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A Self-adaptive Time Slot Allocation Algorithm Based Low Value of SINR in TD-LTE System

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Abstract

In time division duplex Long Term Evolution (TD-LTE) system, the protocol provides 7 different time slot configurations. Only one fixed time slot deployed in mobile network. This paper proposed a dynamic time slot allocation algorithm, the system according to the user equipment (UE) detected the environmental signal to interference and noise ratio (SINR) to dynamically decide the time slot configuration, especially the UE in the situation of relatively bad wireless environment and the lower SINR value, can adopt the polling algorithm, obtained the dynamic time slot configuration. This method is simple in calculation, can reduce redundant computational burden in the system. The result of simulation demonstrated that the algorithm has significant effect in improving the networking throughput、increasing the system spectrum utilization rate.

Keywords: *Time division Duplex Long Term Evolution, Adaptation, Time slot assignment, Throughput; Spectrum utilization*

1. Introduction

TD-LTE network is a full of IP data services network [1], use different carriers to carry data traffic in time slots. TD-LTE system supports seven different time slots ratio [2]. In network deploying, outdoor macro base stations used a fixed time slot ratio, different UE showed different download speeds [3], resulted in system spectral efficiency can't be maximize used, affected system throughput. Along with the number of base stations(eNodeB) of LTE network in construction keeping increase, coveraged more and more extensive, UE's number became more and more larger in the network. UE needed a more rational allocation ratio of uplink and downlink time slots to meet the network experience and better efficiency for the user in TD-LTE system. In paper [4], it showed a comprehensive analysis the influence of interference of the dynamic time slots allocation, and the situation of energy saving, contrasted the fixed and dynamic time slot ratio in the SINR and FDP package through situation in the U:D=2, but only one fixed time slot contrasted. Based on the paper [4]'s research, this paper focus on the lower SINR value in outdoors, taked into account some factors include the user's perception, system throughput and spectrum utilization efficiency, researched the dynamic time slot allocation algorithm, In the case of lower SINR value, According to the wireless environment where UE stayed produced the rate based the SINR values, adaptively selected the right time slots according to the UE rate ratio, improved system throughput and spectrum efficiency within the bandwidth.

2. Time Slot Configuration and Interference Analysis

2.1. Frame Structure and Time Slot Ratio

One of the characteristic in TD-LTE system is UE can use different time slots to complete duplex data transmission within the system bandwidth [5].When deploying network, configuring network parameters, taking into account the number of users and data throughput, and the macro stations and room will divided to the fix slot configuration respectively. In TD-LTE network, a frame length is 10ms, 5ms for a half-frame, the length of one subframe is 1ms, common subframe includes two slots, each one slot is 0.5ms, special subframe includes three time slots, respectively, DwPTS, GP and UpPTS, the frame structure shown in Figure 1 [2]: In the network, RE is the smallest unit in the frequency domain at the physical layer data transmission resource allocation, an RB in the time domain occupied the width of a slot, including a RE; in the frequency domain occupied a total of 12 subcarriers 180KHz bandwidth, in the system bandwidth B is known situation, In the systems f, the number of RB is N_0

$$N_0 = B/180\ K \tag{1}$$

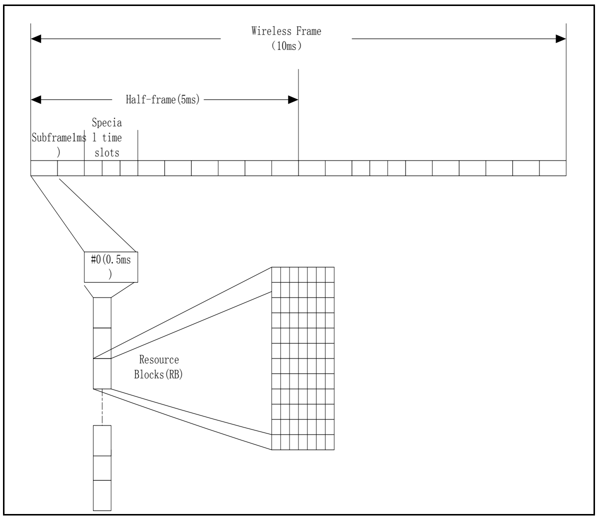

Figure 1. TD-LTE System Frame Structure

RB in different time slots, depending on the system ratio of time slots, transmitted different information content. In one radio frame, system provided such time slots shown in the Table 1, time slots # 0, # 5 are fixed in the system downlink, slot #2 is a fixed uplink slot, slots #1、#6 special time slots that can be flexibly configured according to the system load, the rest of the # 3, # 4, # 7, # 8, # 9 time slots as resources can be dynamically configured, changed these slots ratio to finally determines the system time slots. The time scale of TDD subframe reconfiguration in TDD-LTE system defined, represented the time interval to perform a TDD subframe reconfiguration strategy in the system, which range from {10ms, 200ms, 640ms} [6], in this paper, every 200ms is used to alter the subframe ratio in simulation.

