

Simulation Analysis of Adaptive Power Control Method in TD-SCDMA System

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Abstract—In time-division synchronous code-division multiple access (TD-SCDMA) system, power control is one of the key technologies of radio resource management. It plays a significant role in guaranteeing the high quality communication. In this paper, we propose an adaptive power control algorithm, which is easier implemented than widely used algorithms, for uplink of the power control module through a simple and reliable way. Our method is based on the step size fixed power control algorithm and we use a shift register in the receiver to deposit power control bits, on which we depend to regulate the power-adjusting step size adaptively. First, we define that the bit information be 1 or 0, if the receiving power is smaller or bigger than the target power. When there is 1 or 0 alternately, it means the receiving power is approximate to the target power. When there is 1 or 0 continuously, the step size needs adjusting strongly, for the receiving power is much smaller or bigger. By simulating our algorithm and the step size fixed power control algorithm in the physical layer simulation platform of TD-SCDMA system, we can see the adaptive algorithm has a better performance than the step size fixed algorithm in decreasing the Bit Error Rate (BER) of information transmission. The simulation results also show that system performance may be affected by different number of users and Doppler shift and this adaptive algorithm is applicable to small Doppler shift with the same Signal Noise Ratio (SNR) to the step size fixed algorithm.

I. INTRODUCTION

TD-SCDMA system has been presented by CCSA (China Wireless Communication Standards Organization) and has already become the 3G (3rd Generation) wireless communication standard of ITU (International Telecommunication Union). It's a vivid combination of the two basic modes, TDMA and CDMA. As a CDMA system, TD-SCDMA is a self-interference system [1], whose capacity and quality are limited to the interference from mobile users.

Beside of the multiple access interference, there exists a "near-far effect" [2] because of strong signals' overshadowing of weak signals. There is also "angular effect" [3] and "shadow effect" [4] proceed from users' position at adjacent areola and tall buildings' obstruction to

the electromagnetic propagation, respectively. In order to overcome these disadvantages above, the most available method is to adopt power control technique, which can guarantee system communication with high quality while won't bring interference to other code-division channel in same frequency channel. In a word, power control is one of the key technologies in CDMA system.

In view of uplink and downlink of communication, power control can be divided into forward/downlink (base station to mobile units) power control and reverse/uplink (mobile units to base station) power control. It is more crucial and sensitive on the uplink in the sense that power levels received at the base station from different mobile units should be roughly equal, so that no single mobile unit can dominate and prevent recovery of signals from other mobile units. In this work, we concentrate on the study of power control for uplink.

Considering the type of the power control circuit in TD-SCDMA system, there are open [5] or closed [6]-[8] loop. In open loop power control, each mobile unit adjusts its transmission power assuming that path losses in both directions forward and reverse, are symmetric. It can only compensate for the loss due to long-term fading, and cannot make up for the loss due to short term fading. In closed loop situation, the base station uses the quality of the signal received from a mobile unit to issue a command to tell the mobile unit how to adjust its transmission power. It can be adjusted through feedback and also performs better to compensate for both long- and short-term fading. It adopts open and closed loop power control together for uplink in practice, now we only consider closed loop for our work.

According to the information measured to determine whether to raise or lower the transmission power from a mobile unit, power control is categorized into two types: strength-based, e.g., [6], and signal-to-interference-based (SIR-based), e.g., [7]. In the former schemes, the strength of a signal arriving at the base station from a mobile unit is measured to activate proper power control action, while in the latter design, the quantity measured is SIR, with the interference consisting of both channel noise and multi-user interference. SIR is clearly a more accurate indication of signal quality and provides better performance. However, SIR-based power control may cause positive feedback, which can endanger the stability of the system. One method to make the loss of this deficiency is to have strength-based and SIR-based power control schemes combined [9]. In TD-SCDMA system, Dedicated Physical Channel (DPCH) uses the TPC (Transmit Power Control) symbol in Physical Layer (L1) to conduct closed loop power control for uplink

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and this closed loop control is SIR-based situation. In this work, we study an adaptive power control algorithm based on step size fixed algorithm. Because the step size fixed method has invariant adjustment amplitude, it may not catch on the power alteration rapidly under fast fading but the adaptive method can adjust the step dynamically according to the characteristic of fast fading channel thus gain better control effect.

