Performance Analysis of Mobile Video Networks

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Abstract. With the tremendous growth of mobile videos, mobile video communication is becoming increasingly important to influence users browsing and searching experience.In this paper, we present the approximate average symbol error probability (ASEP) and outage probability (OP) performance for mobile video networks. We derive the exact closed-form OP and ASEP expressions for amplify-and-forward (AF) relaying. The analytical results match perfectly with the simulation results. Further, we evaluate the impact of power allocation on OP performance.

Keywords: mobile video networks; amplify-and-forward, average symbol error probability; outage probability;

1. Introduction

In recent years, mobile video communication has attracted significant attention from both academic and industrial fields [1]. Based semi-blind video watermarking algorithm, [2] proposed a robust block classification to enhance the robustness performance. In [3], the authors presented a framework to collect videos from smartphones in the public.

Cooperative diversity has been employed to improve the quality of service (QoS) for mobile communication.The authors applied the innovative multi-objective optimization methods to maximize the rate quality, and minimize the total transmission power [4]. The authors investigated performance analysis for an energy harvesting relay system with multiple co-channel interferences over Nakagami-m fading channels [5].

In [4,5], the performance is only considered for Rayleigh and Nakagami-m fading channels. However, the effects of mobile video communication is far severe than what can be modeled using the Rayleigh and Nakagami-m fading channels [6].Therefore, the study on the performance of the mobile video networks is essential. In this paper, we derive the exact closed-form average symbol error probability (ASEP) and outage probability (OP) expressions for amplify-and-forward (AF) relaying. Furthermore, the theoretical results demonstrate excellent agreement with Monte-Carlo simulation results,which validates our analysis.

The rest of the paper is organized as follows. The mobile video networks model is presented in Section 2. We have investigated OP and ASEP performance in Section 3,4. Section 5 conducts Monte-Carlo simulations to verify the analytical results. Finally, we conclude the paper in Section 6 .

2. The System Model

Figure 1. shows mobile video transmission networks model. With the help of L single-

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antenna mobile relay (MR) nodes, the mobile source (MS) communicates with mobile destination (MD) node.

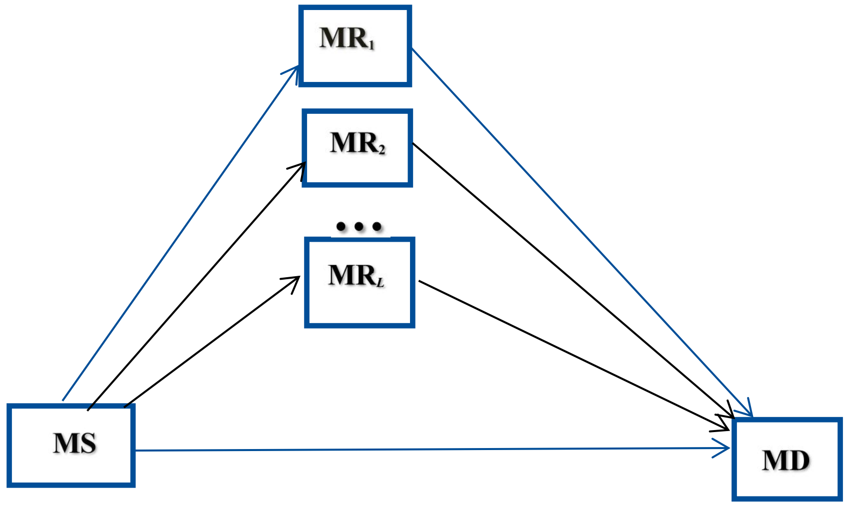

Fig. 1. The system model

We use h=h_z, $z\in\{$SD, SRl, RD$l\}$, to represent the complex channel coefficients.h follows N-Nakagami distribution[6].The total transmission energy is E.

MS transmits the video signal x in the first time slot. MD and MR$_l$ receive video signals as

$$r_{\mathrm{SD}} = \sqrt{KE}h_{\mathrm{SD}}x + n_{\mathrm{SD}} \tag{1}$$

$$r_{\mathrm{SR}l} = \sqrt{G_{\mathrm{SR}l}KE}h_{\mathrm{SR}l}x + n_{\mathrm{SR}l} \tag{2}$$

where the relative gain of the MS→MD link is G_{SD}=1, $G_{\mathrm{SR}l}$ is the relative gain of MS→MR$_l$, the mean and variance of $n_{\mathrm{SR}l}$ and n_{SD} are 0 and N_0/2. K is the power-allocation parameter.