Table 1. The Time Slots Ratio in TD-LTE System [2]

Configuration	Switching point down the line	Subframe number									
		0	1	2	3	4	5	6	7	8	9
1	5ms	D	S	U	U	U	D	S	U	U	U
2	5ms	D	S	U	U	D	D	S	U	U	D
3	5ms	D	S	U	D	D	D	S	U	D	D
4	10ms	D	S	U	U	U	D	D	D	D	D
5	10ms	D	S	U	U	D	D	D	D	D	D
6	10ms	D	S	U	D	D	D	D	D	D	D
7	5ms	D	S	U	U	U	D	S	U	U	D

2.2. Interference Analysis

LTE network used the same frequency to build network system [7], all the user in the cell share the system bandwidth, user at the edge of the cell would get serious interference, in the network, UE can get other cell signal beside the dominant cell, other cells signal would bring serious interference to dominant cell [8].

Give a variable i_0, it indicated the number of cells could affect the dominant cell and produced interference. The SINR, UE got, is:

$$S / I = S / \sum_{i=1}^{i_0} I_i \tag{2}$$

At time t, user i got the SINR in the k-th RS in the cell 0 is:

$$SINR_{i,\ t,0}(k) = \frac{g_{i,t,0}(k) P_{t,0}(k)}{N_t + \sum_{m=1}^{M} \mu_{t,m}(k) g_{i,t,m}(k) P_{t,m}(k)} \tag{3}$$

Definition matrix

$$N_p = \left[n_0, n_1, n_2, n_3, n_4 \dots N_p \right] \tag{4}$$

n represents the total online number at the time t. N_p is a $1 * p$ matrix.

Definition matrix

$$N_{\mathrm{RB}} = \left[n_1; n_2; n_3; n_4; n_5 \dots n_p \right] \tag{5}$$

n represents the total used RB number at the time t. N_{RB} is a $p * 1$ matrix.

At the time t, all the number of user N_p in the cell produced the average of SINR on the RB transmitting, the data is:

$$SINR_{t,0}(k) = \frac{N_p * N_{RB} * \left[\sum_{n=0}^{N_p} \frac{g_{n,t,0}(k) P_{t,0}(k)}{N_t + \sum_{m=1}^{M} \mu_{t,m}(k) g_{n,t,m}(k) P_{t,m}(k)} \right]}{N_p} \tag{6}$$

The channel capacity on the every used RB is:

$$C_{n_p,0}(k) = B_k \log_2 \left[1 + SIINR_{t,0}(k)\right] \tag{7}$$

In the equation 7, B_k is the bandwidth of subcarrier k ; user got the power gain factor $g_{n,0}(k)$ form the cell 0, definited the power gain factor $g = \frac{p_{rx}}{p_{tx}}$; $\mu_m(k)$ means whether to schedule resources on subband k in the target cell; $P_m(k)$ is the transmit power on subband k in the cell m ; N is the white Noise.

3. Dynamic Time Slot Allocation Algorithm

3.1. Polling Algorithm

In formula 8 provided seven kinds of time slots ratio correspond to the downlink peak rate,

$$S_D = (S_{D0},\ S_{D1},\ S_{D2},\ S_{D3},\ S_{D4},\ S_{D5},\ S_{D6}) \tag{8}$$

User N_p got the $SINR_{n,t,0}$ in the cell 0 coverage area, correspond to the channel capacity $C_{n,0}(k)$, in formula 9 got the difference between $C_{n,0}(k)$ and S_D

$$\begin{bmatrix} S_{D0}' \\ S_{D1}' \\ S_{D2}' \\ S_{D3}' \\ S_{D4}' \\ S_{D5}' \\ S_{D6}' \end{bmatrix} = \begin{bmatrix} \left|C_{n,0}(k) - s_{D0}\right| \\ \left|C_{n,0}(k) - s_{D1}\right| \\ \left|C_{n,0}(k) - s_{D2}\right| \\ \left|C_{n,0}(k) - s_{D3}\right| \\ \left|C_{n,0}(k) - s_{D4}\right| \\ \left|C_{n,0}(k) - s_{D5}\right| \\ \left|C_{n,0}(k) - s_{D6}\right| \end{bmatrix} \tag{9}$$

In formula 10 showed the minimum value of the difference in formula 9:

$$S_{D\min}' = \left\{S_{D0}',\ S_{D1}',\ S_{D2}',\ S_{D3}',\ S_{D4}',\ S_{D5}',\ S_{D6}'\right\} \tag{10}$$

Selected the minimum value corresponding the time slot is the suit time slot ratio to the current cell 0. Figure 2, Figure 3 showed simulation flow chart and polling algorithm simulation flow chart.