The rest of this paper is organized as follows. Section 2 presents the process of this closed loop adaptive power control algorithm for uplink. Section 3 introduces simulation platform of TD-SCDMA Link and illustrates some simulation results. Finally, we give a brief conclusion and discussion in Section 4.

II. CLOSED LOOP ADAPTIVE POWER CONTROL ALGORITHM FOR UPLINK

Closed loop power control is the kernel of uplink power control and it is accomplished by mobile units with the assistant of base station. The base station detects SNR of reverse business channel every 1.25ms, and then compares it with a certain threshold. If the received SNR is higher than the threshold value (written as SNR_thre in below), the base station will send an order to mobile units to reduce their launching power, otherwise increase their launching power, while mobile units adjust launching power every 1.25ms with step size 1dB usually. When mobile units can not receive TPC bit because of losing synchronism, the launching power will remain in certain value. Also when base station can not detect SNR without synchronism, the TPC command will be set "increasing" during this period. The step size fixed algorithm is carried out every frame, and the changing of SNR_thre is depending on the comparison result of current frame error (FER) and frame error threshold (FER_thre). If FER is bigger than FER_thre, the error frame may be caused by current error frame or previous error frame, which is different situation and needs discussion respectively. Since the space is limited, we won't give any further analysis.

As to closed loop adaptive power control for uplink, the process of this algorithm is quite simple and we can show it has a better performance than step size fixed algorithm in the following text. The key conception of our method is indicated as follows:

Suppose the number of tapping point of Rake receiver [10] in data receiving is L , then the total receiving power P_R is

$$P_R = \sum_{l=1}^L P_{R,l} \quad (1)$$

where $P_{R,l}$ is the receiving power of the l th tapping point. Now we use a shift register in the receiver to deposit power control bits, on which we depend to regulate the power-adjusting step size adaptively. First, we define that the bit information be 1 or 0, if the receiving power P_R is

smaller or bigger than the target power P_{target} . There is a 7 bit shift register storing the values of current and 6 previous power control bits, which is written as R_0, R_1, \dots, R_6 in sequence. When there is 1 or 0 alternately, it means the receiving power is approximate to the target power. When there is 1 or 0 continuously, the step size needs adjusting strongly, for the receiving power is much smaller or bigger. Assume step size weighting factor is g , ϕ is original step size and Δ is new step size, then Δ is

$$\Delta = \phi + g \lambda \quad (2)$$

where λ is system parameter. The corresponding relationship of R_0, R_1, \dots, R_6 and g is scheduled in Table 1. Under other circumstance g is always 0 and when fading is slow, let $\Delta = \phi$. In fast fading situation, according to the values of R_0, R_1, \dots, R_6 we can easily find g in table 1 and calculate step size in (2).

Table 1. Corresponding relationship of R and g

R_0	R_1	R_2	R_3	R_4	R_5	R_6	g
1	1	1	0	x	x	x	1
1	1	1	1	0	x	x	3
1	1	1	1	1	0	x	2
1	1	1	1	1	1	0	1
1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	3
0	1	1	1	1	1	0	2
0	0	1	1	1	1	1	3
0	0	0	1	1	1	1	2
0	0	0	1	x	x	x	1
0	0	0	0	1	x	x	1
0	0	0	0	0	1	x	2
0	0	0	0	0	0	1	0

III. SIMULATION PLATFORM AND RESULTS ANALYSIS

A. A Brief introduction of simulation platform and model block

The simulation platform of TD-SCDMA Link is developed by our laboratory using Matlab. It based on TD-SCDMA Standard to have simulation of Link Layer of TD-SCDMA system. This platform is consisting of three parts, basic transmission and Physical Layer part, intelligent antenna part and power control part. By means of these model blocks, we can obtain the performance of some key functions in TD-SCDMA system, for instance, the system performance comparison of different channel models, users' number, Doppler shift and different delay. At the same time, some key techniques in TD-SCDMA system can be researched, such as Multiuser detection, intelligent antenna, power control and so

on.

