Two-stage Channel-aware Uplink Transmission Scheme with SC-FDMA in LTE Networks

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Abstract

The primary goal of radio resource management (RRM) is to allocate the radio resources to meet the quality of service (QoS) requirements and improve the system performance. In this paper, we propose an uplink scheduling scheme jointing the bandwidth allocation and the excess bandwidth compensation for GBR (real-time) and Non-GBR (non-real-time) traffics in the LTE (Long Term Evolution) wireless network. Besides, both the short-term and long-term periods are also considered to meet the requirements of real-time service. This strategy comprises of two phases including the minimal bandwidth requirement assignment (MBRA), namely Phase 1, and the minimum guarantee and assignment of remaining resource block (ARRB), namely Phase 2. The MBRA serves the Video and VoIP user equipments (UEs) to achieve a superior performance in terms of the packet delay and jitter; and the ARRB is applied for allocating remaining *resource blocks* (RBs) to the GBR UEs to achieve a higher system throughput by considering the best channel condition and the proportional fairness. Simulation results show that the performance of our proposed scheme outperforms the first maximum expansion (FME) and the proportional fair (PF) schemes.

Keywords: RRM, QoS, LTE, MBRA, ARRB

1 Introduction

Wireless cellular networks have witnessed continuous and increasing popularity, and attracted an ever growing number of users. In addition, the wireless cellular technologies are continuously evolving to meet the increasing demands for high data rate mobile multimedia services with high quality of service (QoS) requirements [1]. In order to meet the forecasted growth of cellular subscribers and the needs for faster and more reliable data services, the orthogonal frequency division multiple access (OFDMA) has been selected as the multiple access scheme for state-of-the-art wireless systems, such as LTE and WiMAX [2-3].

LTE is a standard developed by the 3GPP with targets increasing peak user throughput, reducing short round trip time, enhancing spectral efficiency and reducing latency [4]. To achieve high radio spectral efficiency and enable efficient scheduling in both time and frequency domains, a multicarrier approach for the multiple access was chosen by 3GPP. For the downlink, OFDMA is selected and for the uplink, single-carrier frequency-division multiple access (SC-FDMA) is chosen for the LTE and LTE-A standardizations [5]. These schemes can effectively utilize scare radio resources by dividing the transmission bandwidth into subcarriers to enhance the resource allocation flexibility and to achieve the high spectral efficiency. However, the OFDMA solution for downlink transmission leads to high peak-to-average power ratio (PAPR), then increasing the power consumption for the sender. So, for uplink transmission, the low PAPR of SC-FDMA solution is utilized to greatly achieve the low battery power consumption of user equipment (UE) and provide the bandwidth allocation flexibility.

All of the allocation of LTE *resource blocks* (RBs) is handled by a scheduling function at the base station, Evolved Node B (eNB), and the RBs allocated to user must be contiguous in frequency domain within each time slot. In addition, each RB capacity depends on the channel condition; therefore, the resource allocation concerned with RBs based on the channel condition is a key factor in network performance. The radio resource allocation in LTE is the major issue of radio resource management (RRM) to meet the objectives, such as QoS requirements, maximum system throughput and fairness. However, the LTE/LTE-A specification does not define the schedule algorithm and this is an attractive topic for pursuing a high performance system. Usually, the radio resource allocation algorithm can be classified into two categories, namely ***channel-unaware*** [6-7] and ***channel-aware*** [8-14]. The channel-unaware algorithm does not consider channel condition, that is, it assumes that the network channel quality is constant for all UEs. Indeed, in network environments where there are with high uncertainty of the radio link, such as signal fading,

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interference and noise. In order to adapt to the real network communication environments, the channel-aware algorithm should be employed well. The channel-aware algorithms make use of the channel status and QoS requirements as the allocation criteria to allocate RBs for improving system performance among different traffic services. The comparison of our proposed scheme and several channel-aware algorithms is shown in Table 1.

Table 1. Comparison of channel aware algorithms

	maximize the system capacity	minimum rate requirements	Fairness	Delay constrain	UP/Down link	Channel aware
RCS [8]	Yes	Yes	No	No	D	Yes
Infinitely backlogged model [9]	No	No	Yes	No	U	Yes
RME [10]	No	No	Yes	No	U	Yes
Heuristic scheduling algorithm [11]	No	No	Yes	No	U	Yes
DBWPF [12]	No	No	Yes	Yes	D	Yes
DACSA [13]	No	Yes	Yes	Yes	D	Yes
QGCA [14]	Yes	No	No	No	D	Yes
Search-Tree Based Algorithm [15]	Yes	No	Yes	No	U	Yes
Dynamic RBs Allocation algorithm [16]	No	Yes	Yes	No	D	Yes
QA-ERA [17]	No	Yes	No	No	D	Yes
Throughput-aware [18]	No	Yes	Yes	No	D	No
Utility Functions [19]	No	Yes	Yes	Yes	D	No
E-PF [20]	Yes	Yes	Yes	No	D	Yes
DPRA [21]	No	Yes	No	Yes	U	Yes
NBS [22]	Yes	Yes	No	No	U	Yes
adaptive subcarrier allocation [23]	No	Yes	Yes	No	D	Yes
Proposed scheme	Yes	Yes	Yes	Yes	U	Yes

