SMART M2M UPLINK SCHEDULING ALGORITHM OVER LTE

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Abstract- Currently the Long Term Evolution (LTE) System is an internationally recognized mobile communication standard for 4G. With the advent of Machine to machine (M2M) devices and network capability, a suitable uplink scheduling strategy is strongly needed for such systems. Scheduling method is one of the hot topics among current researches for M2M over LTE. It is found that there are major differences between M2M communications and Human to human (H2H) communications. In this paper, an in-depth research of M2M communication resource allocation and scheduling of LTE system is conducted and a smart M2M Uplink scheduling algorithm based on existing LTE scheduling algorithm is introduced. This algorithm offers an increased system throughput the process and reduces the average delay of system service without affecting into the traditional voice and video communications.

Keywords- M2M, LTE, Scheduling, Uplink, Algorithm

I. INTRODUCTION

As a long-term evolution plan of 3G, Long Term Evolution (LTE) System aims at developing a wireless access system based on low delay and high data rate. M2M communications is a smart Internet-based communication that involves broad areas. Among them, the wireless access enhancement technique of M2M communications is one of the hot spots of M2M standardization. Currently, M2M applications are based on GPRS cellular network. With the increase in the number of M2M interconnection devices, GPRS is proved to be an inappropriate solution because of its limited bandwidth and transmission power.

The design of LTE cellular system is used for Human-to-Human communications. Therefore, it is regarded that the M2M application platform is inappropriate. Its obvious characteristics include: for example, the number of communications devices of M2M communications is far greater than that of H2H communications. It also holds a small amount of data and a large number of nodes, different delay requirements, diversified services, and the "tidal effect", which may cause a surge or sharp decline of traffic.

Therefore, as M2M communications network, many problems are faced by the designed mobile communication network based on the characteristics of H2H.

In order to realize that it can efficiently provide M2M communications service, the existing mobile communication network must be optimized based on M2M communications application to avoid network congestion or overload caused by simultaneous access of huge amounts of M2M terminals to the network. Therefore, several organizations for standardization and international projects are making great efforts to improve the support of LTE cellular networks for M2M applications.

In this paper, a Smart Uplink Scheduling Algorithm based on existing LTE cellular network is proposed according to the characteristics of M2M services and LTE uplink scheduling. The algorithm integrates the improved Proportional Fairness scheduling algorithm with H2H and M2M service mix queuing model.

II. OUR SCHEDULING ALGORITHM

Scheduling plays a key role in the LTE system. Currently, the dominant scheduling algorithms include Round Robin (RR) Algorithm, Maximum Carrier-to-Interference Ratio (Max C/I) Algorithm and Proportional Fairness (PF) Algorithm. Round Robin Algorithm circularly calls for each user and allocate resources to each user. This algorithm is the most fair. At the expense of the throughput of system, it provides the resources to each user in the system fairly. Its disadvantage is that it does not consider the condition of user’s channel, so the reliability of the transmission is not high. Maximum Carrier-to-Interference Ratio Algorithm allocates resources to user who with the best channel quality.

This algorithm can adapt to the time-varying characteristic of the wireless channel and take full advantage of diversity effect of multi-user, and it is able to get the limit of system throughput. However, this algorithm doesn’t consider the fairness principle, i.e. user with good channel conditions are provided with service continuously, while users with poor channel conditions may have no chance to get the service. There are obvious advantages and disadvantages for these two kinds of algorithms. Therefore, they are not used in the practical application. Through simulation, in the author analysis the performance of Round Robin Algorithm, Maximum Carrier-to-Interference Ratio Algorithm and Proportional Fairness Algorithm, this is shown in Tab 1.

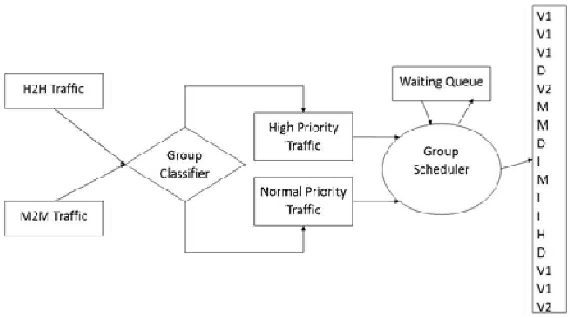
Scheduling algorithm	Sector throughput	High-speed mobile performance	Service fairness	Comprehensive performance
RR	Low	Fair	Very good	Poor
Max C/I	High	Poor	Very poor	Fair
PF	Fair	Good	Fair	Good

Tab.1 Comparison of 3 Kinds of Classic Algorithms

This paper basically discusses Proportional Fairness Scheduling Algorithm. On the basis of this algorithm, H2H and M2M service mix queue model is introduced, and finally an improved LTE uplink smart scheduling algorithm suitable for a great amount of M2M wireless access service is proposed.

