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Generalized selection combining scheme with double threshold in the soft handover region ☆

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ABSTRACT

A new diversity selection combining scheme in a multiple Base Stations (BSs) scenario is proposed, in order to minimize the impact of suddenly losing one active BS in the soft handover (SHO) region. By analyzing the average number of path estimations and the average number of combined paths, we can see that the proposed scheme has a satisfactory average bit error ratio (ABER) but with a low complexity, as compared by the conventional distributed combining schemes. Simulation results validate the superiority of the proposed scheme.

1. Introduction

Diversity combining scheme is an effective technique to combat the multi-path fading by increasing the signal-to-noise ratio (SNR) of the receiver. Although its performance can be improved further by increasing the number of combined paths increasing, the complexity of the receiver becomes severely worse. However, most related studies focus only on a single Base Station (BS), such as the generalized selection combining scheme (GSC), the GSC with threshold test for each path (T-GSC) [1], the minimum selection GSC (MS-GSC) [2,3] and the adaptive GSC (A-GSC) [4].

Recently, some researchers have been attracted to study the diversity combining scheme on a distributed way, i.e. the multi-BS case. Seyeong et al. proposed a new finger assignment scheme in the soft handover (SHO) region [5], in which if the quality of the received signal from the serving BS is unsatisfactory, the receiver begins to scan some additional resolvable paths from a neighboring BS and then selects the strongest paths among the total available paths from both the serving BS and the neighboring BS. Then the two BSs case was extended to a multi-BS case in [6], and two assignment schemes were proposed, i.e., the full scanning scheme and the sequential scanning scheme. In the full scanning scheme, the receiver scans all available paths from all target BSs. While, in the sequential scanning scheme, the receiver sequentially scans the target BSs until the combined SNR is satisfactory or all target BSs are scanned. Other popular finger combining schemes in multi-BS also were proposed, such as the block change scheme [7,8], the distributed GSC and the distributed MS-GSC [9].

We proposed a GSC with a double threshold (DT-GSC) scheme in a single BS scenario [10,11], in which the receiver selects any path whose SNR is above an input-threshold and the process will keep running until the output combined SNR is larger than an output-threshold, or all the paths are examined. The proposed DT-GSC scheme has lower complexity than the conventional single-BS combining schemes while maintains a satisfactory performance. Here, besides we directly extend the DT-GSC to the multi-BS case, we also propose a new version of DT-GSC (NDT-GSC) for the multi-BS case.

The main idea of NDT-GSC is that, if a mobile station (MS) suddenly ends up a connection with one BS due to a corner effect, MS will adaptively adopt some good paths from other BSs in order to minimize the possibility of call drops [9]. In [9], the distributed GSC and the distributed MS-GSC are proposed and they are the extended versions of the GSC and MS-GSC, respectively. Both schemes have to examine and rank all available paths. However, in the proposed NDT-GSC scheme, the receiver selects any path whose SNR is above an input-threshold, and the process will keep running until the output combined SNR is larger than the output-threshold or until all the paths are examined. More important, there is not any ranking operation in NDT-GSC.

By analyzing the average number of path estimations and the average number of combined paths, the proposed scheme maintains a low outage probability but with a low complexity, as compared by the conventional distributed combining schemes. Simulation results will validate the superiority of the proposed scheme.

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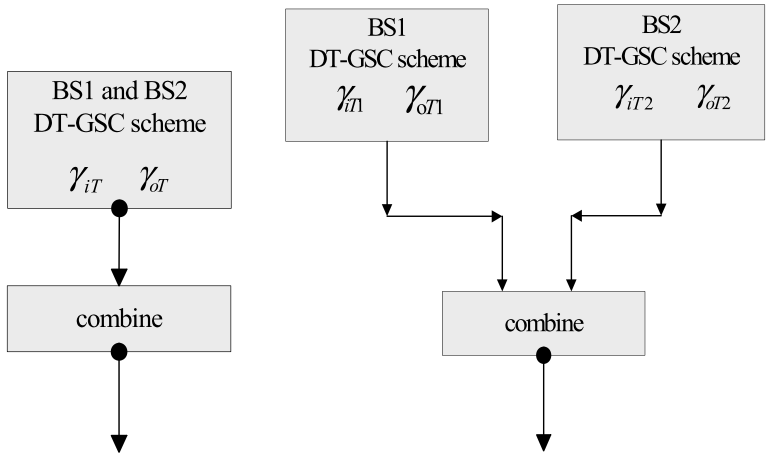

(a) Multi-BS DT-GSC (b) NDT-GSC

Fig. 1. Operation mode of NDT-GSC and Multi-BS DT-GSC scheme in a two BSs case.