In [8], the rate-guarantee competitive scheduling (RCS) used the band selectivity factor (BSF) and competition factor (CF) for user selection and slot allocation. It achieves to maximize the sum-rate for all the users while guaranteeing the minimum and maximum traffic rates for certain users under the limited power consumption. The authors adopted the widely employed proportional fair (PF) algorithm to maximize its objective in the frequency-domain setting [9]. The main idea of first maximum expansion (FME) is to assign a RB to user with the best channel condition, then expanding in both directions as long as the channel maintains its best condition among other users. Recursive maximum expansion (RME) [10] is very similar to the FME, and these two methods can improve the system performance, but suffers from the poor fairness. The authors formulated the uplink scheduling problem with proportional fairness supported by taking two constraints into consideration, which including the allocated subcarriers to a UE must be contiguous in frequency with the same modulation and coding scheme [11]. In [12], a delay-based weighted proportional fair (DBWPF) for the downlink packet scheduling in LTE was proposed. A dynamic ant colony slot assignment (DACSA) algorithm was proposed to achieve highly efficient resource utilization and fairness on the basis of specific channel conditions while guaranteeing the QoS requirements [13]. The paper proposed a QoS guaranteed channel aware (QGCA) scheduler with the consideration of base station buffer status by grouping along with modulation and coding scheme to improve the system capacity [14].

Search-tree based algorithm [15] makes an assumption that required bandwidth to be fixed in size and is equal for all the scheduled users, which is indicated as a resource chunk (RC) and is composed of a set of consecutive RBs. However, the optimal number of users considered at each stage will take the computational time much longer. An approach by dynamically allocating the RBs based on the queue priority was proposed for avoiding the buffer overflow and guaranteeing the statistic QoS [16]. In [17], the authors considered both the multi-input multi-output (MIMO) OFDMA radio access network and RBs to assign sub-channel for the LTE resource allocation. In this work, the user rate constraints were expressed as the per-user QoS requirements which is constrained on the power allocation on different sub-channels and has higher complexity. However, the fairness for different service classes and waste problem were not considered.

The LTE downlink scheduling by adopting the time-domain Knapsack algorithm over the traffic overload patterns was proposed in [18]. An index was introduced based on the utility function to allocate resource according to the requirements and allowable delay for each user [19]. These papers did not discuss the RB allocations in depth; however, the channel-aware RB allocations impact the resource efficiency obviously. In [20], the urgency and efficiency based packet scheduling (UEPS) was proposed to maximize the throughput of non real-time traffic and to satisfy the QoS of real-time traffic by urgency factor. The authors proposed the dynamic priority resource-allocation (DPRA) scheme for uplink in 802.16 communications, which adaptively gives priority values to four traffic classes according to their urgency degrees and uses their priority values to allocate the radio resources [21]. The objective of DPRA algorithm is to meet the QoS requirements and maximize the system throughput, but the fairness index was not considered. The work in [22], a resource allocation problem was formulated in the framework of Nash Bargaining solution; however, its iterative algorithm has relatively high computation complexity. In [23], this paper proposed three schemes, the first allocation algorithm maximizes the system throughput based on the channel condition; however, it induced the unfairness problem. Therefore, two fair slot allocations were proposed to alleviate the drawback that those algorithms formulated an optimal fair slot allocation problem as a non-linear integer programming to find the suboptimal solution. But, this paper did not concern the several constraints of users, including the limited buffer and maximum transmission rate, and wasted resource which are the serious problem. The PF is applied by many researches [9, 22]; however, this approach cannot be performed in the LTE uplink due to the RBs allocated to a single user must be contiguous in frequency domain within each time slot.

In this paper, an uplink scheduling strategy jointing the bandwidth allocation and excess bandwidth compensation for GBR and non-GBR traffics in LTE networks is proposed for both short-term and long-term periods. The uplink scheduling strategy has two phases-the object of Phase 1 is to meet the QoS requirement for all UEs, namely, the minimal bandwidth requirement assignment (MBRA) scheme; and the object of Phase 2 is to achieve the fairness, namely, the minimum guarantee and assignment of remaining resource block (ARRB) scheme.

