An Alternative Algorithm For Forward Resource Scheduling in CDMA2000-1X EVDO Network

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***Abstract*—G-fair algorithm is popularly used for forward resource scheduling in CDMA2000-1X EVDO network. It is generally acknowledged that G-fair algorithm takes into account both maximum system throughput and fairness. However, according to the result of simulation and test in actual network, when G-fair algorithm is used, the resource allocated to users in poor wireless environment is far less than that to users in excellent wireless environment, and the data rate of users in poor wireless environment is very low. In order to improve this situation, we discuss in the paper the possibility of using equal opportunity algorithm for forward resource scheduling in CDMA2000-1X EVDO network, and also introduce the experiment result and effect in actual network .**

Keywords-algorithm; G-fair; EVDO; equal opportunity

I. INTRODUCTION

The forward resource scheduling algorithm is an important topic in 3G mobile communication network. A suitable algorithm can greatly improve the efficiency of the network and provide a better service to users .

In CDMA2000-1x EVDO system, the forward data frames are divided by time slot which is 1.67ms. Each time slot serves only one user at the same time, and all users of the same sector share the time slot resources in system[1]. Thus for EVDO system, how to distribute the precious time slot resources among various users is the main task of the forward resource scheduling algorithm.

In EVDO system, users in different wireless environment apply for different data rate. In order that the data can be correctly received and demodulated, users in excellent wireless environment will apply for a high rate, while users in poor wireless environment will apply for a low rate. As shown in Table 1[2].

Because the 3G data service is generally charged according to data throughput, the network operators are willing to allocate more system resources to the users in excellent wireless environment, so that they can get greater system throughput and have more earnings.

However, it is not without cost. If we give more resources to the users in excellent wireless environment, the users in poor wireless environment can only get less resources and lower data rate.

TABLE I. THE DRC APPLICATION RATE

DRC index	DRC rate(kbps)	SINR threshold(dB)
0	38.4	Lower than -11.35
1	38.4	-11.35
2	76.8	-9.15
3	153.6	-6.5
4	307.2	-3.85
5	307.2	-3.75
6	614.4	-0.35
7	614.4	-0.55
8	921.6	2.55
10	1228.8	4.3
9	1228.8	4.45
13	1536	6.3
11	1843.2	8.7
12	2457.6	11.1
14	3072	13

II. FORWARD RESOURCE SCHEDULING ALGORITHM USED IN EVDO SYSTEM

Nowadays G-fair algorithm is used in most of the EVDO systems for forward resource scheduling. G-fair is an algorithm which tries to ensure a great system throughput, service fairness and the QoS requirements of various services[3].

The general idea of G-fair algorithm is as follows: users get the service priority according to the ratio of "signal quality to cumulative throughput". Users with good signal quality will get higher priority, and obtain more time slots, thus improve the throughput of the whole system. For users with poor signal quality, cumulative throughput will decline when they get no service, which will make their priority rise until they get the opportunity to transmit data.

The details of G-fair algorithm are as follows:

Suppose a priority is calculated for each user in time slot n, and the user of the highest priority will get the service. In time slot n, the priority of user k is calculated as follows:

$$p_K(n) = \frac{DRC_k(n)}{f_k(T)} W_k(\mu) \quad (1)$$

In (1), the $DRC_k(n)$ is the biggest forward link data rate that the user k can support. This rate is calculated according to the forward link SINR and Table I. The $f_k(T)$ is a rate compensation function related to throughput T. The $W_k(\mu)$ is a weighting function, and its influence factors are: system load, residual capacity, sending queue length, receiving queue length and delay ARQ queue length, etc[4].

Through simulation, we can get service opportunities for different application rate with G-fair algorithm. As shown in Fig.1.

From the simulation results, we can see that when we use G-fair algorithm, the users whose application rates are lower than 153.6 kbps get very few service opportunity, and most of the service opportunities are given to the users whose application rates are above 614.4 kbps[5].

Accordingly it can be seen that using G-fair algorithm deprives low rate users of service opportunities, and allocates more service opportunities to high rate users in order to get great system throughput.

However, in the actual network operation, 3G operators may encounter some problems. Fig. 2 shows that the number of user complaints in a EVDO network rises from month to month.

By analyzing the complaints, we find that the main reason of complaints is that users are not satisfied with the data rates. Through field tests we discover that many of these users are in poor wireless environment, their mobile terminals apply for low data rates and get very few service opportunities, so the actual service rates were lower. Some of these users want to change to other networks because they can not achieve satisfied rates at their home or working places.

