Analysis of Relay Capacity over Generalized Fading Channels with Cochannel Interference

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***Abstract*—Relay deployment performance, such as site planing and dimensioning, highly depends on the capacity of the wireless relay link. However, latter's performance can be severely harmed due to cochannel interference (CCI), particularly with the current aggressive reuse of the available radio spectrum. In this paper, we present an analytical framework for amplify-and-forward (AF) relay capacity that can be used for the deployment of two-hop cellular relay networks operating over generalized fading channels in the presence of cochannel interference. Nakagami-m and generalized-$\mathcal{K}$ distributions are used to model the relay and interference links in multipath and composite multipath/shadowing environments, respectively. Multiple antenna AF relaying systems employing transmit beamforming and maximum ratio combining (TB/MRC) are also investigated in the presence of CCI. The derived analytical results provide an efficient mathematical tool for the fast evaluation of the ergodic capacity of the system as well as for the investigation of the impact of key parameters such as fading, shadowing, number of antennas and CCI on the system's ergodic capacity.**

***Index Terms*—Amplify and forward (AF) relaying, ergodic capacity, cochannel interference.**

I. Introduction

Recent proposals for new wireless standards such as IEEE 802.16j and 3GPP-LTE have adopted two-hop relay transmission for cellular communications [1]. The key advantage of relaying is to enable high capacity where traditional architectures are unsatisfactory due to location constraints (cell-edge, shadowing, indoor), leading to a more homogenous user experience. Depending on the nature and complexity of the relaying technique, relay nodes can be broadly categorized as either amplify and forward (AF) or decode and forward (DF) [2]. While AF relays act as repeaters, DF relays decode and recode the received signal prior to forwarding it to the receiver, thereby implying a larger delay than with a simple repeater.

Despite the fact that the performance of two-hop relaying systems have been extensively studied, most of the existing results have been based on the assumption that the system is thermal-noise limited. However, cochannel interference can be a prevailing capacity-limiting factor due to the aggressive reuse of the available radio spectrum in cellular networks. Cochannel interference, which is an essential feature of wireless networks, can cause more severe performance degradation than thermal noise in many wireless networks.

Recently, many studies counting for the impact of CCI on the two-hop relaying performance have been conducted (see, e.g., [3]- [12] and references therein).

In a variable-gain relay scenario, existing contributions range from the analysis of interference-limited relay [3], [5] or destination [4], to multiple interferers at both sides [6]. The focus of this work is to provide analytical results that can quantify the average ergodic capacity of fixed gain AF relaying systems. In a related work [7], the outage probability of a fixed-gain AF relay system with interference-limited destination has been derived assuming Rayleigh fading channels. The analysis has been later extended in [8] to the case of multiple interferers at both relay and destination.

While these works contributed to a better analytical understanding of relay performance, all of them focused on the outage probability and error rate. To the best of the authors' knowledge, the ergodic capacity of dual-hop AF relaying systems in the presence of CCI is almost unexplored from the analytical point of view. Only few contributions have been, so far, proposed, notably [10], [11], and [12]. However, these works only consider relaying systems with perfect channel state information (CSI) at the relaying station. Besides, [10] and [11] proposed some results that are only valid for integer Nakagami-m fading on the desired and interfering links.

To fill this important gap, we develop a unified framework for the ergodic capacity of two-hop fixed gain-AF relaying in the presence of CCI and noise. The results are applicable for arbitrary fading distributions pertaining to the desired and interfering users. In this paper, exact capacity expressions are obtained for arbitrary Nakagami-m as well as composite generalized-$\mathcal{K}$ fading channels. The analysis also considers the case of two-hop multiple-antenna AF relaying employing transmit beamforming and maximum ratio combining (TB/MRC).

The remainder of this paper is organized as follows: First, Section II briefly introduces the system model. Next, section III presents our new integral relation for the ergodic capacity evaluation which is subsequently particularized to more compact forms under Nakagami-m and generalized-$\mathcal{K}$ fading. Section V illustrates the results of our new performance analysis framework by numerical examples, and Section IV concludes the paper.