The rest of paper is organized as follows. In Section 2, we formulate the problem formulation and propose the schemes. Simulation results are conducted in Section 3, and the conclusion is given in Section 4.

2 Problem Formulation and the Proposed Scheme

The Phase 1 of proposed scheme, the minimal bandwidth requirement assignment (MBRA) scheme, supports both the GBR services and Non-GBR services. The MBRA takes the packet delay constraint into account for GBR and fulfills the minimal QoS requirements for each service using the Greedy method to allocate the RBs. In the second phase, the minimum guarantee and assignment of remaining resource block (ARRB) scheme, the available RBs are assigned to the GBR services based on the proportional fairness scheme and the channel condition to achieve the fairness of GBR services.

2.1 Problem Formulation

The transmitted signal in LTE is a RB with 7 symbols in the time domain and 12 consecutive subcarriers in the frequency domain. This paper assumes that each UE has only one traffic service type in transmission time interval (TTI). In the time domain, a 10 ms uplink frame consists of 10 one ms subframes with 20 slots. The transmission can be scheduled by RBs for the duration of one slot (0.5 ms). For the convenience of statement, this paper assumes that each frame has the total number of MxN resource blocks that can be assigned to Ues, where the M is the number of RB in the frequency domain and N is the number of RB in the time domain. Therefore, the RB_{ij} represents the i-th and j-th RB in the frame according to the frequency domain and time domain. Let R_k is the mean throughput of the k^{th} UE, and Eq.(1) represents the maximization amount of system throughput of all UEs.

$$Max\sum_{k=1}^{K} R_k \ ,\forall k \tag{1}$$

where K denotes the number of UEs.

The QoS requirement constraints, as shown in Eqs.(2), (3) and (4), indicate that the total RB capacity assigned to the k^{th} UE must meet the QoS requirements, where $T^k_{GBR\_VOIP}$, $T^k_{GRR\_VIDEO}$ and $T^k_{Non\_GBR\_Web}$ are the minimum QoS requirements for VoIP, Video and Web traffic types, respectively. The S_{GBR_VOIP}, S_{GBR_VIDEO}, and $S_{GNON\_GBR\_WEB}$ are the set of UEs for VoIP, Video and Web services, respectively. The β^k_{ij} denotes the RB_{ij} assigned to the k^{th} UE; β^k_{ij} equals 1 if RB_{ij} is assigned, 0, otherwise, and the C^k_{ij} denotes the capacity of RB_{ij} assigned to the k^{th} UE.

$$\sum_{i=1}^{M}\sum_{j=1}^{N}\beta^k_{ij}C^k_{ij} \geq T^k_{GBR\_VOIP} \ , \forall k \in S_{GBR\_VOIP} \tag{2}$$

$$\sum_{i=1}^{M}\sum_{j=1}^{N}\beta^k_{ij}C^k_{ij} \geq T^k_{GBR\_VIDEO} \ , \forall k \in S_{GBR\_VIDEO} \tag{3}$$

$$\sum_{i=1}^{M}\sum_{j=1}^{N}\beta^k_{ij}C^k_{ij} \geq T^k_{Non\_GBR\_WEB} \ , \forall k \in S_{Non\_GBR\_WEB} \tag{4}$$

Based on Eq.(5), each RB is allocated only to one UE at the same time. In order to maximize the system throughput, the slot with larger capacity will be selected firstly. In phase 1, when the minimum QoS requirement is met, the difference between the amount of RBs capacity assigned to the k^{th} UE and the minimum required bandwidth should be kept low to avoid the system resource waste, as shown in Eq.(6).

RBs allocation constraint $\sum_{k=1}^{K}\beta_{ij}^{k} \le 1, \forall i, j$ **(5)**

Waste constraint

$$Min\left(\sum_{i=1}^{M}\sum_{j=1}^{N}\beta_{ij}^{k}C_{ij}^{k} - BW_{min\_req}^{k}\right), \forall k$$
$$for \quad \left(\sum_{i=1}^{M}\sum_{j=1}^{N}\beta_{ij}^{k}C_{ij}^{k} - BW_{min\_req}^{k}\right) \ge 0 \qquad \textbf{(6)}$$

where the $BW_{min\_req}^{k}$ denotes the minimum bandwidth requirement of the k^{th} UE. Table 2 summaries the symbols in this paper.

