An Adaptive Soft Handoff Algorithm for Mobile Cellular Communication Systems

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ABSTRACT

In this paper, an adaptive soft handoff algorithm, which dynamically calculates the threshold values for soft handoff based on the received signal strength, is proposed for mobile cellular communication systems. An analytical model is developed to study the performance of soft handoff algorithms. Performance is evaluated in terms of the average number active set updates, the mean size of the active set, the mean time of soft handoff, the average signal quality and link degradation probability, where a link degradation is defined to be the event that the signal strength falls below a level required for satisfactory communication. The adaptive soft handoff is shown to yield a significantly better tradeoff than the handoff algorithm with static thresholds.

1. INTRODUCTION

Handoff is an essential component of mobile cellular communication systems [1] [2]. It is the process whereby a mobile station (MS) communicating with one base station (BS) is switched to another BS when the MS moves across a cell boundary during a call. A call in progress could be forced to abort during handoff if sufficient resources cannot be allocated in the new wireless cell. A properly designed handoff algorithm is essential in reducing the switching load of the system while maintaining the quality of service (QoS). The design of reliable handoff algorithms is crucial to the operation of a cellular communication system and is especially important in microcellular systems, where the MS may traverse several cells during a call. The decision to initiate a handoff may be based on different measurements, such as the received signal strength (RSS) from the serving BS and neighboring BSs, the distance between the MS and the surrounding BSs, signal to noise ration (SNR), and bit error rate (BER). The RSS measurement is one of the most common criteria. In general, handoff includes two steps: handoff initiation and execution. In the initiation phase, the RSS is measured according to radio propagation based methods, and a new candidate BS is chosen if necessary. In the execution phase, a new radio channel will be assigned, and the call will be handed over to another BS.

There are two types of handoff: hard handoff and soft handoff. Hard handoff is a break-before-make method, where a new link is set up after the release of the old link. A certain amount of margin is introduced to eliminate the ping-pong effect, which is the scenario of repeated handoff between two adjacent BSs caused by rapid fluctuations in the RSS from both of the BSs. Soft handoff is a make-before-break method [3]-[6]. With soft handoff, an active set is maintained, which is the set of all the BSs with which an MS is communicating. Depending on the changes in RSS from the two or more BSs involved, a hard decision will eventually be made to communicate with only one BS. This normally happens after it is clear that the signal from one BS is considerably stronger than those from the others. In the interim period, the MS has simultaneous communication with all BSs in the active set. Generally, three parameters are specified in a soft handoff algorithm: the add threshold T_{add}, the drop threshold T_{drop}, and the drop timer D_{time}. When the pilot signal from a new BS exceeds that from the serving BS by a threshold value T_{add}, a new link to the new BS is established while maintaining the existing link. In this case, the call is said to be in soft handoff. We here assume that an MS can be in soft handoff with two strong BSs. When the RSS from either the old BS or the new BS weakens below T_{drop} and remains there for D_{time}, the bad connection is released and only a single good connection is maintained. The MS should reset and disable the timer if the level of RSS goes above the drop threshold T_{drop} before the timer expires.

The rest of this paper is structured as follows. The proposed adaptive soft handoff algorithm is presented in Section 2. Performance metrics to measure the performance of soft handoff are derived in Section 3. In Section 4, the simulation environment is described and the proposed adaptive handoff algorithm is compared with the static soft handoff algorithm. Finally, concluding remarks are presented in Section 5.