2.1. Definition of H2H and M2M Service Mixed Queue Model

According to the analysis of M2M service and communications mode, we can draw a conclusion as follows: the amount of M2M terminal in the practical application environment is very large, and the amount of data for each conversation is extremely small, which has a big difference with H2H communications. Relatively speaking, as there is no direct intervention of people for M2M communications, thus the demand on time delay is relatively lower, and the vast majority of service does not need real-time transmission. So according to the characteristics of M2M communications, we propose a discrete-time queue model to deal with H2H communications and M2M communications mixed service situation. The basic model is shown in Fig 1.



Service V1: Voice V2: Video D: Data M: M2M I: Idle
Fig.1 H2H and M2M Service Mixed Queue Model

Where High Priority Traffic includes voice and video communications service of H2H, and M2M service of real-time communications; Normal Priority Traffic includes buffer video and data service of H2H, etc.; Waiting Queue includes all of the remaining M2M non real-time communications data service.

The advantage of mixed queue model is to optimize and utilize network resources, to improve the throughput of the system. Traditional service of H2H under this model will be affected slightly, it is no longer the main service occupied by the resource, but the data service will be more. However, the service rate of M2M data service can be highly improved, which can guarantee the fairness of using the network by H2H traditional service user and M2M non real-time service user. It can guarantee the basic service of H2H user and optimize network transmission, thus reducing the average blocking rate of integral data service based on the original rate.

A. 2.2. Smart M2M Uplink Scheduling Algorithm

Based on the great number of M2M service, the amount of M2M communications data size is very small, the terminal numbers is large and service is diversified, we proposed improvement in LTE Uplink Smart Scheduling Algorithm. This is according to the above mentioned Smart Expansion Algorithm and H2H/M2M mixed queue model, which rely on in-depth research on M2M communications service, and the characteristics of M2M service communications.

The basic idea is to use Smart Expansion Algorithm and H2H/M2M mixed queue model for optimized design, so as to realize the fairness of scheduling and increase the throughput of M2M communications under the LTE system. However, the static priority scheduling strategy of queue model is very complicated, which will be simplified and Smart Expansion Scheduling Algorithm is introduced. The overall process of Smart M2M Uplink Scheduling Algorithm is shown in Fig 2

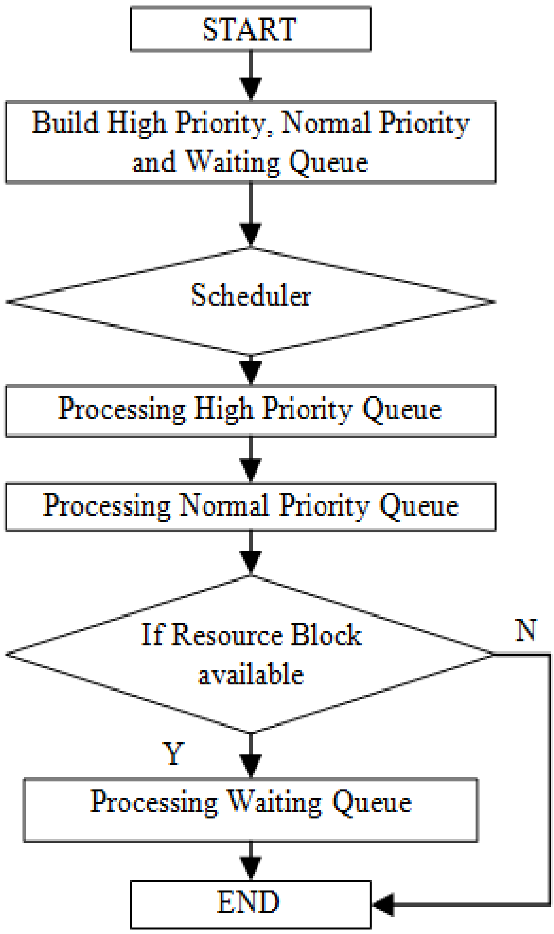


Fig.2 Flow Chart of Smart M2M Uplink Scheduling Algorithm

The basic process is as follows:

Step1. Add H2H service and M2M service in the network.

Step2. Classify the priority of H2H service and M2M service. According to the rule of priority service order, H2H communications and M2M communications service are grouped into the corresponding high priority service queue and common service queue.

Step3. Make Smart Expansion Scheduling for high priority service and common priority service.

Step4. At the end of high priority service and common priority service scheduling, judge whether there is any remaining resource block, if so, continue Step5, otherwise, end and return.

Step5. On the basis of remaining resource block, continue Round Robin scheduling for M2M waiting queue. Until all the resource blocks are assigned, or all the data in waiting queue has been transmitted by user sent out, and then go to step 3 to perform Smart Expansion Scheduling.