Table 2. Applications in each class

Symbol	Description
R_k	Mean throughput of the k^{th} UE
β_{ij}^{k}	Binary decision variables of RB allocation for RB_{ij} and the k^{th} UE
C_{ij}^{k}	Capacity of RB_{ij} allocated to the k^{th} UE
$T_{GBR\_VOIP}^{k}$	Minimum QoS requirement of VoIP traffic type for the k^{th} UE, i.e. Constant Bit Rate (CBR)
$T_{GBR\_VIDEO}^{k}$	Minimum QoS requirement of Video traffic type for the k^{th} UE, i.e. Minimum Bit Rate (mBR)
$T_{Non\_GBR\_WEB}^{k}$	Minimum QoS requirement of Web traffic type for the k^{th} UE, i.e. Maximum Bit Rate (MBR)
BW_{ass}^{k}	Assigned bandwidth to the k^{th} UE
r	Number of UE which traffic type belongs to VoIP and Video services

2.2 The Proposed Scheme

The functionality of the proposed scheme, shown in Figure 1, has two phases in terms of the MBRA and the ARRB.

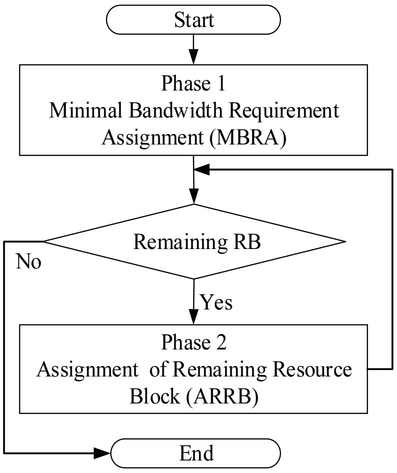


Figure 1. Flowchart of the proposed scheme

Based on Figure 2(a) in Phase 1, first to find out the RB with maximum capacity, RB_{ij}, which will be assigned to the k^{th} UE. If the RB can contribute the maximum capacity to more than one UE, the MBRA will choose one randomly to assign; and the minimum QoS requiremens are checked to meet the requirements. Due to the RBs allocated to a single user must be contiguous in frequency domain and time domain, the set of neighbor RBs of RB_{ij} are searched to be allocated to satisfy the requirement using the Greedy method.

For the purpose of achieving better fairness and improving system throughput, the remaining unassigned RBs are allocated in the Phase 2, shown in Figure 2(b), based on the un-allocation percentage value, $UA_k(t)$, and proportional fairness index, $PF_k(t)$, shown in Eqs.(7) and (8), where r is the number of UE with the traffic types, e.g., VoIP and Video services, in the t^{th} frame.

$$UA_k(t) = \frac{UE\_allocated}{UE\_required}PF_k(t) \qquad \textbf{(7)}$$

$$PF_k(t) = \frac{\left(\sum_{k} BW_{ass}^{k}\right)^2}{r \times \sum_{k}\left(BW_{ass}^{k}\right)^2}, \qquad \textbf{(8)}$$

where $k \in S_{GBR\_VOIP}, S_{GBR\_VIDEO}, S_{Non\_GBR\_WEB}$.

The procedure of ARRB is shown as follows:

Step 1: Let S be the set of remaining unassigned RBs, and expressed as a list.

Step 2: Check the $PF_k(t)$.

Step 3: Sort $UA_k(t)$ by the decreasing order and select the UE_k with minimum one for achieving the fairness.

Step 4: Determine the continuous RBs

Step 4.1: Find out the boundary which has been assigned in Phase 1 from $RB_{e,j}^{k}$ to $RB_{e+h,j}^{k}$, including $RB_{i,j}^{k}$.

