Efficient Resource Allocation with QoS Guarantee on LTE-A Downlink Network Systems

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Abstract—Effective radio resource management is a fundamental component in all wireless communication systems. From the user and service providers point of view, the emerging LTE – A network is expected to deliver high performance sensitive applications like VoIP, videoconferencing, mobile video services, etc. These converged services have unique traffic-handling and QoS requirements. Radio spectrum and transport (backhaul) resources are limited, expensive and shared between many users and services like voice, video and data on a single IP based infrastructure. As many users are sharing the radio resource the QoS guarantee is a challenging issue in LTE-A broadband wireless network. This issue cannot be solved by over provisioning the network instead, RRM leads to determine the optimal use of wireless resources as per the wireless channel information and the QoS requirements of end user. In this paper we propose a resource allocation method called modified PRA scheme. The resource allocation is done based on priority and the priority values are determined by Fuzzy inference system in mPRA. The mPRA scheme effectively computes the QoS requirements such as transmission rate, jitter and end-to-end delay for both video and voice applications. The effectiveness of the proposed mPRA scheme in terms of QoS requirements can be observed via simulation results.

Index Terms—LTE-A; QoS; Resource Allocation; Scheduling

I. INTRODUCTION

As the number of mobile broadband subscribers and the traffic volume per subscriber are rapidly increasing, QoS is becoming significant as operators move from single to multiservice offerings and emerging rich devices capable of functioning multimedia and applications. Today’s popular Internet applications including real time and nonreal time traffic such as multimedia services and online gaming have very different traffic patterns and distinct QoS requirements. The conventional QoS framework does not provide sufficient support to these new mobile Internet applications with better user experience. In [13] a new QoS-aware LTE OFDMA scheduling algorithm is proposed for wireless real-time video delivery over the downlink of LTE cellular network to achieve the best video quality with the given delay constraint. Due to the improper utilization of radio resources, the QoS guarantee is not satisfied for the user in practice. It is most important for the LTE wireless communication system to make efficient usage of the available radio resources. In order to enhance the efficiency of the data transmission, channel conditions among the BS and SS should be taken into account [1]. So the resource allocation should be done with respect to utility function, which considers both channel status information and the QoS requirements to provide fairness among the users. In [12] the QoS parameters of heterogeneous networks are analyzed using fuzzy logic during Vertical handover. Although Fuzzy Inference have been widely adapted in literature for RRA to maximize system throughput and fairness index with traffic load intensity, delay and jitter have not been much discussed. In the conventional RRA method, only the system throughput and the packet dropping rate were analyzed. In our proposed mPRA scheme the traffic load received is analyzed in real time scenario. In LTE-A both voice and video are Delay sensitive (DS) service type and they actually require proper scheduling during service distribution. This is achieved by our proposed scheduling using Fuzzy inference system (FIS). The mPRA effectively computes the priorities for users with fuzzy inference system to provide fairness [2]. As the users are in different sensitive applications it is very difficult to provide a balance between their channel status information and the QoS requirements, which is a challenging issue in LTE downlink network. This issue can be overcome by our proposed mPRA scheme in which the fuzzy inference system determines the priority values for the users based on their channel status information and the QoS parameters Delay and jitter are experimentally verified. The analysis is done in two different scenarios as LTE scheduler with FIS and LTE scheduler without FIS. Comparatively the LTE scheduler with FIS gives better performance than the standard LTE scheduler that is scheduler without FIS. Thus it is advantage that implementation of mPRA with FIS as a mathematical approach to enhance the QoS requirements with respect to delay and jitter. In conventional RRA methods it was considering only QoS enhancement for system throughput, packet dropping ratio and fairness index. But in our proposed method the enhancement of
Delay and jitter analysis with respect to Traffic load intensity is experimentally analyzed and it is compared with the conventional LTE scheduler scheme. In the existing RA scheme the simulation analysis was done with Matlab only, which is applicable only for limited number of user node design. But our proposed scheme is analyzed by OPNET modeler 14.5. It enables the possibility to simulate entire heterogeneous networks with various protocols. OPNET provides graphical editors to edit our own devices, to configure our own networks, to design our own protocols, and define our own packet formats, etc. OPNET Modeler can analyze simulated networks to compare the impact of different technology designs on end-to-end behavior.

A. LTE

LTE is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies. The goal of LTE was to increase the capacity and speed of wireless data networks. A further goal was the redesign and simplification of the network architecture to an IP-based system with significantly reduced transfer latency compared to the 3G architecture. The LTE wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate wireless spectrum.

