which supports new applications and services such as video streaming, TV broadcast, video conferencing, telemedicine applications and many more all while moving. The technology in which operators believe will offer them and their customer the most benefit in turn backing device and infrastructure manufactures as well as content provider support. All based on internet protocol (IP) flat network architecture with a move from traditional circuit switched domain to packet switched domain [2][3]. According to the survey done by Cisco VNI forecast mobile data is going to surpass the world population and expected increase would be more than 13 folds in the mobile traffic. Figure 1 briefs the forecast by 2018 the mobile data traffic [4]. When the traffic grows exponentially next issue cropping up is handling the traffic and providing Quality of Service (QoS). The architecture is designed to cater to little scalability only, if it exceeds different mechanism to handle the traffic need to be incorporated. There has been numerous research done, which primarily emphasized on the network performance of LTE. Distribution of radio resources among the huge LTE users efficiently is a big challenge and has becoming the prominent means to support diverse service. But the challenge of achieving good congestion control at network and end-to-end service remains still. In this paper proposes a conceptual model for LTE architecture to handle congestion.

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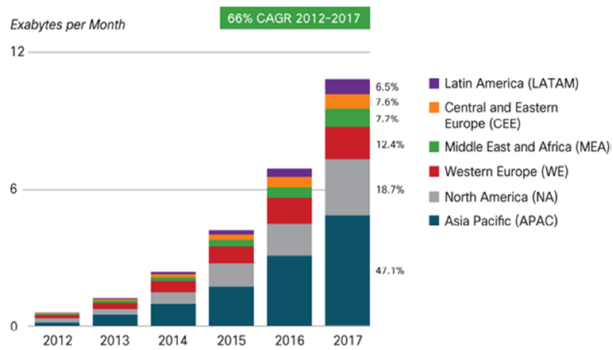


Figure 1. Global mobile data traffic forecast by region [4]

The rest of the paper is organized as follows. Section 2 provides the detailed overview of evolution and migration towards 4G and focuses on the LTE architectural aspects. Section 3 presents the features supported by LTE and Section 4 describes the protocol aspects of air interface. Conclusions are drawn in Section 5.

II. BACKGROUND STUDY

A. Evolution of 4G

In the last few years, mobile communication systems have revolutionized the way they communicate with a clear shift from fixed to mobile cellular telephony. The evolution of technology started with voice-only communication, using an analog radio transmissions technique which was known as 1G which could support data rate less than 10kbps. The 1G used Frequency Division Multiple Access (FDMA) and was based on circuit switched technologies. It had problems with quality, security, battery life and reliable handoff. The 2G networks was better than the 1G whose data rate support was ranging in between 10 to 20 kbps, enabling digital encoding of voice with short message service using circuit switched technology. It is also known as Global Mobile Service (GSM) and supported voice and limited data. There was lack of support for complex data such as video and other multimedia streams. Cell towers had limited coverage area. The 3G is third generation telecommunication network which is known as Universal Mobile Telecommunication Systems (UMTS) aimed to foster global access. It carries voice and non-voice data simultaneously with less complexity and faster transmission, and with better spectral efficiency. The problems were requirement of high bandwidth and high spectrum licensing fee. The 4G is the new era network technology which integrating all types of data on common platform IP-core network facilitating voice, data and streamed multimedia. Higher bandwidth range for new applications is offered [5][6][7].

Basically there were two new technologies recognized as 4G satisfying the specifications namely the Mobile Wireless Interoperability for Multiple Access (WiMAX) and Long Term Evolution (LTE) competing to be the best among each other. The purpose of these two emerging technologies was to meet the standards set for 4G standards by promoting low cost deployment and service models through Internet-friendly architecture and protocols, enabling voice, video and data stream services. Earlier WiMAX was the widely used for wireless communication.

However it had many drawbacks such as low speed of connectivity, low bit rate for long distance, security issues, low coverage area and so forth. LTE is most promising new air interface which overcame almost all drawbacks with the WiMAX. Theoretical study done by Talukder et al. [8] shows that LTE provides better coverage area compared to WiMAX.