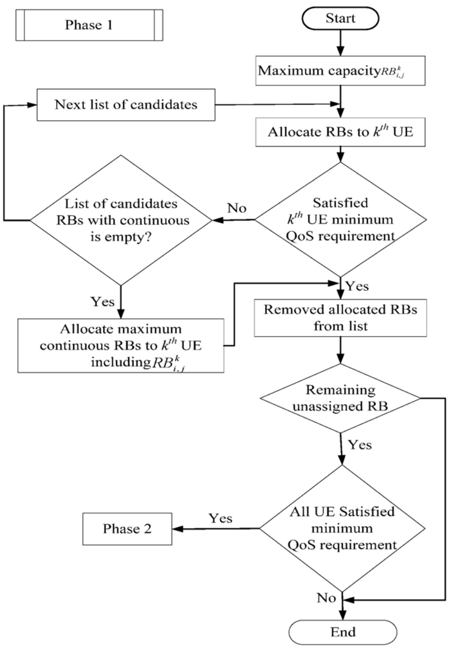


Figure 2(a). MBRA for Phase 1

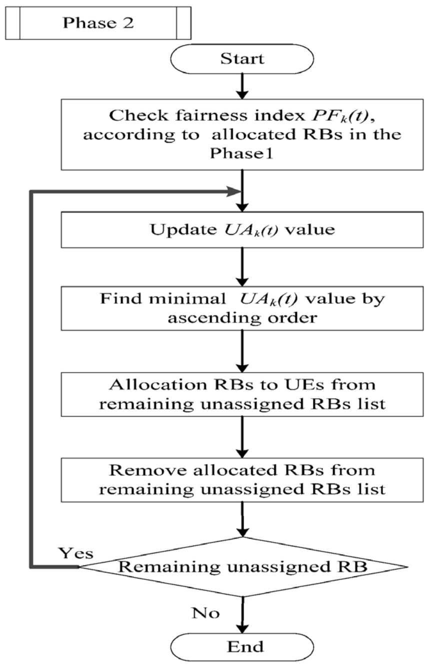


Figure 2(b). ARRB for Phase 2

Step 4.2: Search a $RB_{p,q}$ which adjoins the boundary ($RB^k_{e,j}$, $RB^k_{e+h,j}$) with the maximum capacity.

Step 4.3: Return the $RB_{p,q}$ to the ARRB.

Step 5: Allocate determined RBs to the UE_k.

Step 6: Remove allocated RBs from the remaining unassigned RBs list.

Step 7: If there has the remaining unassigned RBs, return to the Step 1, else terminates the procedure.

3 System Performance Evaluation

In this section, we compare the simulation results of our proposed scheme with the proportional fair (PF) [9] and the recursive maximum expansion (RME) [10] in terms of the delay, jitter, throughput and fairness. Although the proposed scheme can be applied for both downlink and uplink transmissions, we only consider the uplink transmission in this paper. Our proposed approach is implemented using the MATLAB tool and the system parameters is shown in Table 3 [24], and four types of traffic classes are considered, i.e., the GBR User (Video/VoIP), Non-GBR User (FTP/Web) for Video, VoIP, FTP and Web applications are shown in Table 4 [5].

Table 3. System parameters [24]

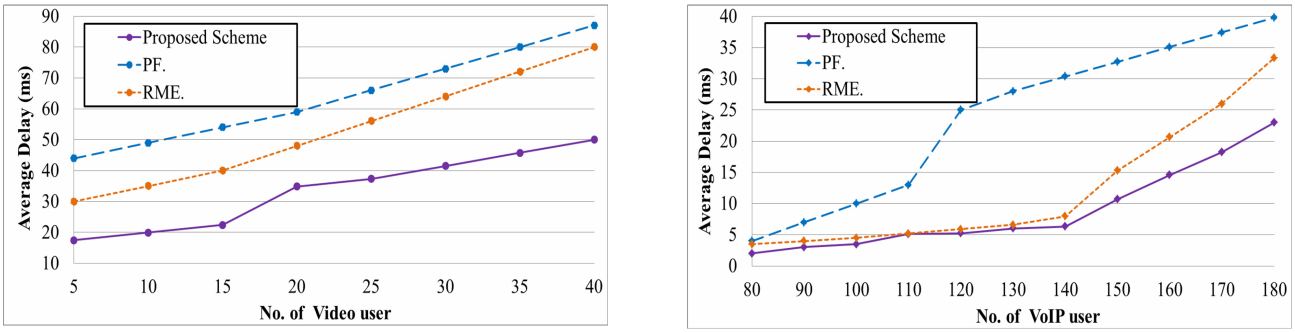
System bandwidth	20 MHz
Subcarrier spacing	15 kHz
Subcarriers of RB	12
Transmission Time Interval (TTI)	10 ms
Number of resource blocks	100
Number of active UEs	20-180

Table 4. Four types of traffic classes [5]

Traffic Type	Distribution	Value
Voice Parameters		
Inter-arrival Time	Constant	10 ms
Packet Size including Headers	Constant	169 Bytes
Constant Bit Rate (CBR)	Constant	64 Kbps
Packet Delay Budget	Exponential	100 ms
Packet Loss Rate	Exponential	10^{-2}
Video Streaming Parameters		
Codec	None	MPEG4
Group of Pictures (GOP)	None	N=12, M=2
Frame Inter-arrival Time	Constant	1/25 s
Display Size	None	176x144
I-Frame Size	Lognormal	5640 Bytes
P-Frame Size	Lognormal	3037 Bytes
B-Frame Size	Lognormal	2260 Bytes
Minimum Bit Rate (mBR)	Constant	470 Kbps
Maximum Bit Rate (MBR)	Constant	800 Kbps
Packet Delay Budget	Exponential	150 ms
Packet Loss Rate	Exponential	10^{-3}
FTP Parameters		
File Size (Mean)	Truncated Lognormal	2 Mbytes
Packet Size including Headers	Constant	576 Bytes
Reading Time (Mean)	Exponential	180 s
Minimum Bit Rate (mBR)	Constant	45 Kbps
Maximum Bit Rate (MBR)	Constant	200 Kbps
Packet Delay Budget	Exponential	300 ms
Packet Loss Rate	Exponential	10^{-6}
Web Parameters		
Packet Size including Headers	Constant	576 Bytes
Page Request Size	Constant	350 Bytes
Main Object Size (Mean)	Exponential	48302 Bytes
Embedded Object Size (Mean)	Truncated Lognormal	8475 Bytes
No Embedded Objects per Page (Mean)	Lognormal	39.9 Bytes
Reading Time (Mean)	Exponential	30 s
Parsing Time (Mean)	Exponential	0.13 s
Maximum Bit Rate (MBR)	Constant	64 Kbps
Packet Delay Budget	Exponential	300 ms
Packet Loss Rate	Exponential	10^{-6}