II. Network and Channel Models

Consider a single-relay communication system where the fading gains from the source-to-relay and relay-to-destination are denoted by h_{SR} and h_{RD}, respectively. In the first time slot, the relay node receives a faded noisy signal from the source and a finite number of faded cochannel interfering signals from L_1 external interferers. Thus, the signal received at the relay node is given by

$$y_{SR} = \sqrt{P_s} h_{SR} s_0 + \sum_{l=1}^{L_1} \sqrt{\alpha_l} h_l s_l + n_r, \tag{1}$$

where s_0 denotes the unit-energy signal transmitted from the source; and P_s indicates the transmit energy from the said node. In the second term of the right-hand-side (RHS) of (1), s_l is the l-th cochannel interferer's signal affecting the relay with energy equal to α_l, L_1 is the total number of interferers that affect the relay, and h_l is the fading coefficient of the l-th interference channel. Finally, the third term of the RHS of (1), i.e., n_r, represents the additive white Gaussian noise (AWGN) term at the relay, with zero mean and variance σ_R^2. In the second time slot, the relay forwards a scaled version of the received signal y_{SR} to the destination

$$y_{RD} = b_F h_{RD} y_{SR} + \sum_{p=1}^{L_2} \sqrt{\beta_p} g_p c_p, \tag{2}$$

where b_F is the amplification coefficient aiming to guarantee that the average transmitted power does not exceed the power budget available at the relay node. As such, let P_r be the transmission power available at the relay, then the amplification coefficient is chosen as

$$b_F = \sqrt{\mathrm{E}\left[Pr/(Ps|h_{SR}|^2 + \sum_{l=1}^{L_1} \alpha_l |h_l|^2 + \sigma_R^2) \right]}. \tag{3}$$

In the R.H.S of (2), c_p is the p-th cochannel interferer's signal affecting the destination with energy equal to β_p, L_2 is the total number of interferers that affect the destination, and g_p is the flat fading coefficient of the p-th interference channel. For the sake of simplicity, we consider the special case of L_2 independent identically distributed (i.i.d.) interfering signals at the destination where AWGN is neglected. It is noteworthy that this case is often encountered in real-world applications especially when the destination is located at the cell-edge where the received interference is dominant. By assuming mutual independency between the different links, the end-to-end signal-to-interference-plus-noise ratio (SINR) at the destination can be obtained as

$$\gamma = \frac{b_F^2 P_s |h_{SR}|^2 |h_{RD}|^2}{b_F^2 |h_{RD}|^2 \sigma_R^2 + b_F^2 |h_{RD}|^2 \sum_{l=1}^{L_1} \alpha_l |h_l|^2 + \sum_{p=1}^{L_2} \beta_p |g_p|^2}. \tag{4}$$

After some manipulations, (4) can be further simplified to

$$\gamma = \frac{\gamma_1 \gamma_2}{\gamma_2 (1+\lambda) + G_F \chi}, \tag{5}$$

where and $\gamma_2 = P_r |h_{RD}|^2$ indicate the instantaneous SNR of the source-to-relay and the relay-to-destination links, respectively. Likewise, $\lambda = \sum_{l=1}^{L_1} Y_l$ and $\chi = \sum_{p=1}^{L_2} Z_p$ denote the total interference-to-noise ratios (INRs) at the relay and the destination, respectively, whereby $Y_l = \alpha_l |h_l|^2 / \sigma_R^2$ and $Z_p = \beta_p |g_p|^2$. Finally, $G_F = P_r / \sigma_R^2 b_F^2$.

III. ERGODIC CAPACITY ANALYSIS

For the dual-hop relay with interference, the ergodic capacity can be obtained as

$$C_E = \frac{1}{2} \mathbb{E} \left\{ \log_2 \left(1 + \frac{\gamma_1 \gamma_2}{\gamma_2 (1+\lambda) + G_F \chi} \right) \right\}, \tag{6}$$

Alternatively, we present the following expression for C_E:

Theorem : The ergodic capacity (bit/s/Hz) of dual-hop fixed gain relaying systems suffering interference is given by

$$C_E = \frac{1}{2\ln(2)} \left\{ \int_0^\infty E_0(\xi) M_\lambda(\xi) M_{\frac{1+\chi}{\gamma_2}}(G_F \xi) d\xi - \int_0^\infty E_0(\xi) M_{\gamma_1}(\xi) M_\lambda(\xi) M_{\frac{\chi}{\gamma_2}}(G_F \xi) d\xi \right\}, \tag{7}$$

where $M_z(\cdot)$ stands for the moment generating function (MGF) of z and $E_\nu(\cdot)$ denotes the exponential integral function of order ν [13, Eq. (8.485)].