2. System model

Just like in [9], we consider a situation in which an MS is moving from a coverage area of its serving BS to that of its neighboring BS. We assume in the SHO region, the distance from the MS to its serving BS and its neighboring BS keep roughly the same. In this paper, we only consider a two BSs case for simplicity, where L_1 and L_2 are the number of available paths from BS1 and BS2, respectively. But the extension of the proposed scheme to a more BSs case is straightforward. Any signal from a resolvable path experiences an independent and identically distributed fading channel. The received signal over the lth diversity path in each BS can be expressed as

$$r_l(t) = a_l e^{-j\theta_l} s(t) + n_l(t) \tag{1}$$

where a_l is the random magnitude of lth diversity path with Rayleigh distribution, θ_l is the random phase shift of lth diversity path with uniform distribution, $s(t)$ is the information-bearing signal with average symbol energy E_s and $n_l(t)$ represents an additive white Gaussian noise (AWGN) with double-side power spectral density N_0 (W/Hz).

We consider two BSs as an example. First of all, applying directly our prior DT-GSC scheme [10,11] in a multi-BS scenario (Multi-BS DT-GSC), shown in Fig. 1(a), in which we set one input-threshold γ_{iT} and one output-threshold γ_{oT} for both BSs. The Multi-BS DT-GSC scheme selects the path over all the BSs whose SNR is above an input-threshold γ_{iT} to be combined, and this process will keep running until the combined output SNR is larger than an output-threshold (γ_{oT}), or all paths are examined. Then we propose the NDT-GSC scheme, shown in Fig. 1(b), in which we set one independent pair of thresholds for each BS (γ_{iTk} and γ_{oTk}, $k = 1, 2$), respectively. For the purpose of comparing with the Multi-BS DT-GSC scheme, we set $\gamma_{iT1} = \gamma_{iT2}$ and $\gamma_{oT1} + \gamma_{oT2} = \gamma_{oT}$. For the BS1, the NDT-GSC scheme selects the path whose SNR is above an input-threshold γ_{iT1} to be combined, and this process will keep running until the combined output SNR is larger than an output-threshold γ_{oT1}, or all paths in BS1 are examined. Similarly, for the BS2, the receiver selects the path whose SNR is above an input-threshold γ_{iT2} to be combined, and this process will keep running until the combined output SNR is larger than an output-threshold γ_{oT2}, or all paths in BS2 are examined. Obviously, we can extend this proposed scheme directly to a multiple BSs case. For NDT-GSC, we set γ_{iTk} and γ_{oTk}, $k = 1, 2, \ldots, n$, for the kth BS and we assume that $\gamma_{iT1} = \gamma_{iT2} = \cdots = \gamma_{iTn}$ and $\gamma_{oT1} + \gamma_{oT2} + \cdots + \gamma_{oTn} = \gamma_{oT}$.[1] We set γ_{iT} and γ_{oT} empirically. γ_{iT} is mainly designed to measure instantaneous SNR of each path. γ_{oT} is mainly designed to make the combined output SNR satisfy some QoS criterion, e.g., the bigger the value of both thresholds is, the better the channel environment is, and vice versa.

3. Performance analysis

Since we have obtained the mathematical expressions for the average number of path estimations and the average number of combined paths of the DT-GSC scheme for a single BS case in [11], the mathematical expressions of Multi-BS DT-GSC are easily obtained. In a similar way, we can obtain the average number of combined paths in NDT-GSC as follows,

$$\bar{N}_C = (1 - P_1)\bar{N}_{c1} + (1 - P_2)\bar{N}_{c2} \tag{2}$$

where P_1 and P_2 are the probabilities of losing BS1 and BS2, respectively, which can be statistically characterized from the corner effect [9]. $\bar{N}_{c1}$ and $\bar{N}_{c2}$ represent the average number of combined paths in BS1 and BS2 which are denoted as

$$\bar{N}_{c1} = \sum_{l=0}^{L_1} l \cdot \Pr[N_{c1} = l] \tag{3}$$

$$\bar{N}_{c2} = \sum_{l=0}^{L_2} l \cdot \Pr[N_{c2} = l] \tag{4}$$

where

$$\Pr[N_c = l] = \begin{cases} q_1^L, \quad l = 0 \\ L \cdot q_1^{L-1} \cdot q_2 + q_3 \cdot \sum_{i=0}^{L-1} q_1^i, \quad l = 1 \\ \binom{L}{l} \cdot F^{(l)}(\gamma_{oT}) \cdot q_1^{L-l} \\ \quad + [q_4 \cdot F^{(l-1)}(\gamma_{oT}) - F^{(l)}(\gamma_{oT})] \\ \quad \cdot \sum_{i=0}^{L-l} \binom{l-1+i}{l-1} \cdot q_1^i, \quad 2 \leqslant l \leqslant L-1 \\ F^{(L-1)}(\gamma_{oT}) \cdot q_4, \quad l = L \end{cases} \tag{5}$$

The detailed derivation of $\Pr[N_c = l]$ can be found from page 9 to page 10 in [11].

[1] We assume that each BS has its unique identified code and each receiver can distinguish the corresponding signal belong to which BS according to its identified code.