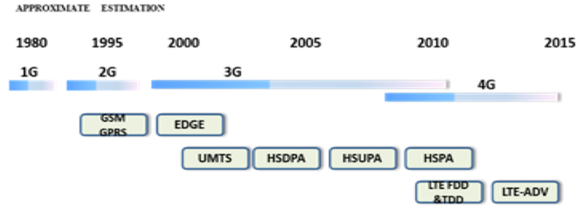


Figure 2. Evolution from 1G to 4G [5]

The capabilities of both the technologies are summarized in the Table I. The comparison specifically includes release, legacy network, system architecture and different radio aspects of the air interface.

TABLE I. COMPARISON, FEATURES OF WIMAX AND LTE

Standard	WiMAX	LTE
First Release	2005	2009
Legacy Network	IEEE 802.16a to IEEE 802.16d	GSM,GPRS, EGPRS, UMTS, HSPA
Network Architecture	IP based flat	IP based flat
Access Technology	Downlink: OFDMA Uplink: OFDMA	Downlink: OFDMA Uplink: SC-FDMA
Channel Bandwidth	1.25,3.5,5,10,20	1.25,2.5,5,10,15,20
FFT Size	128,256,512,1024,2048	128,256,512,1024,2048
Duplexing Mode	TDD and FDD, Focus on TDD	TDD and FDD, Focus on FDD
Peak Data Rate	Downlink: 75Mbps Uplink : 25Mbps	Downlink: 100Mbps Uplink : 50Mbps
Cell Radius	2-7Km	5Km
Cell Capacity	100-200 Users	>200 users at 5MHz >400 users for larger bandwidth.

B. Long Term Evolution and its Architecture

The LTE evolves from the third-generation technology which is based on the Third Generation Partnership Project (3GPP), developed out of GSM cellular standards to meet current user demands of high data rate and spectral efficiencies. It is completely a new radio interface and core network enabling up to 300Mbit/s downlink and 75Mbit/s uplink. Orthogonal frequency domain multiple access (OFDMA) in downlink and Single-Carrier Frequency Domain Multiple Access (SC-FDMA) in uplink is employed. Multiple input multiple outputs (MIMO) antennas technology with the System Architecture Evolution (SAE). Architecture and service features were improved by introducing femto-cells in the form of Evolved Node B (eNodeB) and by more focus towards multimedia broadcast and location based services [9][10].

Architecture design aims to provide open interface to support multivendor deployment, seamless mobility to legacy system and support multi-radio access technology as in Figure 3. LTE architecture broadly comprises of Core Network (CN) and Access Network (AN). CN refers to the Evolved Packet Core (EPC) and AN corresponds to Evolved Universal Terrestrial Radio Access Network (E-UTRAN). The brief description of the components are as follows:

- GERAN (GSM EDGE Radio Access Network) and UTRAN (Universal Terrestrial Radio Access Network) are 2G and 3G mobile cellular system respectively.
- User Equipment (UE) is any device which wants to avail the service.
- Evolved Node B (eNodeB) is an interface between the UE and the core network which can perform functions like radio resource management, scheduling and transmission of paging and broadcast information, mobility management and routing of user plane data to SGW.
- Service GPRS Support Node (SGSN) is a mediator between 2G/3G and LTE.
- Mobility Management Equipment (MME) is key central management entity for LTE access. It is responsible for connecting UE by selecting Serving Gateway (SGW) through which messages are exchanged. It provides authentication, authorization and accounting through HSS. Also provides control plane function for handling mobility between legacy and LTE. In general its responsible for bearer and connection management functions.
- Home Subscriber Station (HSS): It's also known as Home Location Register (HLR), which is a database of user's subscription details such as QoS profiles and roaming restrictions. It's has a dynamically generated data about the identity of the user who is currently connected.
- Serving Gateway (SGW): It is responsible for routing and forwarding user IP packets to and from the eNodeB and Packet Data Gateway while also acting as the local mobility anchor for inter-eNodeB handover and mobility.
- Packet Data Network Gateway (PDNGW): It's an interface between the LTE network and other packets data networks. It allocates the IP address for UE as well as flow based charging and QoS enforcement. Also filters user traffic for QoS, responsible for anchoring mobility between 3GPP access system and all non-3GPP access systems.
- Evolved Packet Data Gateway (ePDG): internetworks with untrusted non 3GPP IP access systems.