B. LTE Advanced

The driving force to further develop LTE towards LTE–Advanced - LTE Release10 is set to provide higher bitrates in a cost efficient way and, at the same time, completely fulfill the requirements set by ITU for IMT Advanced, also referred to as 4G. In LTE-Advanced focus is on higher capacity, increased peak data rate, DL 3 Gbps, UL 1.5 Gbps, higher spectral efficiency, from a maximum of 16bps/Hz in R8 to 30 bps/Hz in R10, increased number of simultaneously active subscribers, improved performance at cell edges, e.g. for DL 2x2 MIMO at least 2.40 bps/Hz/cell.

In Fig. 1 it shows the end-to-end network architecture of LTE and the various components of the network. The entire network is composed of the radio access network (E-UTRAN) and the core network (EPC), both of which have been defined as new components of the end-to-end network in Release 8 of the 3GPP specifications. In is different from UMTS since UMTS defined a new radio access network but used the same core network as the previous-generation Enhanced GPRS (EDGE) network. This obviously has some implications for the service providers who are upgrading from a UMTS network to LTE.

C. System Architecture Evolution

System Architecture Evolution is the core network architecture of 3GPP’s LTE wireless communication standard. SAE is the evolution of the GPRS Core Network, with some differences as simplified architecture, all-IP Network (AIPN), support for higher throughput and lower latency radio access networks (RANs) and Support for mobility between multiple heterogeneous access networks, including E-UTRA (LTE and LTE Advanced air interface),3GPP legacy systems such as GERAN or UTRAN, air interfaces of GPRS and UMTS respectively.

D. E-UTRA- evolved UMTS Terrestrial Radio Access

E-UTRA is the air interface [3] of 3GPP’s Long Term Evolution (LTE) upgrade path for mobile networks. It is a radio access network standard meant to be a replacement of the UMTS, HSDPA and HSUPA technologies specified in 3GPP releases 5 and beyond. Unlike HSPA, LTE’s E-UTRA is an entirely new air interface system, unrelated to and incompatible with W-CDMA. It provides higher data rates, lower latency and is optimized for packet data. It uses OFDMA radio-access for the downlink and SC-FDMA on the uplink.

As shown in Fig. 2 EUTRAN consists only of eNodeBs on the network side. The eNodeB performs tasks similar to those performed by the nodeBs and RNC (radio network controller) together in UTRAN. The aim of this simplification is to reduce the latency of all radio interface operations. The eNodeBs are connected to each other via the X2 interface, and they connect to the packet switched (PS) core network via the S1 interface.
E. Resource Allocation

Resource allocation dynamically assigns the available time-frequency resource blocks to different UEs in an efficient way to provide good system performance. In LTE, channel-dependent scheduling is supported, and transmission is based on the shared channel structure where the radio resource is shared among different UEs. Therefore, multiuser diversity can be exploited by assigning resource blocks to the UEs with favourable channel qualities. Moreover, resource allocation in LTE is able to exploit the channel variations in both the time and frequency domain, which provides higher multiuser diversity gain than HSPA that can only exploit the time-domain variation. However, conventional radio resource allocation (RRA) schemes are generally based on service priority. They are designed according to user’s channel status information (CSI) for throughput maximization [4] or user’s quality-of-service (QoS) fulfillment information (QFI) for QoS guarantee [5]–[6]. They are also based on utility function, which considers both CSI and QFI to maximize overall system utility function [7]. The main drawbacks of conventional RRM schemes are they cannot clearly distinguish the weight between channel status information and QoS requirements. Also providing fairness among users is an essential design consideration which is not done efficiently.

II. RELATED WORK

A new Balanced Resource Scheduling [8] scheme with adaptive priority thresholds for orthogonal frequency division multiple access downlink systems is proposed. But the end-to-end delay is an issue. In [9] a joint transmit scheduling and dynamic sub-carrier and power allocation method is proposed to exploit multi-user diversity in downlink packet transmission in an OFDM wireless network with mixed realtime and nonrealtime traffic patterns. The author proposed an adaptive radio resource allocation algorithm for downlink OFDM/SDMA systems with multimedia traffic in [10]. This Adaptive RRA algorithm performs in terms of system throughput and the traffic load. In [11] a scheduling algorithm with Dynamic Priority Assignment is proposed which is designed for the downlink shared channel of 3G WCDMA systems and operates within a cross-layer framework. Through the cross layer framework, DPA takes into account the variations of the wireless channel and exploits processing gain to improve transmission quality and enable service provisioning when possible.

III. PROPOSED METHOD

In this work we consider a single-cell downlink scenario for an LTE cellular system with two users at a time each for voice and video conferencing applications. The main issue to be addressed in this article is to dynamically assign all the available Radio Resources to the given users. Thus a proper resource allocation can lead to a significant improvement in transmission rate without using more bandwidth. In addition it can make the system flexible enough to operate in adaptation to the channel characteristics and QoS requirements. In general the traffic types supported in LTE-A are Delay sensitive (DS) service, Rate sensitive (RS) service and Best Effort (BE) service. Each service has specific QoS requirements. For Delay sensitive the Voice and Video traffic are considered and the corresponding QoS requirements are throughput, maximum packet end-to-end delay tolerance...
and delay variation (or) jitter. In order to provide efficient service to the user’s (voice and video), it is essential to measure the traffic intensity in LTE-A system.