Proof: : (6) can be further expanded as

$$C_E = \frac{\mathbb{E}\left[\ln(1+\gamma_1+\lambda+\frac{G_F\chi}{\gamma_2})\right] - \mathbb{E}\left[\ln(1+\lambda+\frac{G_F\chi}{\gamma_2})\right]}{2\ln(2)}. \tag{8}$$

Therefore, the key of the proof is to obtain the expectation of the form $\mathbb{E}[\ln(1+Z)]$, which can be computed by considering the following Taylor series expansion of $\ln(1+Z)$ valid for all $Z \geq 0$, [13, Eq. (1.512.3)]

$$\ln(1+Z) = \sum_{n=1}^\infty \frac{1}{n} \left(\frac{Z}{Z+1} \right)^n, \qquad \forall Z \geq 0. \tag{9}$$

Accordingly, we can write

$$\mathbb{E}[\ln(1+Z)] = \mathbb{E}\left[\sum_{n=1}^\infty \frac{1}{n} \left(\frac{1}{1+\frac{1}{Z}} \right)^n \right] \tag{10}$$

$$= \int_0^\infty \sum_{n=1}^\infty \frac{s^{n-1}}{n!} e^{-s} M_{\frac{1}{Z}}(s) ds$$

$$= \int_0^\infty \frac{1-e^{-s}}{s} M_{\frac{1}{Z}}(s) ds. \tag{11}$$

Recalling the MGF-based relation between a random variable Z and its inverse $1/Z$

$$M_Z(s) = 1 - 2\sqrt{s} \int_0^\infty J_1(2\sqrt{s}\xi) M_{Z^{-1}}(\xi^2) d\xi, \tag{12}$$

where $J_1(\cdot)$ is the Bessel function of the first kind, it follows that

$$\mathbb{E}[\ln(1+Z)] = \int_0^\infty \frac{1-e^{-s}}{s} ds - 2\int_0^\infty \underbrace{\int_0^\infty \frac{1-e^{-s}}{\sqrt{s}} J_1(2\sqrt{s}\xi)}_{\Sigma} M_Z(\xi^2) ds d\xi, \tag{13}$$

where, using [13, Eq. (7.811.1)], we get

$$\Sigma = \xi E_0(\xi^2). \tag{14}$$

Finally, substituting (14) into (13) and exploiting the mutual independency between γ_1, γ_2, λ and χ, we obtain

$$\mathbb{E}\left[\ln\left(1+\gamma_1+\lambda+\frac{G_F\chi}{\gamma_2}\right)\right] = \int_0^\infty \frac{1-e^{-s}}{s}ds$$
$$-2\int_0^\infty \xi E_0(\xi^2)M_{\gamma_1}(\xi^2)M_\lambda(\xi^2)M_{\frac{\chi}{\gamma_2}}(G_F\xi^2)d\xi. \quad (15)$$

In a similar fashion, the second expectation form in (8) can be expressed as

$$\mathbb{E}\left[\ln\left(1+\lambda+\frac{G_F\chi}{\gamma_2}\right)\right] = \int_0^\infty \frac{1-e^{-s}}{s}ds$$
$$-2\int_0^\infty \xi E_0(\xi^2)M_\lambda(\xi^2)M_{\frac{\chi}{\gamma_2}}(G_F\xi^2)d\xi. \quad (16)$$

Finally, substituting (15) and (16) into (8) and performing the necessary mathematical manipulations, (7) is easily proven.

The result in (7) offers a flexible and simple MGF-based approach for the computation of the ergodic capacity of fixed-gain relaying systems suffering interference. (7) relies on the knowledge of the MGFs of the first-hop SNR and INR γ_1 and λ, as well as the second-hop inverse SINR χ/γ_2. To the best of our knowledge, closed-form and exact expressions for these MGFs exist for most fading models.

