A Consideration on the Spatial Diversity Effect on Multi-Hop Ad Hoc Networks under Rayleigh Fading Environments

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レイリーフェージング環境下のマルチホップ無線アドホックネットワークにおける空間ダイバーシティ効果に関する一検討

A consideration on the spatial diversity effect on multi-hop ad hoc networks under Rayleigh fading environments

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1 Introduction

Although applications of diversity antennas to wireless ad hoc networks have been paid attention, the performance of multi-hop networks under Rayleigh fading has not been very well examined. In this short paper, the performance improvement brought by the diversity antenna will be clarified through computer simulations.

2 Formulations

The received signal consisting of M element waves received by N antennas are expressed as a vector of size $(N \times 1)$ as follows:

$$\boldsymbol{x}(t) = \sum_{m=1}^{M} \frac{\sqrt{P_S}}{M} \boldsymbol{a}(\theta_m) s(t) e^{j\phi_m} + \sqrt{\frac{P_N}{2}} \boldsymbol{\eta}(t) \quad (1)$$

where $\boldsymbol{a}(\theta_m) \in \mathcal{C}^{N\times 1}$ is the steering vector as a function of the direction of arrival (DOA) $\theta_m$while ϕ_m is the initial phase. The subscript $\cdot_m$ denotes the m-th element wave. The noise vector with the unit power is denoted by $\boldsymbol{\eta}(t) \in \mathcal{C}^{N\times 1}$. Then, the signal-to-noise power ratio (SNR) of the received signal Γ_{in} is defined as P_S/P_N.

Then, the correlation matrix $\boldsymbol{R}_{xx} \in \mathcal{C}^{N\times N} = \mathcal{E}[\boldsymbol{x}\boldsymbol{x}^{\mathcal{H}}]$ is decomposed by the eigenvalue decomposition (EVD) to obtain the weight vector $\boldsymbol{w} \in \mathcal{C}^{N\times 1}$ by the eigenvector corresponding to the maximum eigenvalue. Here, $\mathcal{E}[\cdot]$ denotes the emsemble average. Note that $\|\boldsymbol{w}\| = 1$. Then, the antenna output is obtained by $y(t) = \boldsymbol{w}^H \boldsymbol{x}(t)$ with the antenna output SNR Γ_{out} as:

$$\Gamma_{out} = \frac{|\sum_{m=1}^{M} \frac{\sqrt{P_S}}{M} \boldsymbol{w}^H \boldsymbol{a}(\theta_m)|^2}{P_N} \quad (2)$$

3 Computer simulations

Table 1 lists simulation conditions. We assume an on-demand type wireless ad hoc network with AODV [1] for the route finding. Also, it is assumed that the media access control employs CSMA/CA. All nodes are under Rayleigh fading consisting of 10 element waves. Then, we compare the performance in terms of the number of the necessary hops till the arrival of Route REQest (RREQ) packets to the destination with and without the antenna diversity. In this simulation, it is considered that the channel is unavailable if $\Gamma_{out} < 8.5$[dB]. Figure 1 shows the success rate of RREQ versus the number of nodes. It is seen that the antenna diversity contributes to the improvement of the RREQ success rate due to the compensation of fading. Figure 2 shows Cumulative probability Distribution Function (CDF) for the number of hop only when RREQs are successful. It is clearly found that the antenna diversity reduces the number of hops also drastically.

表 1 Simulation conditions

Antenna	6-element circular
Path loss	Free space (square-law)
Receiving SNR Γ_{in}	10[dB] @ 10m
Num. of element waves M	10
DOA θ_m	Uniformly random within [0,360][deg]
Phase ϕ_m	Uniformly random within $[0, 2\pi]$[rad]

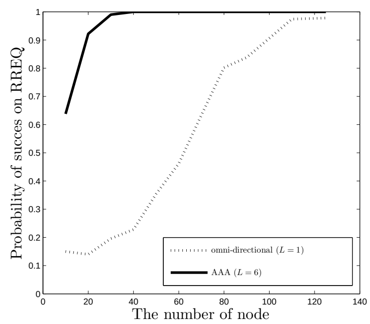

図 1 The number of nodes versus RREQ success rate

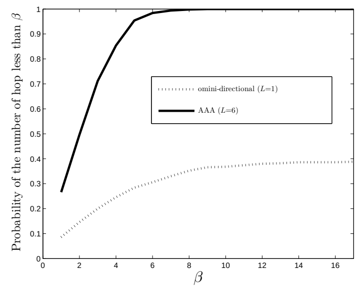

図 2 CDF of the number of hop

4 Concluding remarks

In this short paper, we clarify the effect of the antenna diversity under Rayleigh fading to the performance of the wireless ad hoc networks with AODV in terms of the number of hops. More realistic scenario will be reflected in the simulations as a further consideration.

参考文献

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