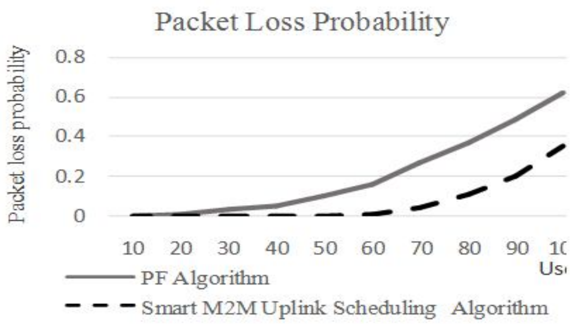
III. RESULT AND DISCUSSION

In order to assess the performance of our algorithm, SC-FDMA uplink system simulation is based on the 3GPP LTE system model, we use trace generation type for assessment of 3GPP deployment based on the typical urban channel model. According to 3GPP TR25.814 specification, default simulation parameters and assumptions are presented in Tab 2.

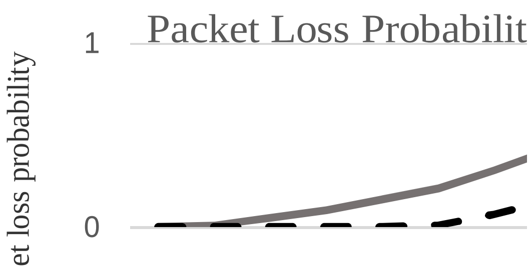
Parameter	Parameter Values
System bandwidth	5MHz
Numbers of cells	7
Sub-carrier bandwidth	15KHz
Distance between BS	500m
Numbers of System RB	25RBs
RB bandwidth	180KHz
Sub-carriers per RB	12
Max receiving antenna gain	20dBi

Tab.2 System Configuration Parameters

In the LTE system, we consider making comparison of Smart Uplink Scheduling Algorithm and classic PF Algorithm only under the condition of traditional voice and video service, so as to basically analyse the packet loss probability and the system throughput of traditional uplink service under these two kinds of algorithms.



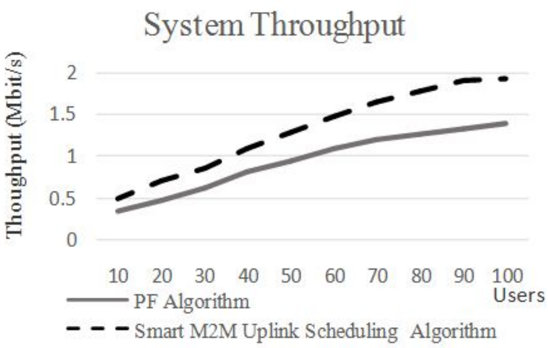
a. 500 Users



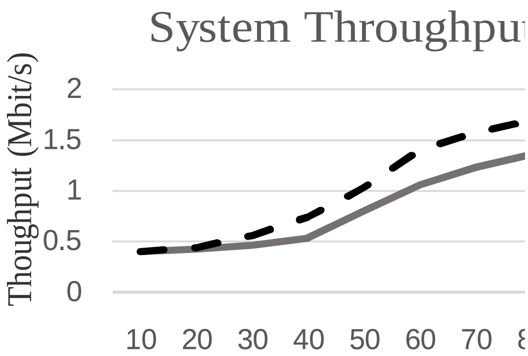
b. 1000 Users

Fig 3 Packet Loss Probability of H2H Service under the Background of 500 M2M Users and 1000 M2M Users

Fig 3 shows the variation of packet loss probability of H2H service under the background that the cell has 500 and 1000 M2M users respectively. This Fig shows the packet loss probability of H2H service to M2M Uplink Scheduling Algorithm. This is obviously smaller than that of PF Algorithm. Also the packet loss probability of a great amount of M2M Uplink Scheduling Algorithm, which is basically to be zero when there is a small amount of H2H users on the internet. In LTE network, the disadvantage of PF Algorithm is that it has more M2M users. So these M2M users may pre-empt resources of H2H users, thus making H2H service tough to allocate resources required and result in bigger group time delay and also higher packet loss probability. However, the Smart M2M Uplink Scheduling Algorithm will use queue scheduling model to firstly provide H2H users with service. This makes H2H users get sufficient resources, so the group time delay will be effectively reduced, and the packet loss probability will be improved greatly.



a. 500 M2M Users



b. 1000 M2M Users

Fig 4. System Throughput variation under the Background of 500 M2M Users and 1000 M2M Users

Fig 4 shows that the system throughput will change with the increasing number of H2H users under the background that the cell has are 500 and 1000 M2M users respectively. The throughput of a great amount of M2M Uplink Scheduling Algorithm is much higher than that of PF Algorithm. This is the advantage of using waiting queue and phased scheduling when M2M scheduling is ongoing, so as to maximally use channel quality for data transmission. But in turn, the M2M group time delay of M2M is bigger, which is acceptable by M2M service. The above simulation results shows that compared with PF algorithm, Smart M2M Scheduling Algorithm shows significant improvements.

CONCLUSION

This paper introduces Smart M2M Scheduling Algorithm, which is based on LTE uplink and supports M2M communications. Throughput and the maximum allowable time delay of LTE system will be taken into account respectively when a great amount of M2M device exists. This is done through group queue and queue priority scheduling strategy. The system throughput can be significantly improved, and the maximum time delay as well as the packet loss probability of H2H service can be reduced. This enables the system to have better performance.

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