QoS-Constrained Resource Allocation Scheduling for LTE Network

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ABSTRACT

The goal of LTE (Long Term Evolution) is to provide high data transmission rate, scalable bandwidth, low latency, high-mobility, etc. LTE employs OFDM (Orthogonal Frequency Division Multiplexing) and SC-FDMA (Single Carrier - Frequency Division Multiple Access) for downlink and uplink data transmission, respectively. As to SC-FDMA, there are two constraints in doing resource allocation. First, the allocated resource blocks (RBs) should be contiguous. Second, those of the allocated RBs are forced to use the same modulation technique. The aim of this research is to propose a QoS-constraint resource allocation scheduling to enhance data transmission for uplink SC-FDMA. The proposed scheduling is a three-stage approach. In the first stage, it uses a time domain scheduler to differentiate user equipment (UE) services according to their distinct QoS service requirements. In the second stage, it uses a frequency domain scheduler to prioritize UE services based on channel quality. In the third stage, it limits the number of times of modulation downgrade of RBs allocation in order to enhance system throughput. In the simulations, the proposed method is compared to fixed sub-carrier dynamic resource allocation method and adaptive dynamic sub-carrier resource allocation method. Simulation results show that the proposed method outperforms the other two methods in terms of throughput, transmission delay, packet loss ratio, and RB utilization.

Keywords: *Classification, Long-Term Evolution (LTE), Quality of Service (QoS), Resource Allocation, SC-FDMA*

INTRODUCTION

3GPP LTE specifies OFDM (Orthogonal Frequency Division Multiplexing) and SC-FDMA (Single Carrier - Frequency Division Multiple Access) as its downlink and uplink data transmission techniques, respectively. Both of them use Fast Fourier Transform (FFT) to divide bandwidth into smaller units, which are shared among UEs. In comparison with OFDMA, SC-FDMA is able to reduce the power consumption of UE due to its modulation power is much lower than that of OFDMA.

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The aim of this research is to propose a QoS-constraint resource allocation scheduling to enhance data transmission for uplink SC-FDMA. Chen and Ke (2013) proposed a Gale–Shapley algorithm to find the optimal matching between resource blocks and UEs by considering channel conditions and the desired QoS. Dechene and Shami (2014) formulated resource allocation as a two-stage problem where resources are allocated in both time and frequency. They proposed two suboptimal approaches to minimize average power allocation required for resource allocation while attempting to reduce complexity. Nwamadi, Zhu, and Nandi (2011) proposed three dynamic PRB allocation algorithms, which are maximum greedy (MG), mean enhanced greedy (MEG) and single mean enhanced greedy (SMEG) algorithms. Lei, Yuan, Ho, and Sun (2013) proposed a unified graph labeling algorithm based on the structural insight that SC-FDMA channel allocation can be modeled. In the general case, the proposed method is able to attain near-optimal solutions. Calabrese (2009) designed a scheduling algorithm, which integrates both fixed transmission bandwidth and adaptive transmission bandwidth into the scheduler. The algorithm is shown to provide flexibility in terms of inbuilt adaptation to cell load, user power limitations and QoS requirements when driven by appropriate scheduling metrics. Calabrese further proposed Maximum Carrier-to-Interference Ratio (Max C/I) method to prioritize services based on channel throughput. Max C/I always selects the UE with the best C/I of channel quality according to the feedback from UEs. When the channel quality of the selected UE becomes poor, the scheduler turns to select the other UE with the best C/I of channel quality. Though Max C/I method can help to achieve a better system throughput, it loses fairness. This is because Max C/I method tends to serve those UEs with better channel quality. For those UEs in the remote sites, their channel quality may be usually poor due to terrain interference or too far away from Base Station (BS). Max C/I method has "unfair" problem in resource allocation in that it is not able to properly serve those UEs with low CQI (Channel Quality Indicator) and is possibly making them "starved" due to long time without resource. Round Robin (RR) method stems from the concept of "fairness" and considers nothing about channel quality. Each UE has equal opportunity to use resource in turn. RR method ensures the system resource will not be occupied by limited UEs and is the fairest method. Proportional Fair (PF) method can be thought as the hybrid of Maxi C/I and RR methods (Chen & Hu, 2010). The throughput and fairness of PF method are somewhere between Max C/I and RR methods. The design philosophy of PF method is to balance the resource competition among UEs. However, none of these methods considers the quality requirement issues of different service classes (QoS). In this paper we propose a QoS-constrained resource allocation scheduling for uplink SC-FDMA. The proposed method considers not only the overall system performance but also QoS issues of each service class.

METHOD

The proposed QoS-constrained resource allocation scheduling is a three-stage approach as shown in Figure 1. In the first stage, it uses a time domain (TD) scheduler to classify services into different QoS service classes. Those services with delay constraints are specially noted. In the second stage, it uses a frequency domain (FD) scheduler to prioritize UE services based on channel quality (SINR) and calculates the amount of system available RBs. The operation flow of TD / FD scheduling is shown in Figure 2. In the third stage, it optimizes RBs allocation by appropriate modulation downgrade under the two constraints of SC-FDMA.

Stage1.1 (TD): QCI Based Resource Type Classification

Table 1 shows the QCI based resource type classification proposed by 3GPP. It classifies resource types into GBR and non-GBR categories, respectively. They are further divided into 9 QCI (QoS Class Identifier) subclasses