A. Arbitrary Nakagami-m Fading

For Nakagami-m fading channels, we assume that γ_1, γ_2 and $Y_l, l = 1,\ldots,L_1$ are independent and non identically Gamma distributed with fading severity parameters m_1 , m_2 and m_{Y_l} , and channel powers $\bar{\gamma_1}$, $\bar{\gamma_2}$ and $\bar{Y_l}$, respectively. Nonetheless, for the sake of simplicity, we assume that the interference links at the destination are subject to identically-distributed Nakagami-m fading with $m_{Z_1} = \ldots = m_{Z_{L_2}} = m_I$ and $\bar{Z_1} = \ldots = \bar{Z_{L_2}} = \bar{Z_I}$

In this case, the ergodic capacity of the two-hop fixed gain relay system is shown to be given by

$$C_E = \frac{\Gamma(m_2+L_2m_I)}{2\ln(2)\Gamma(m_2)}\int_0^\infty E_0(\xi)\prod_{l=1}^{L_1}\left(1+\frac{\bar{Y_l}}{m_{Y_l}}\xi\right)^{-m_{Y_l}}$$
$$\left(1-\left(1+\frac{\bar{\gamma_1}}{m_1}\xi\right)^{-m_1}\right)\Psi\left(L_2m_I;1-m_2;\frac{G_Fm_2\bar{Z}_I}{m_I\bar{\gamma_2}}\xi\right)d\xi \quad (17)$$

where $\Psi(a;b;z)$ is the Triconomi confluent hypergeometric function [13, Eq. (9.211.4)].

Proof: Under Nakagami-m fading, the MGFs of the SNR γ_1 (or γ_2) and individual INR Y_l (or Z_p) are given by

$$M_{\gamma_1}(s) = \left(1+\frac{\bar{\gamma_1}}{m_1}s\right)^{-m_1}, \quad M_{Y_l}(s) = \left(1+\frac{\bar{Y_l}}{m_{Y_l}}s\right)^{-m_{Y_l}}, \quad (18)$$

On the other hand, the MGF of the combined INR λ (or χ), which is the sum of independent Gamma-distributed random variables Y_l (or Z_p), is equal to the product of the individual MGFs, yielding

$$M_\lambda(s) = \prod_{l=1}^L M_{Y_l}(s) = \prod_{l=1}^L\left(1+\frac{\bar{Y_l}}{m_{Y_l}}s\right)^{-m_{Y_l}}. \quad (19)$$

To solve (7), the MGF of the ratio $\frac{\chi}{\gamma_2}$ is required. For convenience, let $U=\frac{\chi}{\gamma_2}$, then the MGF of U can be obtained by exploiting [13, Eqs. (3.351.3) and (9.211.4)] as

$$M_U(s) = \frac{\Gamma(m_2+L_2m_I)\left(\frac{m_2\bar{Z}_Is}{m_I\bar{\gamma_2}}\right)^{m_2}}{\Gamma(m_2)}$$
$$\Psi\left(m_2+L_2m_I;m_2+1;\frac{m_2\bar{Z}_I}{m_I\bar{\gamma_2}}s\right), \quad (20)$$

Then, substituting (18), (19) and (20) into (7) yields the end-to-end ergodic capacity expression under Nakagami-m fading as given in (17). Nevertheless, to compute (17), an analytical expression of G_F is required. The latter is shown to be given by

$$G_F^{-1} = \frac{m_1}{\bar{\gamma_1}}\Phi_2\left(1;m_{Y_1},\ldots,m_{Y_L};m_1;\frac{\bar{Y}_1m_1}{m_{Y_1}\bar{\gamma_1}},\ldots,\frac{\bar{Y}_Lm_1}{m_{Y_L}\bar{\gamma_1}},\frac{m_1}{\bar{\gamma_1}}\right), \quad (21)$$

where $\Phi_2(a;b_1,\ldots,b_K;z;x_1,\ldots,x_K,y)$ is the second-kind confluent hypergeometric function of multiple variables given by [14]

$$\Phi_2(a;b_1,\ldots,b_K;z;x_1,\ldots,x_K,y) = \frac{1}{\Gamma(a)}\int_0^\infty \exp(-yt)t^{a-1}(1+t)^{a-z-1}\prod_{k=1}^K(1+x_it)^{-b_i}dt. \quad (22)$$