3.1 Delay and Jitter

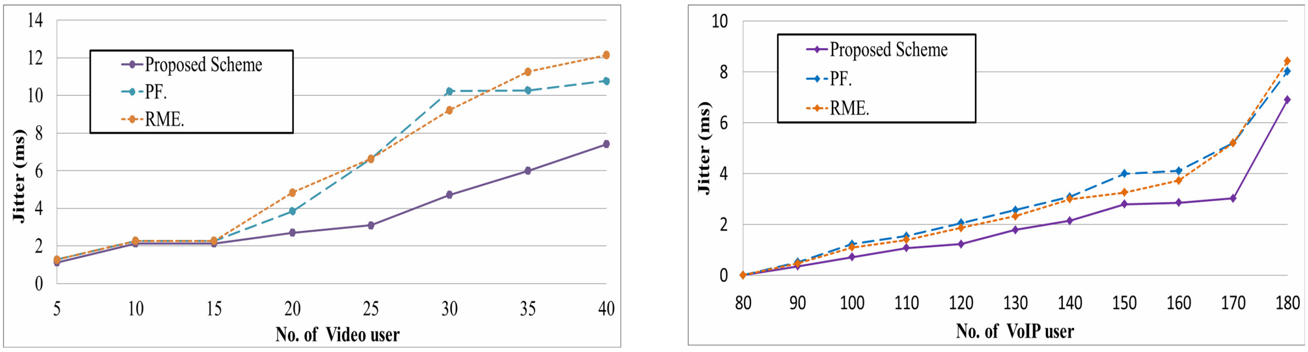
Figures 3(a) and 3(b) show the average delay for the GBR UEs under different Video and VoIP traffics, respectively. In Figure 3(a), due to the highest priority and considering the characteristic of periodical arrival packet for real-time traffic, the average delay of proposed scheme is lower than the PF and FME schemes for different video traffics. It is observed that the average packet delay of the Video traffic starts to increase when the number of UEs over 15 which causing the bandwidth resource is insufficient in heavy loading situation. Based on Figure 3(b), for the same reason, the average delay of proposed scheme is lower than the PF and FME schemes for different VoIP traffics. We can observe that the average packet delay of VoIP traffic of the proposed schem starts to increase when the number of UEs is 150 which the bandwidth resource is insufficient in heavy loading situation. Besides, for the PF and FME schemes, the average packet delay of VoIP traffic starts to increase when the number of UEs is more than 120 and 150, respectively.



(a) (b)

Figure 3. Average delay for different (a) Video users, (b) VoIP users

Figures 4(a) and 4(b) show the jitter for the GBR UEs for different Video and VoIP traffics, respectively. According to Figs. 4(a) and 4(b), the jitter is stable and lower compared with the PF and FME schemes due to the frame-based scheduling and considering the characteristic of periodical arrival packet for real-time traffic. Besides, the FME scheme does not consider the minimum requirement for VoIP traffic and only provide the proportional fairness to all UEs; therefore, the allocated RBs capacity is not enough.