- Policy and Charging Control Function (PCRF): It is part of PDNGW, which aggregates information to and from network helping in decision making by formulating policy rules that will apply to user's service enforcement by PGW. Assuring the dataflow according to the subscription of user profile.

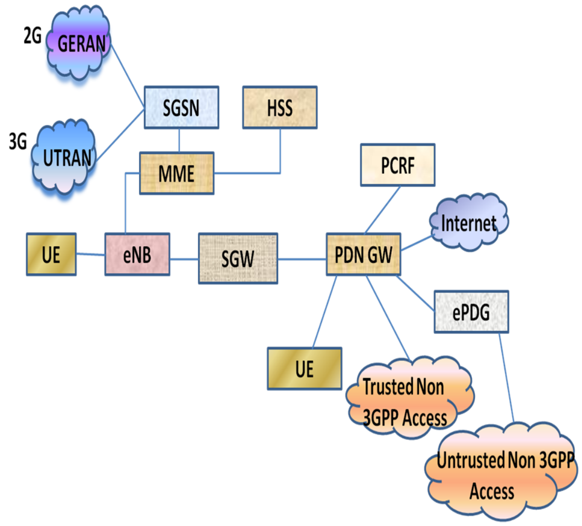


Figure 3. LTE Network Architecture [11][12]

In short EPC-based LTE architecture is designed with a new IP connectivity control platform offering seamless connectivity for various service platforms. The architecture is able to sustain throughput enabling new wireless broadband offering diverse services and backing plethora of applications.

C. Congestion Control

The applications can be categorized from simple data transfers (FTP, Web browsing), streaming and interactive applications. Each category defines its own requirement for better Quality of Experience (QoE). For streaming applications, effective throughput defines its QoE ignoring other network parameters like network latency, queuing delay and packet loss. Whereas interactive applications require good throughput coupled with queuing delay and packet loss. This part of queuing delay and packet loss can be congestion induced. Hence employing proper congestion Control mechanism can check the issue and enhance QoE to different class of applications. Addition to the queuing delay and packet loss overall network performance is affected by fairness issue also introduced due to congestion.

Congestion is the root cause in traffic differentiation and Quality of Service (QoS) provisioning. Researchers categorized congestion control into two categories namely the network side CC and the End-to–End system CC.

Network Side CC is primarily achieved by employing good Active Queue Management (AQM) techniques. End-to-End System CC can be achieved by employing Transmission Control Protocol (TCP) in various flavors. In order to detect and control congestion both at network and end points lots of research is done and still going to enhance for better QoS, few are presented in Section 3.

III. RELATED WORKS

Kasera et al. [13] proposed congestion control mechanism to maximize network capacity simultaneously achieving good voice quality. They achieved it by three-layered mechanism of admission control, diversity control and router control. Firstly enhancing the CDMA call admission control by combining IP Radio Access Networks (RAN) and air interface resources. Secondly incorporating diversity control technique for soft-handoff feature to choose and drop specific frames to maintain the voice quality from degrading at the time of congestion.

Vulkan and Heder [14] employed an ECN-based CC mechanism to achieve end-to-end system CC. When congestion is detected the packets waiting for transmission at the Packet Data Convergence Protocol (PDCP) buffer are dropped. It's a type of admission control. The solution is proposed for heterogeneous networks, which involves both legacy and flat architecture.

Adams [15] reviewed and presented a survey on general aspects of AQM since its beginning in 1993 with Random Early Detection (RED) to all the variants till 2011.The survey mainly focuses on QoS of DiffServ in wireless domain. Rapid convergence of voice, data, video and mobility in a single IP platform has outstretched need to efficiently serve diverse application requirements concurrently. AQM to all these above framework are explored here. Also mentioned the vital role played by AQM in fourth generation wireless communication with DiffServ for better QoS.

