Chapter 1 Introduction

1.1 Background

Today, mobile communication systems are anticipated to provide mobile users with various multimedia services including voice, data and video. In order to support these services which have bursty (elastic) data characteristics and different quality of service (**QoS**) constraint, high data rate transmission is vital [9]. Many new systems, evolving from the second-generation systems such as GSM, IS-368, and IS-95, have been proposed to provide higher bit rates. An example of these systems is IS-856 which offers high speed, high capacity wireless Internet technology. IS856 is compatible with code-division-multiple access (**CDMA**) networks but optimized for packet data services [11].

Data waveform over time-varying channels subject to cochannel interference is one essential feature in wireless communications. The time-varying characteristic is mainly caused by radio propagation environment, user mobility, and reuse of limited frequency spectrum, but also slightly affected by background thermal noise. Its effects at a radio receiver are the fluctuations of received signal in fast fading, slow fading, or shadowing, in addition to distance-related attenuation. Such time-varying effects in general impair the capacity of information carried by a data waveform. A traditional technique to resolve this problem is power control which has been used in CDMA system to improve link quality over slow fading and shadowing channels and large-scale distances [9].

In the code-division-multiplexing (**CDM**) forward link of CDMA system, some power control schemes have been introduced. The power-adaptation scheme in [13,14] considered a weight function that determines the amount of transmission power of each traffic channel and a zone based scheme that has the advantage in the interference suppression as well as the performance improvement in the outage probability. Another power adaptation scheme in [2] improved system throughput by estimating short-term fading; when the estimated short-term fading is severe, the base station (**BTS**) suspends the transmission and resumes the transmission when the short-term fading is not severe. The last one in [4] uses a threshold to enhance system capacity, by suspending packet transmission when required transmit power is higher than the threshold.

In [5], two methods of rate adaptation are compared. One is to reduce the link data rate of mobile connections (**MC**) which consume large fractions of BTS power. The other is to reduce the link data rate of some MCs whose users subscribe to lower QoS while keeping the data of mobile terminals (**MT**) whose users subscribe to higher QoS at a full data rate all the time. Propagation conditions that reduce the gap of required power among MTs diminishes the advantage in capacity gained by the first method. In the second strategy, the improvement in capacity depends mainly on the ratio of high to low QoS subscribers in the network at any given time.

However, high-speed data systems prefer using the time-division-multiplexing (**TDM**) technique rather than the code-division-multiplexing

(**CDM**) one to transmit data waveforms over forward link. This is because by transmitting data in TDM fashion, full antenna power can be allocated to a single user at any transmission instant and the access terminal (**AT**) can receive them at high noise power ratio (S/I, or SINR) while extra intra-interference from non-orthogonal factors, which usually exists in CDM, is completely avoided [8,9]. Consequently, the TDM technique not only provides higher instantaneous data rates but also improves cell coverage.

There is a trade-off issue between user fairness and multiuser diversity gain for system throughput in scheduling TDM waveform transmissions over forward link. For example, a packet-level which always picks one AT with maximum SINR to serve could get higher system throughput; However, the AT in the cell boundary becomes starved of service opportunities due to low SINR, which thus raises the issue of fairness. To avoid unfairness, the proportional fair scheduler has been proposed in [3, 7, 18], essentially based on the approach that the weighting factor of current SINR is in inverse proportion to the average received throughput.

1.2 Objective

Previous study of packet-level schedulers for TDM forward-link data service considered that the access point transmitter (**APT**) has a fixed level of transmitter power. For radio coverage, adjacent cells overlap, which also leads to the issue of intercell interference particularly at cell boundary areas. Most ATs in this area are unable to receive high data rates (i.e. SINR) because of low received signal power and significant intercell interference. It is, however, possible to improve received SINR if the transmitter power of APT is adjustable and determined at a proper level. This was considered in the study [12, 16], showing that if the transmitter power of neighboring APTs can be turned on and off, the cell can provide higher feasible data rates for ATs at some areas by controlling neighboring antenna on-off power patterns. However, it is unclear whether this result for a single cell can directly apply to multiple cell environments where antenna activities should be coordinated to satisfy traffic patterns. The study in [6] showed that the forward link throughput improves if each APT periodically alternates two levels of transmission power and randomly selects one of two modes of activity pattern. Essentially, the benefits of coordinating antenna activity to reduce intercell interference and to satisfy the demand of traffic dynamics are not addressed.

In this thesis, we investigate APT power control strategy for wireless forward link data services. We assume that each APT has two levels of transmission power. The objective is not only to improve system throughput by reducing intercell interference but also to adapt ATP power level activity to alleviate the impact of temporal and spatial traffic dynamics among cells. The approach is to coordinate APT power level activity essentially according to traffic loads and traffic spatial distributions. Moreover, we consider that the frequency of switching ATP power levels is an important measure of system complexity. We then propose a hysteresis approach using two hysteresis thresholds to damp down the frequency of changing ATP power activity patterns besides using a single threshold. In addition, we study the effect of adapting APT power level activity on the behavior of the proportional fair scheduler which is considered as the forward link service scheduler in this work.

In order to obtain performance data for the proposed APT power level control algorithms, we carry out several computer simulations in a linear wireless network topology. In the network, each forward link channel is subject to distance-related path loss and intercell interference, besides artificial shadowing effects from changing APT power patterns. We exclude fast fading effects at the current stage of this study.

1.3 Related Work

In [6], the authors combine packet scheduling with a simple power control scheme in CDMA high data networks. The APT transmission power alternates low level with high level slot by slot. They showed that the performance with the proposed scheme is better than one without power control no matter what the packet-level scheduling is proportional fair scheme or Round-Robin scheduling scheme. Their simulation results also showed that the ratio of reduced power (i.e., low power level) and fixed maximum power (i.e., high power level) at 0.25 has higher cell throughput.

The authors in [12] analyzed power requirement for each position regarding angle and distance from the serving APT, and also provided a downlink interference model which gives the ratio of the other cell interference to the total received power from the serving APT. Their results showed that there are great benefits for system performance if the APT transmit power can be reduced.

Particularly, the on-off power pattern gives rise to performance enhancements obviously.

The paper in [16] analyzed the impact of intercell interference on feasible rates in a linear network and a hexagonal network with omnidirectional APT antennas. It was shown that the reference cell would get higher rate if intercell interference were reduced by turning off the neighbor APT; However, the performance of neighboring cells is sacrificed when they are turned off. It thus raises the issue that to what level and when the APT power should be reduced.

1.4 Thesis Organization

In the next chapter, we present system models and proposed schemes. In chapter 3 and 4, we describe simulation model and numeric results. Chapter 5 concludes the thesis.