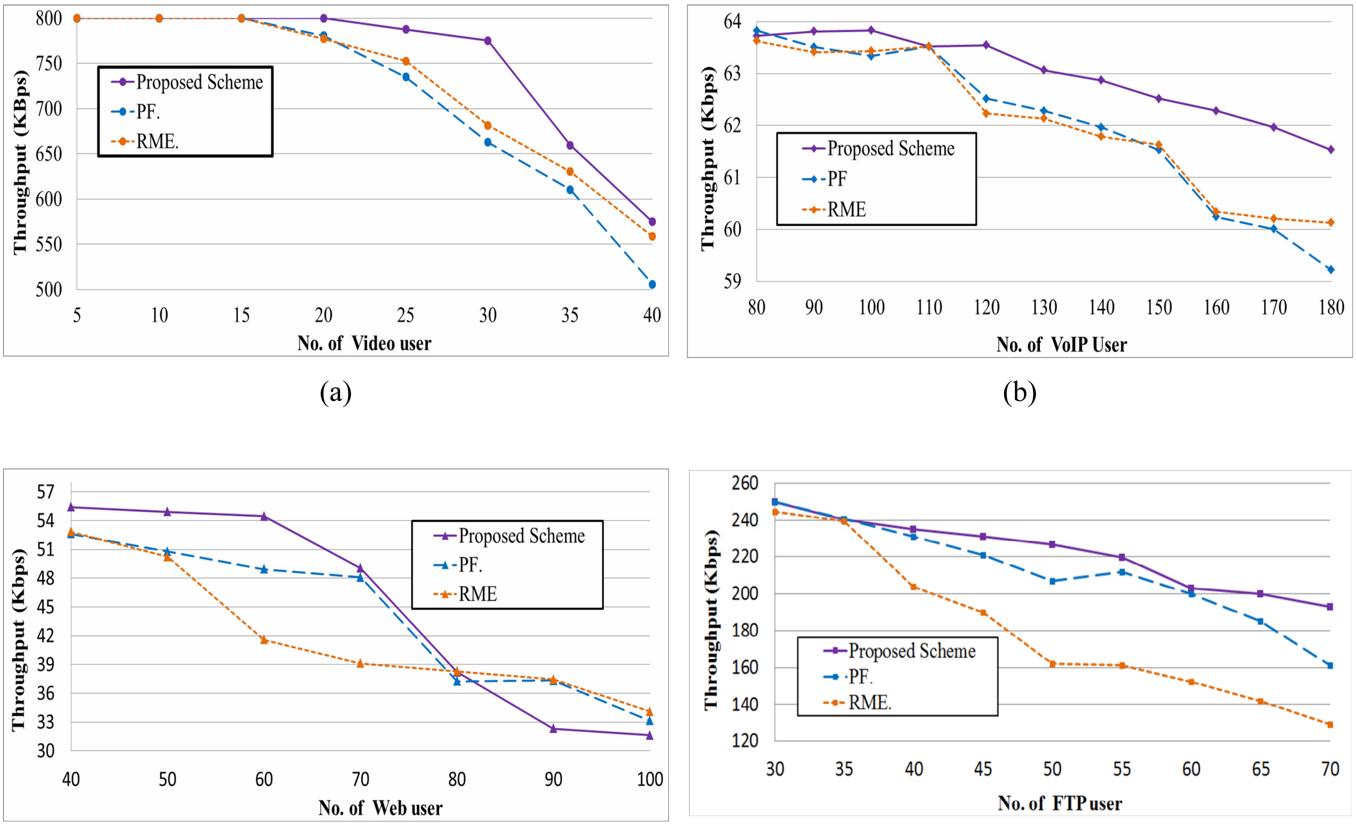
(a) (b)

Figure 4. Jitter for different (a) Video users, (b) V oIP users

3.2 Throughput

Figure 5 shows the average throughput of Video, VoIP, FTP and Web users for different algorithms. According to the Figs. 5(a) and 5(b), the average throughput of the proposed scheme for GBR traffic type is higher than the PF and FME schemes that is due to the proposed scheme satisfies the QoS requirement of real time services preferentially and the Greedy method is applied after meeting the minimum requirement. On the other hand, the PF scheme focuses on fairness and does not consider the strict priority on different traffic types, thus more RBs capacity is allocated to the Non-GBR traffic types which causing the GBR traffic type get fewer resources.

Figures 5(c) and 5(d) show the throughput for Non-GBR traffic type which it is starved when the system in high loading situation. Besides, the FME scheme provides higher priority to the GBR traffic type; therefore, the Non-GBR traffic type cannot be served sufficiently and causing the lower throughput. On the other hand, the Non-GBR traffic type for the PF scheme will not get starvation due to the PF scheme allocates the RBs among all UEs fairly.



(a) (b)

(c) (d)

Figure 5. Throughput of (a) Video traffic, (b) VoIP traffic, (c) Web traffic, (d) FTP traffic for different algorithms

Figure 6 shows the total system throughput for all the traffic classes. Since our proposed strategy estimates the long-term bandwidth requirement for the GBR traffics and allocates the granted bandwidth in a short-term period as frame duration. We can observe that the total system throughput is higher than others to meet the required QoS in Phase 1; then, the remaining resource is allocated to the Non-GBR UEs to achieve a higher system throughput in Phase 2. The throughput starts to saturate when the number of Video UEs is more than 35, which is higher than others.