Sarker et al. [16] reviewed the Real Time Protocol (RTP) circuit breaker performance in LTE networks. The AQM algorithms become very conservative in overload situations with low delay and high loss in simple TCP model. Hence a new enhanced RTP circuit breaker with TCP throughput model is prosed that is more sensitive towards packet loss.

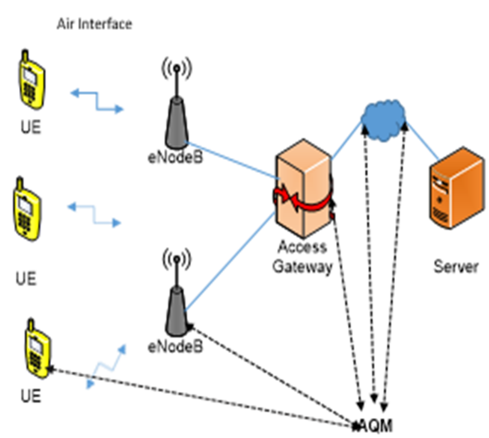
Burst et al. [17] explored an alternative deployment for voice over IP exploiting the traditional approach of Multi-Protocol Label Switching (MPLS) called Delay Based Congestion Detection and Admission Control (DBCD/AC). This method is employed at all the edge devices like media gateways to detect the impeding congestion. Research examines the characteristics of Admission Control (AC) and discovers that DBCD/AC is better substitute to alleviate congestion rather than the reservation based admission control technique.

Lee et al. [18] analysed characteristics of different congestion control applications-scheduling and queue management and proposed novel application specific acceleration technique to exploit both instruction and packet level parallelism in these applications. The Packet Level Parallelism (PLP) proposed hardware based acceleration model for congestion control application. To gain large throughput, huge number of processing elements and a parallel comparators were designed. The Instruction Level Parallelism (ILP) supported fast conditional operations in congestion control applications.

According to Dhadse and Chandavarkar [19], the bottleneck in all IP-networks is at the base station, which deals with both wired and wireless link. Implementation of AQM at base station will steady networks systems in dynamic conditions while attaining low delay and packet loss with better link utilization.

IV. AQM- DiffServ- based Congestion Control Mechanism

The traditional mechanism of best effort does not encompass the demand of applications required by the 4G LTE, so the Differentiated Service (DiffServ) framework is must. DiffServ will not solve the problem of CC. Integration of Active Queue Management (AQM) with CC in DiffServ network core framework will reduce the dropping of packets marginally. The previous section of literature review showed the different method employed by researcher's .In this paper a conceptual model is presented based on the previous literature work. The incorporation of AQM at all end points would be done from User Equipment (UE) till the server of access and back which is shown in Figure 4. The implementation of AQM in All IP networks like LTE will help in lowering delay and packet loss with good link utilization.



Figute 4.Location of AQM in LTE Infrastructure Network

The AQM-DiffServ should be a layered approach here, first level at the end system, which is from user equipment to the eNodeB, eNodeB to Core Network gateway and next from gateway to the outer world through IMS (IP Multimedia Sub-Systems). At the entry level the different class of services need to be profilated based on the class of service required as per the DiffServ Architecture. For better handling of the Class LTE offers a QCI (QoS Class Index), which aids to classify the traffic, based on the priority. In other words, a level of admission control. Next level handling it at the network in conjunction with transport protocol and scheduling algorithm will reduce the packet loss to greater extent yielding better fairness.

V. Conclusion and Future work

LTE architecture are required to deal with large traffic volumes with different QoS requirement. In this paper a brief overview of evolution of 4G LTE along with its network architecture is presented. Need of Congestion Control to achieve good QoS, with AQM-DiffServ a conceptual model is presented. In future the same model with specific AQM technique will be implemented and will be verified with different parameters.