The main function of power control block is to maintain communication quality with as little as power loss thus decrease interference mutually in network and prolong the utility tie of terminal batteries. This model block can generate power control command and current power control bits information. In this paper we give simulation of closed loop power control for uplink, and it is SIR-based scheme to investigate system performance of BER and SNR. Seen from Fig. 1, after adding power control bits information, data source should judge how to adjust launching power and then pass it through Rayleigh Channel. Receiving end not only gets data but receives power control bits to decide TPC command and then gives sub-block calculating launching power a feedback. On the other hand, receiving end computes SIR and compares it with target value to generate new power control bits information. Without considering bit error amount, SIR-based closed loop power control model can be simplified as Fig. 2.

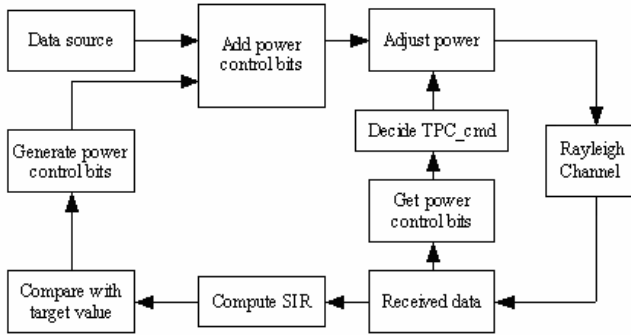


Fig. 1. SIR-based closed loop power control model

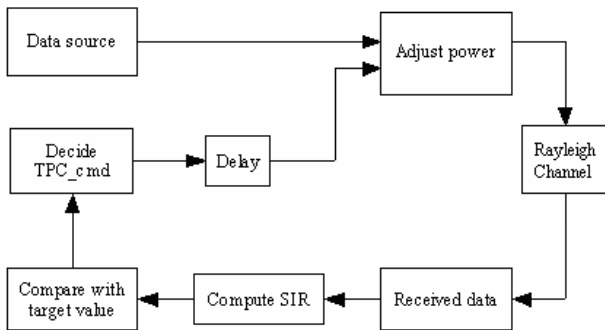


Fig. 2. Simplification of Fig. 1 without considering bit error amount

B. Simulation results and analysis

In order to verify our algorithm in a convenient way, we make simplification in three aspects in the simulation. Suppose the velocity of data source is 9.6kbit/s, which means transmission in full velocity. Assume that the noise in channels is absolute white noise and it takes the place of multiuser interference. We only consider closed loop power control for uplink, but not simulating open loop situation.

We simulate different number of users in single areola, for example one user, four users and eight users. As shown in Fig. 3, abscissa represents SNR of transmission channel and ordinate represents BER of transmission data. Because TD-SCDMA is a code-division multiple access system, all users utilize wireless channels with same frequency range and time slot. And users only depend on differences between spread spectrum codes of address, which is also their cross correlation characteristic, to be distinguished. Simulation results show that, if cross correlation of users is not zero, there will be some interference, and without power control the more users an areola has, the stronger interference between each others will be.

At the same time, we simulate system performance under different circumstance, no power control, step size fixed power control and adaptive power control. According to the power control bits generated by computed SIR value, the step size fixed method adopts the step size as 1dB while the adaptive method chooses adaptive step size based on the comparison of receiving signal's power with target power. Transmission channel adopts Additive White Gaussian Noise channel and four-path Rayleigh Channel. Doppler shift is 30Hz. The power control executes 0~200 times per second with smallest interval, which is a sub-frame period. Of course, the transmitting error bit of power control bits is ignored. From Fig. 4 we can draw the conclusion that power control technique can descend transmission BER and raise system performance significantly, while using adaptive power control algorithm is more effective than step size fixed algorithm.