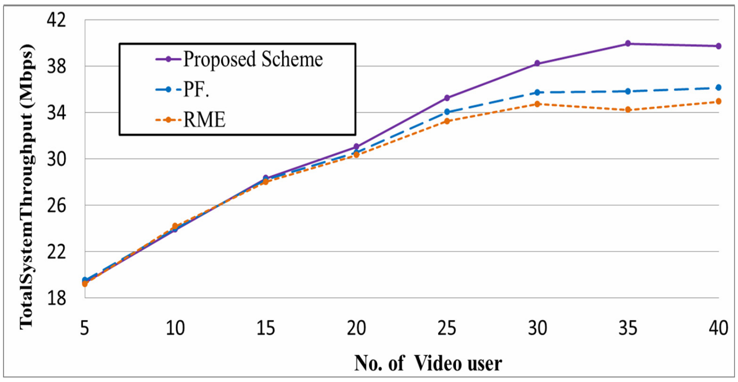
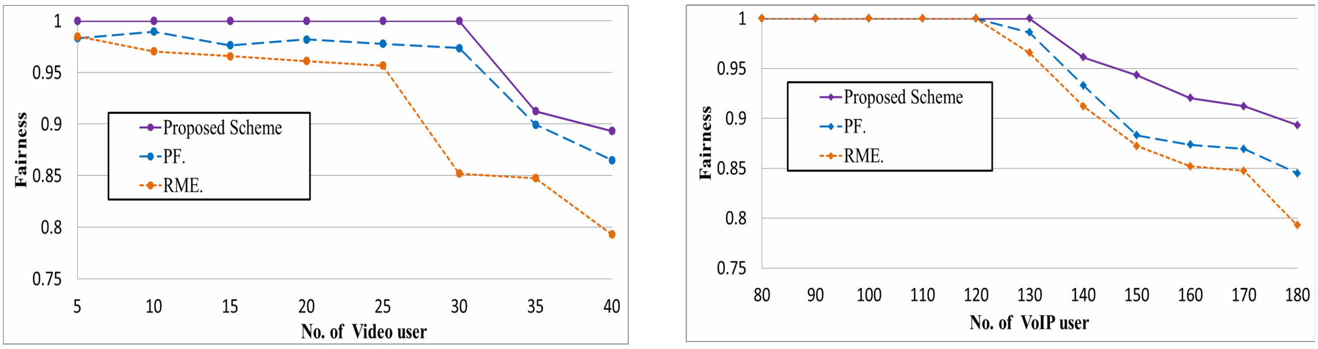


Figure 6. Total system throughput

3.3 Fairness

The proportional fairness index, defined as Eq.(7), is evaluated between UEs of the same traffic class. Figures 7(a) and 7(b) show the proportional fairness for the Video and VoIP classes traffics for different algorithms, respectively. Due to the proposed scheme allocating the remaining RBs to the Non-GBR UEs in Phase 2 based on the $UA_k(t)$ and $PF_k(t)$, the proposed scheme provides a better proportional fairness for GBR UEs even in heavy loading situation.



(a)

(b)

Figure 7. Fairness of (a) Video traffic, (b) VoIP traffic for different algorithms

4 Conclusion

In this paper, we proposed an uplink scheduling strategy jointing two phase scheduling schemes to enhance the RRM in LTE network. The MBRA (Phase 1) serves the Video and VoIP UEs and takes advantage of the perspective of short-term and long-term periods to estimate the required bandwidth to achieve a superior performance in term of the packet delay and jitter. The ARRB (Phase 2) is applied for allocating the excess bandwidth to UEs based on the channel condition and the proportional fairness to achieve a higher system throughput when the number of GBR users increases. Simulation results show our scheme can achieve the QoS requirements, efficient resource allocation and get better proportional fairness for real time service. Table 5 summarizes the performance improvement of the proposed scheme with PF and FME schemes in terms of delay, jitter, throughput and fairness. Our future research will emphasize and compare the different joining uplink and downlink scheduling strategies for asymmetric traffic.

Table 5. Performance improvement comparison

	PF(%)	RME(%)
delay (No. of Video user)	48.9	37.3
delay (No. of VoIP user)	62.6	22.9
jitter (No. of Video user)	29.2	32.0
jitter (No. of VoIP user)	29.2	24.0
throughput (No. of Video user)	9.6	5.8
throughput (No. of VoIP user)	1.6	1.5
throughput (No. of Web user)*	5.9	14.0
throughput (No. of FTP user)	4.8	23.7
system throughput	4.1	6.1
fairness (No. of Web user)	2.1	6.8
fairness (No. of FTP user)	4.5	7.6

Note. *: No. of Web user is in the case of lower than 80.

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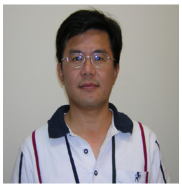

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