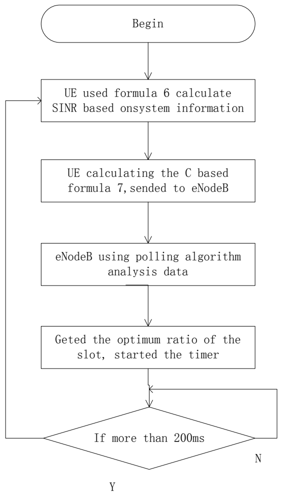

Figure 2. Simulation Flow Chart

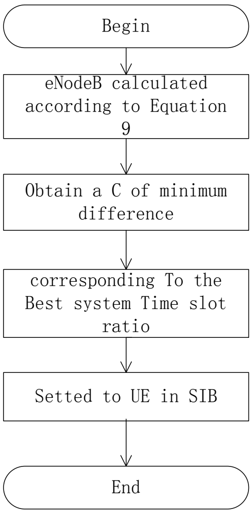

Figure 3. Polling Algorithm Simulation Flow Chart

4. Simulation and Results

This paper adopted the network model as shown in Figure 4, each eNodeB contributed interference to around 7 eNodeBs, the main direction of the cell consider the interference from two layers eNodeB, on this basis, taken into account the interference from the micro- eNodeB, as shown in Figure 4 there are 18 cells interfering from macrocells and one interference from micro-eNodeB. Table 2 shown the simulation parameters of the system, the rate and, interference in the system taken into account under the full scheduling when simulating.

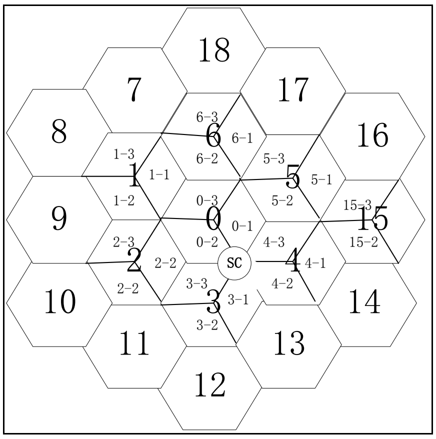

Figure 4. Simulation Distribution Model between Cells

Table 2. Simulation Parameters Table

Simulation parameters		parameter value
Bandwidth		20M
carrier frequency		2.0GHZ
network topology		19 eNodeB, 3 sections
sector size		500m
simulation scene		LTE macrocell、Picocell
Path loss model	macro cell	L=128.1+37.6lgR, R (km)
	Picocell	L=140.7+37.6lgR, R (km)
transmission power	macro cell	46dBm
	Picocell	30dBm
The standard deviation of shadow fading	macro cell	8dB
	Picocell	10dB
channel model		SCM
penetration loss		20dB
service model		full buffer
access way		According to the power access

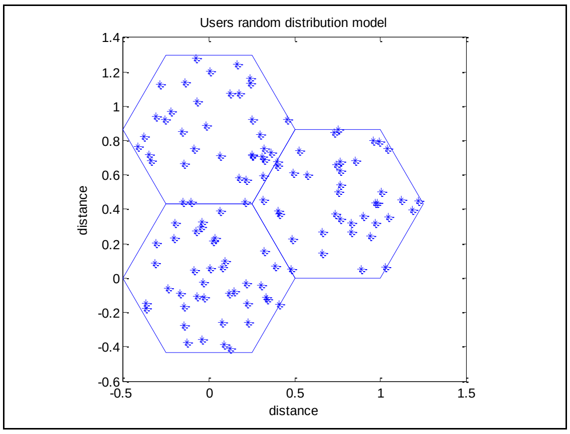

Figure 5. Users Random Distribution Model in the Enodeb

When simulating, every cell had 50 random distributed users, the distribution shown in Figure 5;

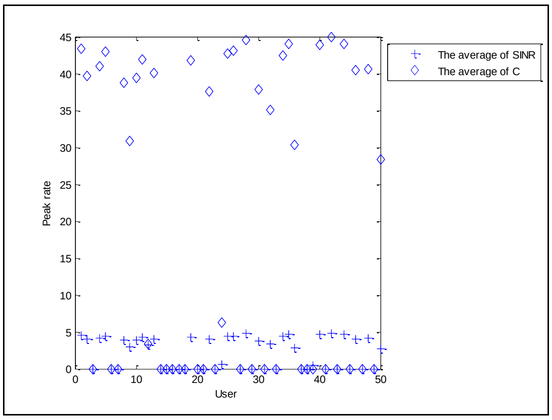

Figure 6. The Rate of Cell Users at Low SINR Value

In Figure 6 indicated that the data was sent by UE, when UE had the relatively serious interference, UE used Shannon theorem to calculate the user peak rate.

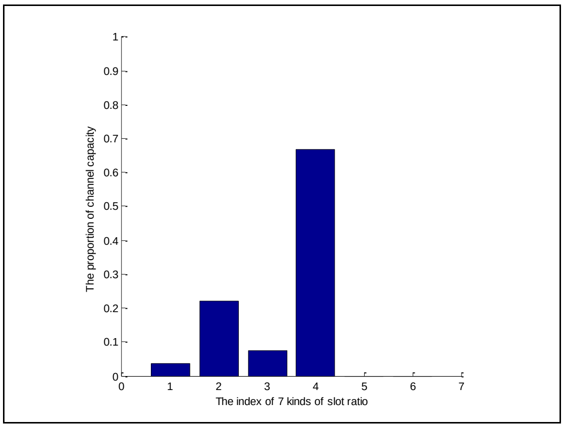

Figure 7. The Results of Polling Algorithm

The results of polling algorithm shown in the Figure 7, comparison of user throughput and the peak rate of different time slots ratio, indicating in the case of the index 4 of time slot ratio, the number of users was relatively large, also shown that UE occupied bigger probability to obtain the index 4 of time slot ratio and longer time, when system dynamically configure time slot ratio. According to the results of the polling algorithm, after the UE access the system, the system can adaptively allocate time slots ratio for UE to transmit data, finally, improved the spectrum efficiency and the throughput of system.

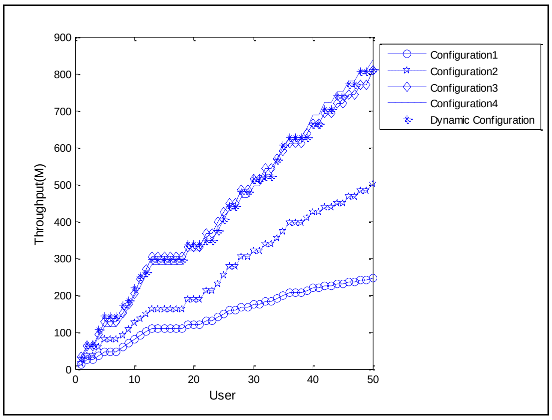

Figure 8. Compare With the Fixed Time Slot Ratio and Adaptive Time Slot Ratio about the Throughput

The simulation results of the fixed time slot ratio and adaptive time slot ratio about the throughput as shown in Figure 8, indicated that system used adaptive time slot ratio can improve the system throughput, the more user, the more advantages of the algorithm.

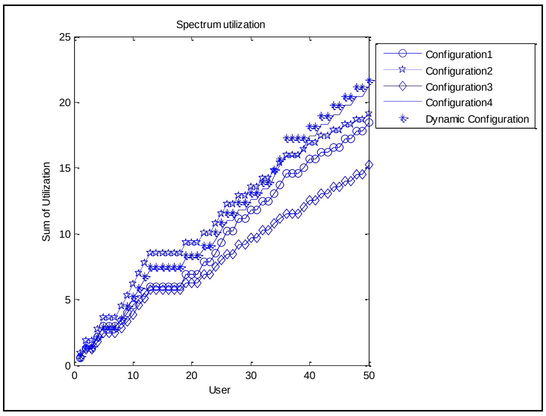

Figure 9. Spectrum Utilization

In the spectral efficiency, system got more efficiency used adaptive slots than the fixed time slot, in Figure 9, the more user in the cell, the more spectrum utilization we got and the algorithm's advantage became more obvious.

5. Conclusion

In this paper, when UE stayed in a poor environment, proposed an self-adaptive dynamic time slot distribution algorithm based on polling algorithm. In the same wireless environment, compared with the fixed time slot, the algorithm had certain advantages on increasing the throughput and system spectrum utilization efficiency. On throughput indicator, adaptive time slot ratio compared with the fixed time slot #1, #2, #4 configuration, the throughput was increased, respectively, 69.55%, 38.36%, 3.19%; in #3 time slot, U:D=3:1, had the largest proportion in the system downlink, self-adaptive time slot ratio obtained the system throughput compared to fixed just under 0.47%; however, in the spectrum utilization indicator, self-adaptive slot ratio compared with the fixed time slot #1, #2, #3, #4 configurations, spectrum efficiency improved 14.79%, 11.69%, 29.64% , 2.01%, respectively, system spectrum resources has been fully used.

Acknowledgments

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