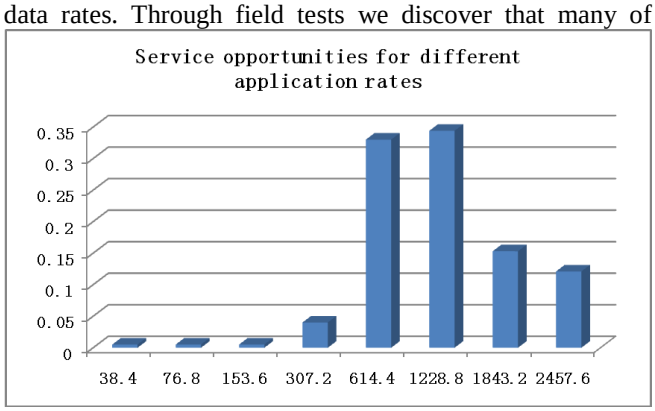

Figure 1. Service opportunities for different application rates

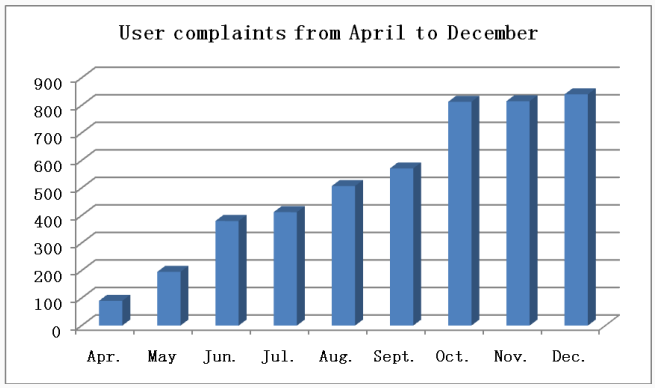

Figure 2. User Complaints from April to December

Since 3G users not only use data service, they also use voice service, the network operators will lose both data and voice business if they lose the users. According to statistics, users in poor wireless environment (SINR less than -4 dB) account for 33% of the total in some cities.

So it is necessary that we should pay more attention to the users with low rate when we choose the forward resource scheduling algorithm in order to avoid losing of them.

III. INTRODUCTION EQUAL OPPORTUNITY ALGORITHM IN EVDO NETWORK

Based on the above analysis, we try to allocate more forward resources to users in poor wireless environment than G-fair algorithm to improve their data rate.

In order to build an experiment environment, we choose an EVDO base station in a city which has not been put into operation. We use six terminals for test. Three of them are in excellent wireless environment and the other three terminals are in poor wireless environment.

First, we test the forward link data rate of the six terminals by G-fair algorithm. Then we replace the G-fair algorithm by equal opportunity algorithm-forward resource are allocated to all users whether their wireless environment is excellent or poor-and test again. The test result is shown as Table II.

We can see from Table II that after equal opportunity algorithm takes the place of G-fair algorithm, the average forward link data rate of the three terminals in excellent wireless environment decreases from 390 kbps to 323 kbps, that is 17%; Meanwhile, for the three terminals in poor

TABLE II. USER RATES AND SECTOR THROUGHPUT BY DIFFERENT ALGORITHM

Wireless Environment	**Terminal**	**Forward Link Data Rate (kbps)**		**Forward Link Sector Throughput (kbps)**	
		G-fair Algorithm	***Equal Opportunity Algorithm***	***G-fair Algorithm***	***Equal Opportunity Algorithm***
Excellent	1	430	350	1540	1460
	2	420	320		
	3	320	300		
	Average	390	323		
Poor	4	120	160		
	5	100	150		
	6	150	180		
	Average	123	163		

wireless environment the average forward link data rate increase from 123 kbps to 163 kbps, that is 33%. At the same time the sector throughput declines slightly.

In order to check the effect on actual users, we choose two buildings for testing, where many users often complain. These two buildings are far from the base stations, and the building penetration loss is great, so the wireless environment in the buildings is poor.

To improve the user's data rate inside the buildings, G-fair algorithm is replaced by equal opportunity algorithm at the base stations which cover these two buildings. From March 2 to March 5 G-fair algorithm is used and from March 6 to March 8 equal opportunity algorithm is used. The comparison of data rates before and after the replacement is shown in fig. 3.

Fig.3 shows that when using G-fair algorithm, the forward data rates in building A and B are between 40 and 110 kbps, when using equal opportunity algorithm, the rates increase to between 150 and 210 kbps. The users in these two buildings feel satisfied with the rate increase.

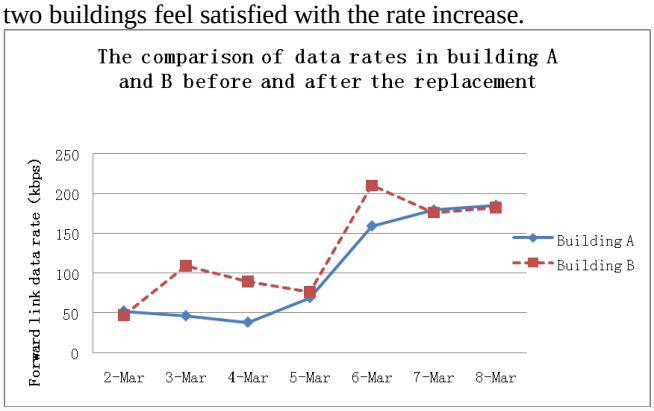

Figure 3. The comparison of data rates before and after the replacement

IV. CONCLUSION

In order to achieve great system throughput and more operating earnings in data service, G-fair is widely used in CDMA2000-1x EVDO network as forward resource scheduling algorithm. But if we consider not only data service but also voice service, we may try using equal opportunity algorithm to improve the data rate of users in poor wireless environment so as to avoid losing these users. Although the system data throughput may decline slightly, the overall income from voice and data service will increase.

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