EFFECT OF POWER-UPDATE RATE AND POWER-UPDATE STEP SIZE ON OUTAGE PROBABILITY OF CDMA SYSTEMS

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ABSTRACT

The CDMA system has been used extensively in satellite communications. This is due to advantages of spread spectrum techniques used in CDMA systems, and their higher capacity in compare to FDMA & TDMA systems [1]. However, since the advantage of CDMA is related to interference level, CDMA systems needs to have perfect power control for minimizing the interference and obtaining required qualities. Power update rate and step size are two most important parameters which have the high effects on the precision of power control. Power update rate and power update step size are related to satellites propagation channel conditions, and should be determined based on rate and level of fading in the channel. In this paper the effects of these parameters (i.e. power update rate and step size) are investigated and the outage probability is calculated and compared for different values of these parameters. Based on our results it will be shown that, the outage probability is highly related to the variation of the above mentioned parameters. Our results are demonstrated by different curves and graphs.

Key words: CDMA systems, power control, power update rate and power update steps.

I- INTRODUCTION

CDMA Technology possesses advantages such as higher capacity in cellular mobile systems in compare to TDMA and FDMA [1]. This higher capacity is related to its power control ability especially in reverse link. Satellite receives a stronger signal from near distance ground stations, in compare to stations located in a larger distance, when power control is not used. This in turn will results a reduction in capacity of CDMA. Power control can overcome the near-far problem and at the same time is very effective for minimizing the transmitted power to each user. Power control in revers link will adjust power transmitted from ground stations in such a way that the same power level receives to the satellite from all users. Since propagation loss and slow fading in reverse link behave in a same manner, one can use the information received from the forward link and with the use of open loop control, eliminate near-far effect problem. However, for solving the fast fading problem, considering the fact that its behavior is different in reverse and forward links, closed loop power control is suggested. In this method, satellite will predict the next SIR based on the previous received measured SIR, and transmit the control bits for adjusting power of the ground users (i.e. fixed and mobile users). In the following section, the effect of power-update rate and power-update step size will be explained, and finally calculation and evaluation of their effect on the outage probability will be presented.
II- POWER-UPDATE STEP SIZE

Power-update step size is a parameter which is used by users to control their transmitted power to satellite. Power steps is determined by power control command (PCC) bits using quantized information $e(t)$, received to the ground users. Two different methods for quantization and sending power control bits are usually reported. In first method which is called variable step power control, the $e(t)$ signal after quantization is transmitted with several PCC bits. In second method, which is called fixed-step power control, $e(t)$ signal is quantized and transmitted by only one PCC bit. Each of these two methods has their own advantages and disadvantage. In variable-step power control, quantization $e(t)$ is quantized by a PCM system. Having a larger numbers of bits for signal, will results in a better accuracy in quantization of information. In this case, the transmitted power of users can vary according to the difference between received and desired SIR. Since this algorithm, uses several PCC bits, it can overcome the fading effect problem by only one time power update. On the other hand, this method requires several PCC bits in each power control process.

Since the rate of signaling for power control is several times larger then the fading speed, large amounts of control bit are required in this method. As a result, large band width in forward link is needed. In second method which is called fixed step power control, PCC has only one bit and result is in minimization of band width. In this case, if estimated SIR, $\gamma_{est}$, is less than the desired SIR, $\gamma_t$, then for increasing the transmitted power by the amount of $\Delta p(dB)$, one PCC bit, for instance "1", will be transmitted to the user. If on the other hand, $\gamma_{est}$ is larger than $\gamma_t$, one PCC bit, for instance "0", is sent to the user, in order to reduce its power by $\Delta p(dB)$. This method in practice can be implemented using delta modulation (DM). By only one PCC bit, the ground user will either increase or decrease its power by $\Delta p$. In this case the quality of system decreases, however, the required bandwidth for power control signaling in forward link, will be smaller. In section IV, the effect of increasing control bits (from one bit to three bits) on outage probability is discussed.

III- POWER UPDATE RATE

It has been shown that for having an effective closed loop power control, power update rate should be at least ten times larger than the fading rate [1]. For instance for a moving object with the velocity of 60km/hour and frequency of 1.8GHz, the maximum Doppler spreading would be 100Hz. Since the maximum Doppler spreading is proportional to the fading rate, for having an effective power control, the power update rate should be larger than 1KHz. Power update rate of 800Hz, in second generation (IS-95) of CDMA systems is used. However, in third generation systems the value of 1.5 up to 2 KHz has been proposed for power update rate [2].

In next section the effect of change in power update rate on outage probability of system for different rates of 600, 800, 1600 and 2000 is discussed.

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1 - $e(t)$ is the difference between received the and desired SIR.
IV- SIMULATION

For investigating the effect of power update rate and power update step size, a satellite communication system with desired and interferer signals are considered in our model. Closed loop power control is used to solve fast fading problem. The main signals and all other interfering signals are assumed to have Rayleigh fading, where they are generated in our model.

Satellite, after calculating received SIR, will estimate the next SIR, and the difference between these two in the form of control bits is sent to the ground user. If there is no limitation in number of control bits and also the required value for power changes, then it would be possible to change the user's power by the exact amount of difference between measured and estimated SIR. This is shown in figure (1) for rates 600 and 800 times per seconds and in figure (2) for rates 1600 and 2000 times per seconds. However, in practice, due to limitation in number of control bits, it is not possible to do exact change in power transmission of mobile users. Therefore, One bit (2 levels) and 3 bits (8 levels) are usually used. Outage probability, for one bit (DM) and 3 bits (PCM) are shown in figures (3) and (4) respectively. As it can be seen in these figures the quality of system for 3 bits is much better than one bit. However, this improvement is achieved by the cost of high band width used in forward link. The results for power update rate of 600, 800, 1600, 2000 times per second is calculated. As it can be seen, by increasing the power update rate, the quality of systems greatly improves, and at the same time, number of control bits increases. Increasing the number of bits means increase of band width in forward link. It is worth mentioning that in calculating the outage probability, an specific level for SIR (i.e. based on the simulated system) is assumed and whenever, the SIR level, after power control, becomes less than this value, it would be assumed the system is outaged [4].

V- CONCLUSION

In previous sections, power control in CDMA systems and their effecting parameters such as power up-date rate and power update step size have been discussed. The effect of these parameters on the outage probability is modeled. According to our modeling results, by increasing the rate of power adjustment, the ability of system for solving the fast fading problem in closed loop power control improves. In addition, increasing the number of power adjustment levels (i.e. power-update step size), will results in a better performance of system. However, in both cases, the number of control bits increase. This is due to the fact that these bits multiplexes with information bits. Since the spectral quality of system reduces with increasing control bits, there should be a trade off between outage probability and required band width.

VI-REFERENCES

Fig. 1 - Outage probability for power-update rate of 600 and 800.

Fig. 2 - Outage probability for power-update rate of 1600 and 2000.
Fig. 3- Outage probability for power-update rate of 600, 800, 1600 and 2000

Fig. 4- Outage probability for power-update rate of 600, 800, 1600 and 2000