



## Performance analysis of a distributed fixed-step power control algorithm via window concept in cellular mobile systems

Young-Long Chen<sup>a</sup>, Chih-Peng Li<sup>b</sup>, Jyu-Wei Wang<sup>c</sup>, Jyh-Horng Wen<sup>d,\*</sup>

<sup>a</sup> Department of Computer Science and Information Engineering, National Taichung University of Science and Technology, Taiwan, ROC

<sup>b</sup> Department of Electrical Engineering and Institute of Communications Engineering, National Sun Yat-Sen University, Taiwan, ROC

<sup>c</sup> Department of Photonics and Communication Engineering, Asia University, Taiwan, ROC

<sup>d</sup> Department of Electrical Engineering, Tunghai University, No. 181, Sec. 3, Taichung Harbor Rd., Taichung, Taiwan, ROC

### ARTICLE INFO

#### Article history:

Received 12 September 2011

Received in revised form 1 August 2012

Accepted 2 August 2012

Available online 23 August 2012

#### Keywords:

Power control

Convergence region

Convergence rate

Step size

Window size

### ABSTRACT

In cellular mobile systems, the received carrier-to-interference ratio (CIR) can be maintained within the desirable range provided that the path gain remains approximately constant over a number of consecutive power control steps. However, when channels suffer short-term fading, it is not clear whether existing power control algorithms remain convergent. This paper proposes a distributed fixed-step power control algorithm with binary feedback via window concept for cellular mobile systems. The essence of the proposed algorithm is that the power control step size can be regulated by window size. The performance of the proposed scheme is analyzed in short-term fading channels. A sufficient condition for system stability is derived using a simple received CIR model and a power control window. It is shown herein that the bound of the received CIR of each user varies as a function of the target CIR, the size of the power control step and the link gain. The analysis and simulation results show that if the step size is properly set according to the window size, the proposed algorithm can achieve a small convergence region and a fast convergence rate.

© 2012 Elsevier B.V. All rights reserved.

## 1. Introduction

Power control is an important element of resource management in cellular mobile systems, and is an essential technique for reducing co-channel interference, thereby increasing the system capacity. In addition, power control also plays a vital role in coping with the near-far problem in direct-sequence code-division multiple-access (DS-CDMA) systems. In mobile communications, the quality of a communication link is generally measured in terms of the carrier-to-interference ratio (CIR). Various optimum power control (OPC) methods have been proposed [1,2]; they operate in a synchronous and centralized manner with the assumption of the link gains being known. The OPC methods are optimum in the sense of minimizing the outage probability. To minimize the outage probability, Zander derived an optimal power vector [1], which is equivalent to the Perron–Frobenius' eigenvector. In addition, a two-level hierarchical power control structure was proposed in [3] to carry out the eigen decomposition process required for a CIR-balanced OPC. The computations performed by the algorithms in [1–3] are based on global information; hence, these schemes are generally referred to as centralized algorithms.

In [4], Foschini and Miljanic developed a distributed power control algorithm to establish the power allocation solution which minimizes power consumption while simultaneously satisfying the quality-of-service (QoS) requirements. In [5], Sung and Wong developed a distributed fixed-step power control algorithm and investigated the convergence properties of the

\* Corresponding author. Tel.: +886 4 23590121x33901; fax: +886 4 23598748.

E-mail address: [jhwen@thu.edu.tw](mailto:jhwen@thu.edu.tw) (J.-H. Wen).

algorithm for time invariant systems. Sung and Wong's algorithm, a discrete version of the scheme proposed by Foschini and Miljanic, employs a two-bit power control command; the received CIR of each user is thereby converged to a fixed value.

In [6], the authors proposed a fixed-step power control scheme for a finite state Markov channel model and evaluated the bit error rate performance. An adaptive two-loop power tracking control scheme was proposed in [7] for DS-CDMA cellular systems. The scheme combined the two controllers in the outer loop and inner loop; target CIR tracking and utility optimization can thereby be achieved. In addition, the stability and convergence of the proposed scheme was discussed.