References

[1] S. Schwarz, J. C. Ikuno, M. Simko, M. Taranetz, Q. Wang, and M. Rupp, "Pushing the Limits of LTE: A Survey on Research Enhancing the Standard," Access, IEEE, vol. 1, pp. 51–62, 2013.

[2] D. Astély, E. Dahlman, A. Furuskär, Y. Jading, M. Lindström, and S. Parkvall, "LTE : The Evolution of Mobile Broadband," no. April, pp. 44–51, 2009.

[3] S. Jimaa and Y. Alfadhl, "LTE-A an overview and future research areas," 2011 IEEE 7th Int. Conf. Wirel. Mob. Comput. Netw. Commun., pp. 395–399, Oct. 2011.

[4] C. V. N. I. (VNI), "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013 - 2018," White Pap.

[5] M. F. L. Abdullah, "Performance of LTE Release 8 and Release 10 in Wireless Communications," no. release 8, pp. 236–241.

[6] K. R. Santhi and G. S. Kumaran, "Migration to 4 G: Mobile IP based Solutions," *Adv. Int'l Conf. Telecommun. Int'l Conf. Internet Web Appl. Serv.*, pp. 76–76, 2006.

[7] D. Eberle, "LTE vs. WiMAX 4th generation telecommunication networks."

[8] Z. H. Talukder, S. S. Islam, D. Mahjabeen, A. Ahmed, S. Rafique, and M. A. Rashid, "Cell Coverage Evaluation for LTE and WiMAX in Wireless Communication System," vol. 22, no. 12, pp. 1486–1491, 2013.

[9] V. H. Muntean and M. Otesteanu, "WiMAX versus LTE - An overview of technical aspects for next generation networks technologies," *2010 9th Int. Symp. Electron. Telecommun.*, pp. 225–228, Nov. 2010.

[10] M. Rinne and O. Tirkkonen, "LTE, the radio technology path towards 4G," *Comput. Commun.*, vol. 33, no. 16, pp. 1894–1906, Oct. 2010.

[11] M. Corici, D. Vingarzan, and T. Magedanz, "3GPP Evolved Packet Core - the Mass Wireless Broadband all-IP ar chitecture," pp. 46–51, 2010.

[12] L. Marchand, "A CCEPTED FROM O PEN C ALL A Potential Evolution of the Policy and Charging Control / QoS Architecture for the 3GPP IETF-Based Evolved Packet Core," no. May, pp. 231–239, 2011.

[13] S. K. Kasera, R. Ramjee, S. R. Thuel, and X. Wang, "Congestion control policies for IP-based CDMA radio access networks," Mob. Comput. IEEE Trans., vol. 4, no. 4, pp. 349–362, Jul. 2005.

[14] C. Vulkan and B. Heder, "Congestion Control in Evolved HSPA Systems," in *Vehicular Technology Conference (VTC Spring), 2011 IEEE 73rd*, 2011, pp. 1–6.

[15] R. Adams, "Active Queue Management: A Survey," *Commun. Surv. Tutorials, IEEE*, vol. 15, no. 3, pp. 1425–1476, 2013.

[16] Z. Sarker, V. Singh, and C. Perkins, "An evaluation of RTP circuit breaker performance on LTE networks," in Computer Communications Workshops (INFOCOM WKSHPS), 2014 IEEE Conference on, 2014, pp. 251–256.

[17] K. Burst, L. Joiner, and G. Grimes, "Delay Based Congestion Detection and Admission Control for Voice quality in enterprise or carrier controlled IP Networks," Netw. Serv. Manag. IEEE Trans., vol. 2, no. 1, pp. 1–8, Nov. 2005.

[18] B. K. Lee, L. K. John, S. Member, and E. John, "Control Applications," vol. 14, no. 6, pp. 609–615, 2006.

[19] J. S. Dhadse and B. R. Chandavarkar, "Comparative Analysis of Queue Mechanisms With Respect to Various Traffic In Wired-cum-wireless Network," pp. 0–3, 2014.