In the second time slot,we only select the best MR to participate in cooperation

$$\gamma_{\mathrm{R}^*} = \max_{1\le l\le L}(\gamma_l) \tag{3}$$

where

$$\gamma_l = \frac{\gamma_{\mathrm{SR}l}\gamma_{\mathrm{RD}l}}{1+\gamma_{\mathrm{SR}l}+\gamma_{\mathrm{RD}l}} \tag{4}$$

$$\gamma_{\mathrm{SR}l} = \frac{KG_{\mathrm{SR}l}\left|h_{\mathrm{SR}l}\right|^2 E}{N_0} = KG_{\mathrm{SR}l}\left|h_{\mathrm{SR}l}\right|^2\bar{\gamma} \tag{5}$$

$$\gamma_{\mathrm{RD}l} = \frac{(1-K)G_{\mathrm{RD}l}\left|h_{\mathrm{RD}l}\right|^2 E}{N_0} = (1-K)G_{\mathrm{RD}l}\left|h_{\mathrm{RD}l}\right|^2\bar{\gamma} \tag{6}$$

MD receives the signal as

$$r_{\mathrm{R}^*\mathrm{D}} = \sqrt{cE}h_{\mathrm{SR}^*}h_{\mathrm{R}^*\mathrm{D}}x + n_{\mathrm{DD}} \tag{7}$$

where the mean and variance of n_{DD} are 0 and N_0/2. c is given as [7]

$$c=\frac{K(1-K)G_{\mathrm{SR}^*}G_{\mathrm{R}^*\mathrm{D}}E/N_0}{1+KG_{\mathrm{SR}^*}\left|h_{\mathrm{SR}^*}\right|^2E/N_0+(1-K)G_{\mathrm{R}^*\mathrm{D}}\left|h_{\mathrm{R}^*\mathrm{D}}\right|^2E/N_0} \tag{8}$$

MD uses the selection combining (SC) scheme and receives the SNR as

$$\gamma_{\mathrm{SC}}=\max\left(\gamma_{\mathrm{SD}},\gamma_{\mathrm{SRD}}\right) \tag{9}$$

where

$$\gamma_{\mathrm{SD}}=\frac{K\left|h_{\mathrm{SD}}\right|^2E}{N_0}=K\left|h_{\mathrm{SD}}\right|^2\bar{\gamma} \tag{10}$$

$$\gamma_{\mathrm{SRD}}=\frac{\gamma_{\mathrm{SR}^*}\gamma_{\mathrm{R}^*\mathrm{D}}}{1+\gamma_{\mathrm{SR}^*}+\gamma_{\mathrm{R}^*\mathrm{D}}}=\max_{1\le l\le L}(\gamma_l) \tag{11}$$

With the aid of [8], we can obtain an upper bound γ_{up} as

$$\gamma_{\mathrm{SRD}}<\gamma_{\mathrm{up}}=\min(\gamma_{\mathrm{SR}^*},\gamma_{\mathrm{R}^*\mathrm{D}})=\max_{1\le l\le L}(\min(\gamma_{\mathrm{SR}l},\gamma_{\mathrm{RD}l})) \tag{12}$$

3. The OP of Mobile Video Networks

We obtain the cumulative density functions (CDF) of γ_{up} as

$$F_{\gamma_{\mathrm{up}}}(r)=\prod_{l=1}^{L}\left(\begin{array}{l}\frac{1}{\prod_{t=1}^{N}\Gamma(m_t)}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SR}l}}\prod_{t=1}^{N}\frac{m_t}{\Omega_t}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\+\frac{1}{\prod_{tt=1}^{N}\Gamma(m_{tt})}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{RD}l}}\prod_{tt=1}^{N}\frac{m_{tt}}{\Omega_{tt}}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\-\frac{1}{\prod_{t=1}^{N}\Gamma(m_t)\prod_{tt=1}^{N}\Gamma(m_{tt})}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SR}l}}\prod_{t=1}^{N}\frac{m_t}{\Omega_t}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\\times G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{RD}l}}\prod_{tt=1}^{N}\frac{m_{tt}}{\Omega_{tt}}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\end{array}\right) \tag{13}$$

where $G[\cdot]$ is the Meijer's G-function [6].

The CDF of γ_{SD} is given as

$$F_{\gamma_{\mathrm{SD}}}(r)=\frac{1}{\prod_{i=1}^{N}\Gamma(m_i)}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SD}}}\prod_{i=1}^{N}\frac{m_i}{\Omega_i}\Big|_{m_1,\ldots,m_N,0}^{1}\right] \tag{14}$$

We obtain the approximate OP as

$$F_{\gamma_{\mathrm{SCA}}}(r_{\mathrm{th}})=F_{\gamma_{\mathrm{SD}}}(r_{\mathrm{th}})F_{\gamma_{\mathrm{up}}}(r_{\mathrm{th}}) \tag{15}$$

where r_{th} is a given threshold.

4. The Approximate ASEP of Mobile Video Networks

With the aid of [9], the approximate ASEP is given as

$$P=\frac{a\sqrt{b}}{2\sqrt{\pi}}\int_0^{\infty}\frac{\exp(-br)}{\sqrt{r}}F_{\gamma_{\mathrm{SCA}}}(r)\mathrm{d}r \tag{16}$$

where the different modulation types determine the parameters a and b .