The time varying nature of channels as a result of fading and user mobility is common in practical networks. Various investigations of power control algorithms for time varying systems can be found in the literatures (e.g., [8–10]). In [8], the authors developed a distributed power control scheme based on the fixed-step approach introduced in [5] and demonstrated that this scheme is robust in coping with time varying link gains and noise variations. The results of the proposed algorithm showed that the CIR of each user successfully converged to a specified target region. In [11], a general formula for the bound of the received CIR is derived in the presence of short-term fading. The bound of the received CIR is shown to be a function of the number of power control steps, the step size and the dead factor.

In [12], the author employed a binary feedback scheme to investigate the stability behavior of the system. In the fixed-step power control algorithm, the power level of each transmitter is changed by a fixed amount at every iteration; the transmission power has also been shown not to converge to a fixed value, as shown in [13–15]. However, in [16], it was shown that the received CIR of each user can be controlled to fall within a specific range which is governed by the target CIR and the step size. In [16], the convergence property of a cellular system was investigated under the assumption that all of the link gains were fixed for a number of consecutive power control steps. However, when varying link gains are considered, i.e., when short-term fading is taken into account, it is not clear whether the power control algorithm presented in [16] remains stable. In [17], the system stability of a binary fixed-step power control algorithm in short-term fading channels was analyzed using a simple received CIR model. The results showed that the received CIR could be maintained within a specific range provided that the absolute value of the maximum interference variation between two consecutive measurements was no larger than the power control step size; however, when the interference variation between two consecutive measurements was larger than the step size, the bound did not exist.

In this paper, we consider the case that the interference variations between two consecutive measurements may be larger than the step size. We use a binary fixed-step power control algorithm with a simple received CIR model of the time varying systems to investigate the bound of the received CIR in short-term fading channels. Our proposed algorithm regulates the step size by a sliding window. The sliding window is used to average the link gains difference between a number of consecutive measurements. We mathematically show that if the step size is properly set according to the size of the window, the system can be stable so that the bound of the received CIR can be determined by the target CIR and the power control step size. We also conduct a series of simulation experiments to investigate the convergence rate of the proposed power control scheme.

The remainder of this paper is organized as follows. Section 2 describes the system models. Section 3 presents the convergence analysis. Section 4 presents the simulation results. Finally, some concluding remarks are offered in Section 5.

## 2. System descriptions

In a mobile radio environment, the statistical characteristics of a channel can be modeled in terms of three independent components: the path loss, the long-term fading and the short-term fading.

The path loss, denoted by  $D(t)$ , can be expressed as:

$$D(t) \propto r^{-\gamma}, \quad (1)$$

where  $r$  is the distance between the mobile station and the base station and  $\gamma$  is the path loss exponent, ranging from 2 to 5. In this study, we set  $\gamma = 4$ , corresponding to an urban environment [18].

The long-term fading, denoted by  $L(t)$ , is modeled as a log-normal distribution:

$$L(t) = 10^{\frac{X(t)}{10}}, \quad (2)$$

where  $X(t)$  is a Gaussian process with a mean  $\mu$  and a variance  $\sigma^2$ . The standard deviation,  $\sigma$ , is determined by the terrestrial configuration and ranges from 5 to 12, with 8 being a typical value [19].

The short-term fading can be described using the multipath fading model given in [3]:

$$S(t) = \sum_{i=1}^M A_i e^{j2\pi(f_o + f_{D,i})t + \theta_i}, \quad (3)$$

where  $M$  is the number of multipath beams,  $A_i$  is the amplitude of the  $i$ th path,  $f_o$  is the carrier frequency,  $f_{D,i}$  is the Doppler shift and  $\theta_i$  is the random phase with a value uniformly distributed over the interval 0 to  $2\pi$ . In (3), the value of  $M$  is chosen such that the in-phase and quadrature components of  $S(t)$  are uncorrelated [20]. If a mobile station is moving along the  $x$ -axis with velocity  $v$ , then  $f_{D,i}$  is given by:

$$f_{D,i} = f_m \cos \varphi_i, \quad (4)$$

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات