

## Research Article

### Performance Analysis of Channel-borrowing Hand-off Scheme in CDMA Cellular Systems

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**Abstract:** For cellular communication systems, mobility and limited radio coverage of a cell require calls to be handed over from one Base Station System (BSS) to another. Due to the limited band width available in various cells, there is a finite probability that an ongoing call, while being handed off, may get dropped. Minimizing the dropping of ongoing calls during hand off is an important design criterion. Some digital cellular systems, e.g., the Global System for Mobile Communications and the IS-136, use Mobile-Assisted Hand off (MAHO), in which a Mobile Terminal (MT) assists, its BSS and a mobiles witching center in making hand off decisions. MAHO requires an MT to regularly report, back to its serving BSS, its current radio-link state (defined in terms of the Received Signal Strength Indicator (RSSI) and the Bit Error Rate (BER)) of transmissions received from neighboring BSSs. In the proposed technique, the MT reports back not only the RSSI and the BER but the number of free channels that are available for the hand off traffic as well. This will ensure that a handed-off call has acceptable signal quality as well as a free available channel. The performance of this hand off technique is analyzed using an analytical model whose solution gives the desired performance measures in terms of blocking and dropping probabilities.

**Keywords:** Bit Error Rate (BER), cellular communications, handoff, HC-handoff call, NC-new call

## INTRODUCTION

Handoff is an important aspect of cellular and mobile communication. Typically, a Mobile Terminal (MT) has a radio link to a Base Station System (BSS) that provides “best service” to the MTs that are currently located within a cell. A cell’s BSS provides a radio link to each MT that is active in this cell. One or more BSSs are, Interns, under the control of a Mobiles witching Center (MSC). Aside from other functions, an MSC has the primary responsibility of managing mobility. If and when an MT moves, it is quite possible that the currently serving BSS may no longer be able to provide reasonable quality of service as compared to some other BSS. Rather than dropping the service to this MT, the currently serving MSC may decide to hand over this service to some other better serving BSS or, in some cases, to another MSC. Several different hand-off techniques have been proposed and implemented.

A detailed survey of different hand off techniques that are deployed in various cellular net works can be found in Veeravalli and Mantravadi (2002). However, soft hand off is not technically convenient for the time-division multiple-access-based GSM or DAMPS. The

possibility of handing off calls from one cellular technology, e.g., DAMPSIS-54, to another standard (Suwon *et al.*, 1996). The newer mobile IP-based standards such as the IEEE802.16e (Almutairi *et al.*, 2010) allow both the MT and the network to initiate and make hand off decisions. However, the criterion used for making hand off decisions is still based on the link quality alone.

There are variety of studies which can be explained how to resolve the handoff problems about strength of signal, station distance, traffic coverage and soft handoff schemes have been conveyed in the performance of analysis process. About Soft handoff Studies reconnoitered the effect of the dimension of the CDMA system capacity, hard handoff mechanism. For Load analysis and System efficiency (Goldsmith and Varian, 1997) are studied in various levels.

In CDMA Cellular communication system contains lot of essential enactment analysis like soft handoff and communication passing mechanism (Kim *et al.*, 2001), Known problem in soft handoff process, is nothing but connection of mobile between two stations. Signal overlap is looked-for because handoff is mandatory in mobile communications systems when an MS passages

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from one BS coverage area to another for the duration of a conversation. Link between old BS and MS becomes unusable since the dialogue requests to be tendered above to the channel are always critical. Otherwise, the call is lost. For this handoff issues handled by Handoff Detection, Channel Assignment, Coverage Link Transfer.

## MATERIALS AND METHODS

Our intended CDMA cellular system which is given in a geographical network area is divided into limited cells. The mutual exclusive prying lower a unobjectionable inception is achieved by allocating a stable set of duplex channels in each cell is differed from the adjacent cells. In idle case or free channel the NC is connected and it makes the availability of the new call is attempted when base station starts with hexagon cells if this attempts meet failure then the arrival of fresh call is jammed.

At the moment of traveling Mobile Station (MS) is crossed above the NC region and the network in the earlier is portion cell and recreated from started region and an lazy network is mandatory in the objective cell (near base station), its acts as the fresh offering cell for that existing call. This is called as handoff. If there is an existence of idle or free channel is the objective cell, with the remarkable Handoff Call (HC) remains virtually visibly to the handler. If not, the handoff call is released. This research fully focuses on both radio network distribution and radio frequency disasters. This inspected analysis scheme involves of a vile location organizer networks with multiple vile positions.

Blocking with respect to the New Call (NC) is painstaking less forbidding compare with sinking of a handoff call. The purpose of dropping call is to minimize the probability and serve to the preset number of channels. These kind of reserved methods are called as guard channels. These methods are temporary and numerous frequency letdown and salvage are discussed in Zhang and Holtzman (1998).

Mobility of transfer from Mobile station into Service station is less forbidding with less energy and sinking between channels is also the primary motive. Frequencies between the channels and dropping calls are always decided the performance measurements (Suwon *et al.*, 1996). Remarkable performances of the systems are totally enhancing and cut off the free handoff techniques are always measurable at the time of evaluation (Rappaport, 1996). Synchronization and measurements between the channels are always measured with bandwidth and frequencies.

In the previous section, we analyzed multi criteria hand off technique in which an MSC makes hand off decisions based on two parameters, viz., RSSI and channel availability. This section describes two possible

ways to implement this multi-criteria hand off scheme. This hand off scheme assumes that the controlling MSC assisted by the MT makes and implements the handoff decisions. The controlling MSC makes these decisions based on the following:

- Downlink (BSS to MT) RSSI measurements made by the MTs by measuring the signal strength of the Forward Control Channel (FCCH) from different BSSs.
- Uplink (MT to BSS) channel information provided by the BSSs to the MSC periodically or when ordered to do so by the MSC.
- Channel availability at different base stations.

The down link RSSI measurements are made by an MT either periodically or on specific orders sent by its serving MSC. The channel availability in a cell can be evaluated in two different ways.

A BSS regularly broad casts data about the number of free channels available with it. ABSS may send this information over its FCCH (i.e., from the BSS to the MTs). FCCH (being abroad cast channel) information pertaining to the number of free channels currently available in a particular cell thus gets communicated to all the reachable.

Cell is always covered with handoff area and normal boundary and assumed that six cells are surrounded. A handoff threshold like TADD and TDROP is serving as a broadcast by the base station. Communication Ratio minimal of  $\beta$  is the handoff part to the complete cell part is given as:

$$\beta = \frac{\text{the area of the handoff region}}{\text{the area of the cell}} \quad (1)$$

**Implementation:** Even in TDMA systems modeling accurate hand off are a difficult problem because of various factors, such as irregular cell boundaries, traffic conditions and the movement of MS's (Goldsmith and Varian, 1997). To analyze soft hand off we make the following assumptions:

- The cell is square shaped (Ligdas and Farvardin, 2000; Lawrence, 1999).
- MS's initiating calls are uniformly distributed through-out all cells.
- The residual times are generally distributed (Suwon *et al.*, 1996).
- New call arrival per cell follows a Poisson process with rate  $\lambda_n$ .
- The call holding time  $T_c$  is exponentially distributed with mean  $1/\mu_c$ .

Figure 1 illustrates an example of regions and boundaries based on a square cell structure. For

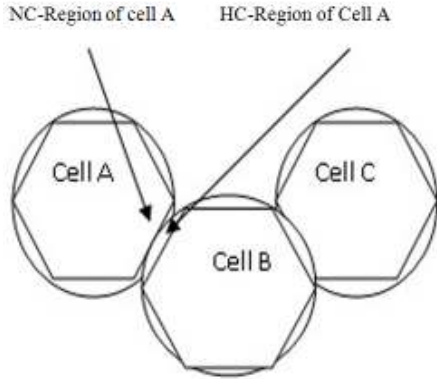


Fig. 1: Process model of soft handoff

geometrical simplicity it is assumed that one cell area is divided into three regions in the analysis of soft hand off. These regions are:

- The inner cell region
- The SR
- The outer cell region

These regions are bounded by an inner boundary and an outer boundary. The region bounded by a cell boundary is called an ordinary cell. Even when an MS is in soft hand off, another hand off occurs if the pilot signal from a third BS becomes stronger than one of the

original pilot signals. Thus, we here introduce an overlap region, which is the region between two overlapping adjacent outer cells. In this cell structure the SR is sub divided into four overlap regions. For hexagonal cell structure, the SR consists of six overlap regions. The region excluding the SR in the ordinary cell is called a non-SR.

Two cases of mobile calls can be considered to investigate soft hand off. In the first case, an MS that makes a new call in an NSR (A0) requests a hand off at an inner boundary (A1) and then the old BS (cell 2) releases the old connection to the MS at an outer boundary (A2). Finally, the mobile call is terminated at A3. In these condcase, an MS requests a hand off just after its new call connection. Then the BS (cell 4) executes (Fig. 2).

**Hand off call attempt rate:** To calculate the handoff call attempt rate  $\lambda_{hs}$ , we first consider when anew call arrives in an NSR with probability  $P_{NS}$ . Noh and off Request (HOR) occurs if the new call is blocked or if the remaining call holding time is shorter than the residual time in an inner cell. Otherwise, an HOR occurs. No more HOR's occur if the following conditions are satisfied. Residual times in an inner cell, in an overlap region and in an outer cell are denoted by  $T_{li}$ ,  $T_{vi}$  and  $T_{vi}$  for a new call, respectively and  $T_{lh}$ ,  $P_{NS}$ , and  $P_{NS}$  fore hand off call, respectively. These

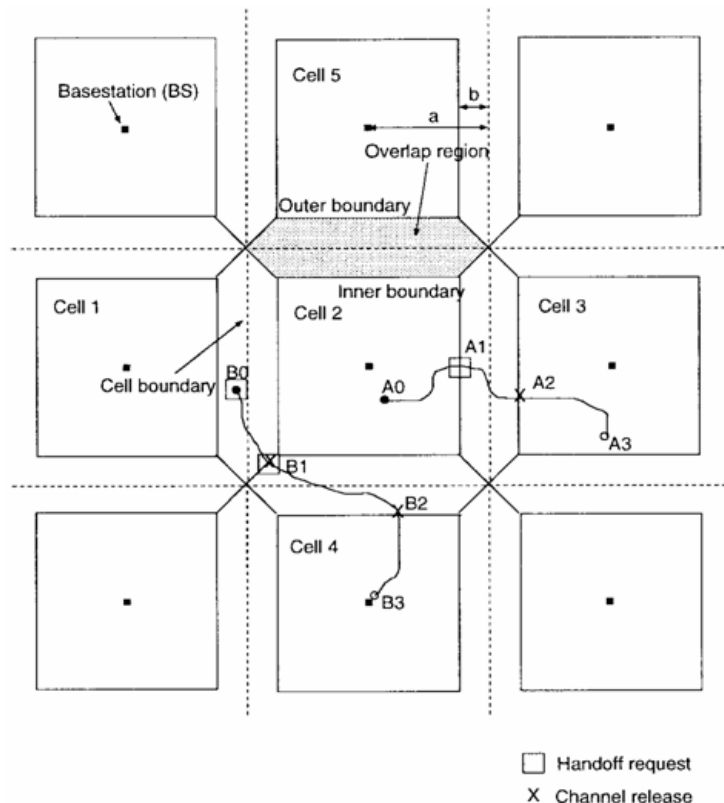


Fig. 2: Process model of two cases of mobile calls to investigate soft hand off

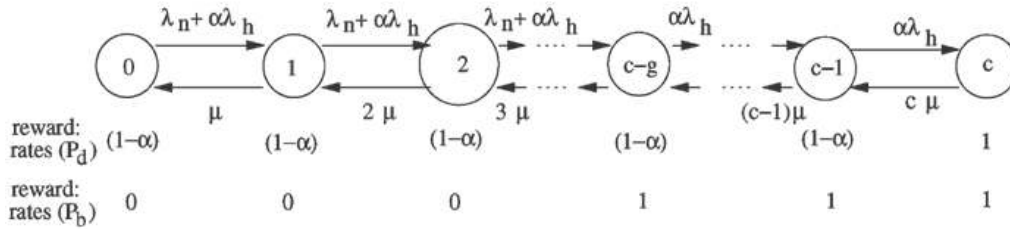


Fig. 3: Obtained channel holding time

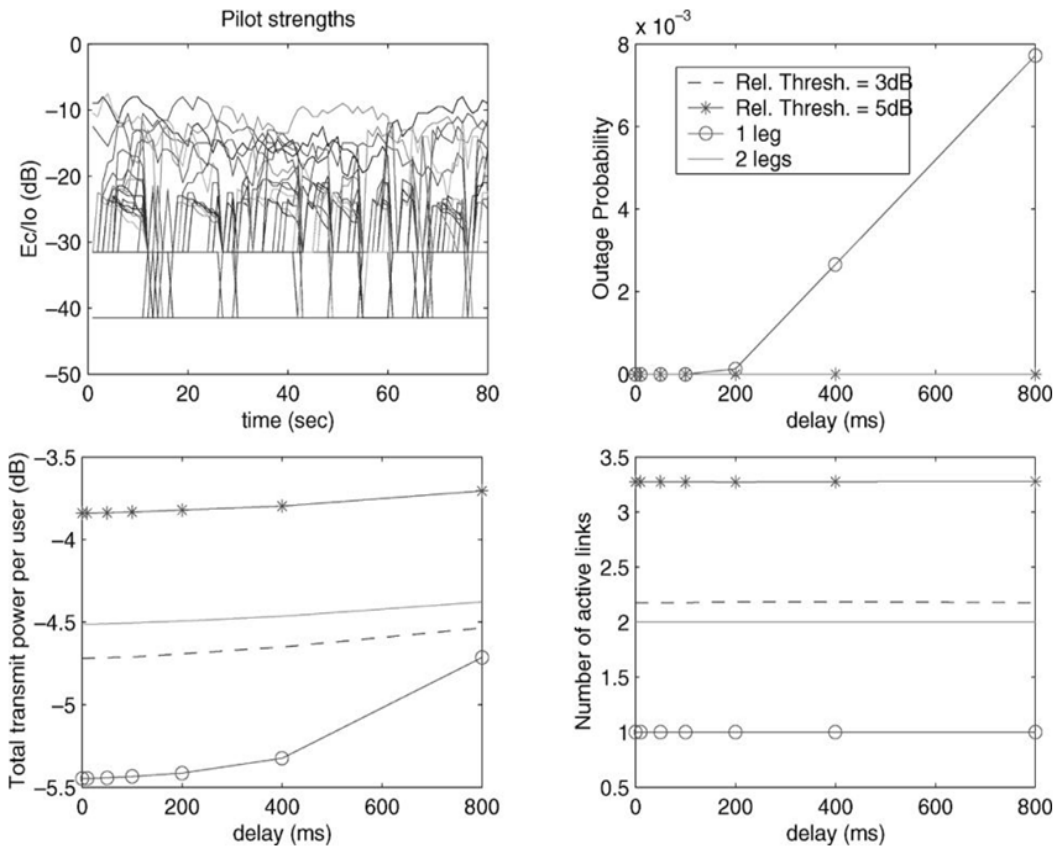


Fig. 4: Active-set update corresponding to the handoff decision at a given time is performed after the pre-scribed delay

Residua times depend largely on cell size and terminal mobility factors, such as terminal speed and direction. Let  $P_{li}$  ( $P_{Vi}$ ) and  $T_{Vi}$  ( $P_{Vh}$ ) denote the probability that a new call leaves the inner cell (over lap region) before its call completion and the probability that a hand off call leaves the inner cell (over lap region) before its call completion, respectively.

**Channel holding time:** Applying the above assumptions the hand off call attempt rate and the channel holding time can be obtained. The hand off call attempt rate  $\lambda_h$  is given by Zhang *et al.* (2009) and can be obtained as (Fig. 3):

$$\frac{(1 - P_B)x(P_{NS}P_I + P_S)}{\{1 - (1 - P_{fh})y\}^2}$$

## RESULTS AND DISCUSSION

In this section, we present results obtained by analyzing data collected from field measurements. Pilot SINR measurements of all the pilots in the neighbor list (the set of all signals that the mobile has to search for potential handoffs) of an IS-95 CDMA system were obtained using standard drive test techniques for a suburban morphology. The pilot SINR data was then used to study the effect of handoff delay. We essentially replace the path loss model by the measured pilot SINRs and study the effect of handoff delay by simulation. The simulation study using the measured data is described later.

At each time sample, an active-set update decision is implemented based on the active-set selection criterion. Handoff decisions are made every 10 msec

based on linearly interpolated measurements of the SINR. The active-set update corresponding to the handoff decision at a given time is performed after the pre-scribed delay. This delay is a variable and the performance is shown in Fig. 4.

### CONCLUSION

In this study, we presented a semi analytical model to study the performance degradation of soft and hard handoff schemes in a downlink CDMA system due to delay in the completion of handoff decisions. We also verified conclusions drawn from our analytical models through simulations based on data collected from field measurements in an IS-95 CDMA system. We studied the total power requirement and probability of outage of such a system as a function of the handoff-completion delay. From the results, we can conclude that soft handoff is indeed required for reasonable values of handoff execution delay that is expected in practical systems. However, if handoffs can be completed considerably faster, in less than 50 msec or so, hard handoff can provide a capacity enhancement. A larger delay can be tolerated when other forms of link diversity, such as antenna diversity, mitigate the fast fading component of the signal, thereby reducing the rate of time variations of the signal. The average transmitted power can be reduced by reducing the completion delay, thereby increasing system capacity. The gain that can be achieved is a function of the deployment scenario, nature of the environment and proximity and number of the surrounding base stations.

Our results are based on the sensitivity of soft and hard handoff schemes to hysteresis threshold, distance from the base stations and the nature of signal fading through our analytical model. As the channel uncertainty increases (increase in standard deviation of shadow fades) and as the dominance of the signal from a single base station reduces, handoff completion delay plays a more important role in system performance.

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