We obtain the approximate ASEP as

$$P=\frac{a\sqrt{b}}{2\sqrt{\pi}}G \tag{17}$$

where

$$\begin{aligned}G=&\int_0^{\infty}\frac{1}{\sqrt{r}}G_{0,1}^{1,0}\left[br\Big|_{0}^{-}\right]G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SD}}}\prod_{i=1}^{N}\frac{m_i}{\Omega_i}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\&\times\prod_{l=1}^{L}\left(\begin{array}{l}\frac{1}{\prod_{t=1}^{N}\Gamma(m_t)}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SR}l}}\prod_{t=1}^{N}\frac{m_t}{\Omega_t}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\+\frac{1}{\prod_{tt=1}^{N}\Gamma(m_{tt})}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{RD}l}}\prod_{tt=1}^{N}\frac{m_{tt}}{\Omega_{tt}}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\-\frac{1}{\prod_{t=1}^{N}\Gamma(m_t)\prod_{tt=1}^{N}\Gamma(m_{tt})}G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{SR}l}}\prod_{t=1}^{N}\frac{m_t}{\Omega_t}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\\\times G_{1,N+1}^{N,1}\left[\frac{r}{\gamma_{\mathrm{RD}l}}\prod_{tt=1}^{N}\frac{m_{tt}}{\Omega_{tt}}\Big|_{m_1,\ldots,m_N,0}^{1}\right]\end{array}\right)\mathrm{d}r\end{aligned} \tag{18}$$

5. Numerical Results

In this section, we define $\mu=G_{\mathrm{SU}}/G_{\mathrm{RU}}$ as the relative geometrical gain. E =1.

Figure 2 presents the ASEP performance versus L. Here, QPSK is used. L=1, 2, 3, μ=0dB, K=0.5, N=2, m=1. We can find that the Monte-Carlo simulation results match perfectly with the theoretical results. Increasing L improves the ASEP performance. For example, when SNR=12dB, the ASEP is 6.6×10^{-2} with L=1, 2.8×10^{-2} with L=2, 1.3×10^{-2} with L=3.

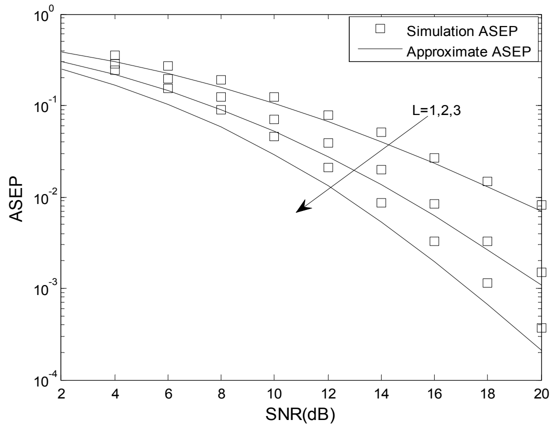

Fig. 2. The ASEP performance versus L

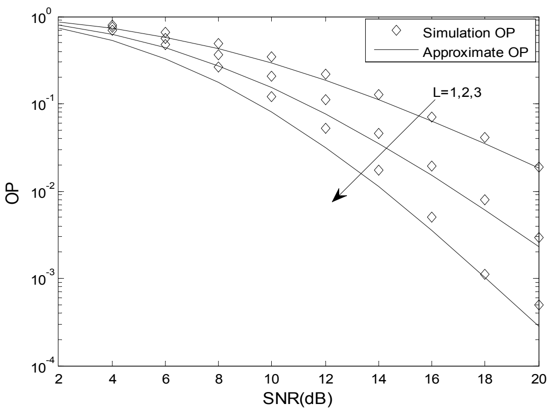

Fig. 3. The OP performance versus L

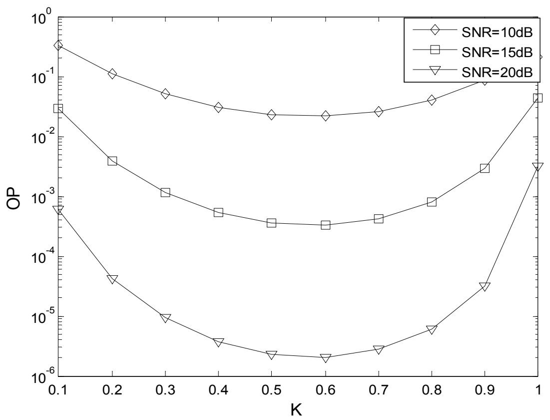

Fig. 4. The OP performance versus K

Figure 3 presents the OP performance versus L. L=1, 2, 3, μ=0dB, K=0.5, N=2, m=1, r_{th}=4dB. From Fig.3, it is observed that the Monte-Carlo simulation results match perfectly with the theoretical results. Increasing L improves the OP performance. For example, when SNR=14dB, the OP is 1.1×10^{-1} with L=1, 3.5×10^{-2} with L=2, 1.1×10^{-2} with L=3.

In **Figure** 4, the OP in (15) is plotted as a function of K. N=2, m=2, μ=0dB, L=2, r_{th}=4dB. Here, we use Golden-Section search method to find the optimum power allocation (OPA) values of K. For example, K =0.58 with SNR=10dB; K= 0.58 with SNR=15dB; K =0.58 with SNR=20dB.

6. Conclusions

In this paper, we had investigated the performance of the AF relaying mobile video networks. The simulation results show that L and K have a significant influence on the ASEP and OP performance of mobile video networks.

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