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Transmit Power Efficiency of Multi-Hop Hybrid Selection/MRC Diversity for a DS-CDMA Virtual Cellular Network

Imane DAOU, Eisuke KUDOH and Fumiyuki ADACHI
Department of Electrical and Communication Engineering, Graduate School of Engineering, Tohoku University

1. Introduction

In a multi-hop virtual cellular network (VCN) proposed for high data rate mobile communication network, the signal transmitted from a mobile terminal is received by the wireless ports distributed in a virtual cell and relayed to the central port that acts as a gateway to the core network. In this paper, Multi-Hop Hybrid Selection/MRC is introduced to reduce the transmit power in the DS-CDMA VCN. The transmit power efficiency is evaluated by computer simulation.

2. Multi-hop Hybrid Selection/MRC diversity

Fig. 1 explains the concept of multi-hop H-S/MRC with J selected received signals. We assume that the received signal from the immediately previous port is always selected in H-S/MRC. We consider an n-hop connection from the mobile terminal to the central port; port #i=0 is the mobile terminal and port #i=n is the central port, whereas port #i=1~n-1 the intermediate port. Port #i=2~n receives not only the signal transmitted by the port #i-1, but also the same signal from ports #0, #1,…, #i-2.Therefore the port #i selects J-1 strongest received signals among the received signals from ports #0, #1,…, #i-2, and combines them with the one received from immediately previous port #i-1 using MRC combining, before relaying the combined signal to port #i+1. MHMRC diversity is a special case of multi-hop H-S/MRC with J equal to the number of the previous ports. In order to evaluate the transmit power reduction with H-S/MRC, the transmit power is derived below.

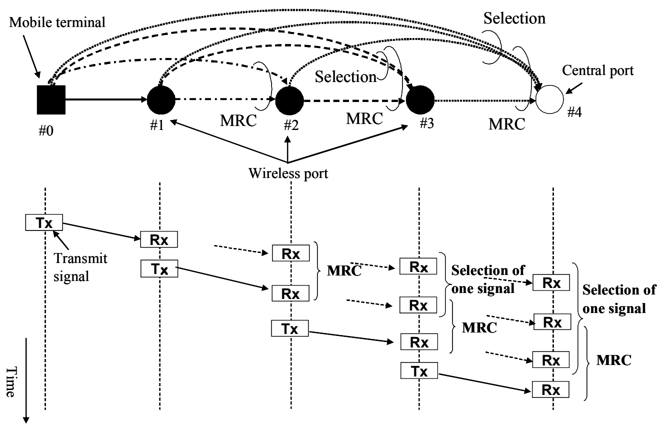

Fig. 1 Multi-hop H-S/MRC process for J=2.

For an n-hop connection, in the multi-hop H-S/MRC, in order to decide the transmit power of the port #i-1, the wireless port #i selects J-1 strongest received signals to combine them. Therefore the transmit power $P_t(i-1)$ is given by

$$P_t(i-1)=\frac{P_{req}-\sum_{j=0}^{J-2}P_t(s_j)d_{s_j,i}^{-\alpha}10^{-\frac{\eta_{s_j,i}}{10}}\sum_{l=0}^{L}\left|\xi_{s_j,i}(l)\right|^2}{d_{i-1,i}^{-\alpha}10^{-\frac{\eta_{i-1,i}}{10}}\sum_{l=0}^{L}\left|\xi_{i-1,i}(l)\right|^2} \quad ,(1)$$

where s_j is the selected wireless port index, and $(s_0, s_1, \ldots, s_{J-1}) \in (0,1,2,\ldots, i-1)$. Since the received signal from the immediately previous wireless port is always selected, signal $s_{J-1}=i-1$. P_{req} is the required received signal power, α is the path-loss exponent and $d_{i,j}$, $\eta_{i,j}$ and $\xi_{i,j}$ are respectively the distance, the shadowing loss (in dB) and the l-th path complex path gain between wireless ports #i and #j. Assuming the uniform power delay profile of the multi-path channel, $\{\xi_{i,j}\}$ are independent complex Gaussian variables with zero-mean and $E[|\xi_{i,j}|^2]=1/L$, where E[*] denotes the ensemble average operation.

If the sum of the received powers, $P_r(i)$, at the port #i from the ports #s_0~#s_{J-2} is larger than the required received power P_{req}, i.e., $P_r(i) \geq P_{req}$, the port #(i-1) can be removed from the constructed route, i.e., $P_t(i-1)=0$; the port #i re-selects the (J-1) strongest received signals from the previous ports excluding the port #(i-1), and the transmit power $P_t(i-2)$ of the port #(i-2) is given by Eq. (1) with replacing (i-1) by (i-2). Using this route modification algorithm, the number of hops decreases and consequently, the delay time also decreases.

Fig. 2 plots the multi-hop H-S/MRC total transmit power along the route normalized by that of single-hop case as a function of the maximum number N of allowable hops with J as a parameter for α=3.5, σ=7dB, L=2, the fading correlation ρ=0, and the number of wireless ports K=50. MHMRC diversity is a special case of multi-hop H-S/MRC with J=10. It is seen that as J increases, the power reduction also increases, and MHMRC gives the best performance since it combines all the received signals. However, the loss in the power reduction with J=5 is only 20% when N=10.

3. Conclusions

In this paper, Multi-hop H-S/MRC diversity was introduced to reduce the route total transmit power in the multi-hop VCN and reduce the diversity complexity. A route modification algorithm was also presented. The number of selected received signals effect in the Multi-hop H-S/MRC diversity gain was evaluated by computer simulation. MHMRC (J=10) gives the largest power reduction from the case of no diversity. It was found that as J decreases, the power reduction effect decreases, but the loss in the power reduction with J=5 is only 20% when N=10.

Acknowledgement

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References

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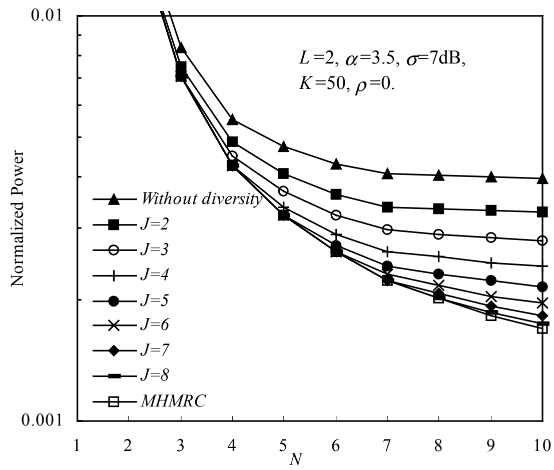

Fig. 2 Impact of the number of selected signals J in the transmit power.