Traffic intensity is a measure of the average occupancy of a server (or) resource during a specified period of time, normally a busy hour. It is defined as the ratio of the time during which a facility is cumulatively occupied to the time this facility is available for occupancy. The CSI and Qos requirements are the important values in determining the priority values since the users are urgent (or) nonurgent for QoS violation avoidance. So we propose a priority scheme to enhance the QoS of the LTE-A system. In our proposed method the Radio Resource Allocation is done based on service priority and the priority is determined by our proposed mPRA scheme. This mPRA along with Fuzzy inference system (FIS) can effectively determine a suitable priority value for each user based on its channel status information and QoS requirements. Then the resource allocation is done based on the priority values determined by the FIS, and it provides fairness among the users. Thus the QoS requirements of the two users such as video and voice applications are satisfied. The conventional resource allocation scheme is discussed only on system packet dropping ratio and fairness while the other QoS requirements such as throughput, packet end-to-end delay and delay variation (or) jitter have not been much discussed. Our proposed scheme helps to determine the other QoS requirements like traffic received, jitter experienced and packet end-to-end delay for the users in real time scenario. The simulation of this proposed scheme is implemented with OPNET Modeler, while in conventional scheme it was done with Matlab.

IV. SIMULATION RESULTS

A. Simulation Results

Simulations are performed using OPNET Modeler 14.5 to validate the analytical models. We simulate a simple LTE-A network in OPNET Modeler. The network consists of a single cell-based structure containing one base station and some mobile users, as shown in the Fig. 3. The base station is then connected to a backbone. Here we are considering the basic voice and video applications. The assumption is that each user is using only one type of application at a time. The different traffic characteristics are defined at the base node as per the different QoS requirements of the traffic. The application is defined in the application definition. In this paper we have considered the two basic applications. They are Voice and Video. Each application is corresponding to a single user respectively. Thus the performance improvement is achieved by using proposed mPRA implemented with FIS scheduler. Finally the proposed scheme’s experimental results are compared with the standard LTE scheduler without FIS. It is observed that the proposed scheme gives better performance than the standard scheduler.

B. Experimental Results

Fig. 4 compares the jitter experienced by the user in voice application. We observe the jitter determined by our proposed mPRA scheme is less when compared with the standard scheme which gives higher values. It reveals that the jitter variation is reduced due to prioritizing done by the proposed mPRA scheme. But this jitter variation was not considered in the conventional method. Whereas in our proposed scheme, this is achieved and compared with the standard scheduling scheme. It is quite evident that the jitter experienced in the prioritizing scheme is less as compared to the normal scheduling scheme.
prioritization only the users are allowed in the network which leads to some delay in the transmission. Due to this reason only the delay is existing in our proposed mPRA scheme. Thus the end-to-end delay is reduced considerably in video application and in this way the priority for this user who is in video service is enhanced.

![Figure 5. Traffic received (bytes/sec) in voice application](image)

Though the end to end packet delay is present, it does not affect the traffic received by the node in any way or cause any delay in the propagation.

![Figure 6. Packet end to end delay(sec)in video conferencing](image)

In Fig. 7 it is shown that the traffic received by the node which is using video application. we observed in the previous graph that the delay is reduced considerably for the same user. This reduction in end-to-end delay leads to better traffic arrival after prioritization by our proposed mPRA scheme. This means the data transmission also improved for the same user. The traffic received as time goes, shows that after prioritization only the data transmission is done in a better manner when compared to the non prioritizing scheduling scheme or the standard scheduling scheme. Since the delay is reduced the efficiency of data transmission is increased and thereby the priority for the video service is increased.

V. CONCLUSION

The proposed mPRA, for the RRM techniques in LTE- A downlink system, supports different types of service flows and makes resource allocation that is dynamic, fair, and efficiently utilized. It is observed that the transmission rate of video application is higher than the voice application. This reveals that the priority is given for the user in video application. We have shown by simulation results that mPRA could deliver better QoS support and resource allocation while being fair to all classes of service defined by the standard. The prioritizing scheme shows superior performance compared to the normal standard scheduling scheme, while considering the traffic received and also the jitter experienced by the users using video and voice applications. The simulation in OPNET is more accurate when compared to the other conventional tools. The fluctuations in all graphs shows that the simulation is done under a real time scenario with the OPNET Modeler 14.5.

REFERENCES


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