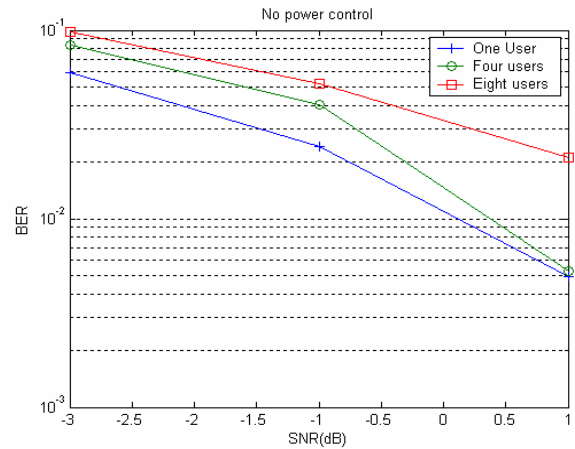


Fig. 3. Different number of users with no power control situation

Besides, we also simulate the influence from different Doppler shift (see Fig. 5). If Doppler shift is too high, the application of power control will not decrease BER evidently; on the contrary it will be inferior to no power control situation. Because when Doppler shift is too high, the speed of power control can not keep up with channel fading, therefore power control technique is suitable for low Doppler shift environment.

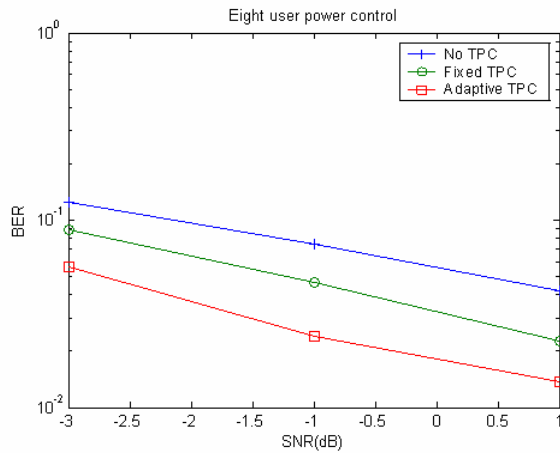


Fig. 4. Different power control algorithms comparison

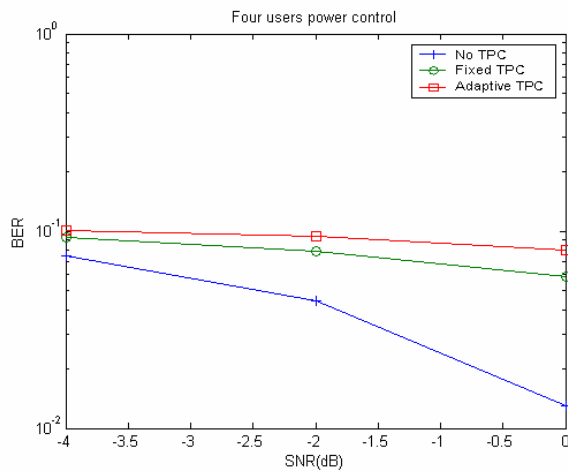


Fig. 5. Doppler shift is 235Hz, we can see power control hardly lowering down BER.

IV. CONCLUSION

In this paper we present an adaptive power control algorithm for TD-SCDMA system and proceed some simulation work of step size fixes algorithm and our algorithm in simulation platform of TD-SCDMA Link. We get the conclusion that users' number and Doppler shift can make influence on power control. According to the increase of users, interference between them must grow stronger and power control technique will maintain system performance. It is also clearly that adaptive power control algorithm is more effective than step size fixes algorithm in lowering down BER with the same SNR value. However, this adaptive method is suitable for low Doppler shift environment.

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