Proof: Recalling the definition of G_F in section II, this constant can be calculated in view of [15] as

$$G_F^{-1} = \mathrm{E}\left\{\frac{1}{\gamma_1+\lambda+1}\right\} = \int_0^\infty \exp(-\xi)M_{\gamma_1}(\xi)M_\lambda(\xi)d\xi,$$
$$= \int_0^\infty \exp(-\xi)\left(1+\frac{\bar{\gamma_1}}{m_1}\xi\right)^{-m_1}\prod_{l=1}^{L_1}\left(1+\frac{\bar{Y_l}}{m_{Y_l}}\xi\right)^{-m_{Y_l}}d\xi. \quad (23)$$

By performing the change of variable $z=\frac{\bar{\gamma_1}}{m_1}\xi$ in (23), one can recognize that the latter can be expressed in terms of $\Phi_2(a;b_1,\ldots,b_K;z;x_1,\ldots,x_K,y)$ as shown in (21). Note that in the absence of interference, G_F reduces to the already known expression in the literature [15], given by

$$G_F = \left[\frac{m_1}{\bar{\gamma_1}}\Psi\left(1;2-m_1;\frac{m_1}{\bar{\gamma_1}}\right)\right]^{-1}. \quad (24)$$

1) Multiple Antenna Relay Channels: Capitalizing on (7), dual-hop multiple antenna AF relaying systems using TB/MRC (Transmit Beamforming/Maximal Ratio Combining) is also of interest. Indeed, consider that the source and the destination are equipped with N_t and N_r antennas, respectively. The TB vector at the source is $\mathbf{w} = \mathbf{h_{SR}}/||\mathbf{h_{SR}}||_F$ where $\mathbf{h_{SR}}$ is the $N_t\times 1$ channel vector for the source-relay link, and its entries are independent non-identically Nakagami-m distributed. Hence, the MGF of the first hop SNR $\gamma_1 = P_s||\mathbf{h_{SR}}||_F^2/\sigma_R^2$ is given by

$$M_{\gamma_1}(s) = \prod_{l=1}^{N_t}\left(1+\frac{\bar{\gamma}_{tl}}{m_{tl}}s\right)^{-m_{tl}}. \quad (25)$$

At the destination, $\mathbf{h_{RD}}$ is the $N_r\times 1$ channel vector for the relay-destination link, and its entries are i.i.d. Nakagami-m

distributed. Using the fact that $\gamma_2 = P_r||\mathbf{h_{RD}}||_F^2$, we show that the MGF of $U = \chi/\gamma_2$ is given by

$$M_U(s) = \frac{\Gamma(N_r m_2 + L_2 m_I)\left(\frac{m_2 \bar{Z}_I s}{m_I \bar{\gamma_2}}\right)^{N_r m_2}}{\Gamma(N_r m_2)} \Psi\left(N_r m_2 + L_2 m_I; N_r m_2 + 1; \frac{m_2 \bar{Z}_I}{m_I \bar{\gamma_2}} s\right). \quad (26)$$

Finally, substituting (19), (25), and (26) into (7), the exact ergodic capacity can be efficiently evaluated with a single numerical integration. In this case, the constant G_F can be expressed, by following the same rationale leading to (21), as

$$G_F^{-1} = \frac{m_{t1}}{\bar{\gamma_{t1}}} \Phi_2\left(1; m_{t2}, \ldots, m_{tN_t}, m_{Y_1}, \ldots, m_{Y_L}; m_{t1}; \frac{\bar{\gamma_2} m_{t1}}{m_{t2}\bar{\gamma_{t1}}}, \frac{\bar{\gamma_{tN_t}} m_{t1}}{m_{tN_t}\bar{\gamma_{t1}}}, \frac{\bar{Y_1} m_{t1}}{m_{Y_1}\bar{\gamma_{t1}}}, \ldots, \frac{\bar{Y_L} m_{t1}}{m_{Y_L}\bar{\gamma_{t1}}}, \frac{m_{t1}}{\bar{\gamma_{t1}}}\right). \quad (27)$$

B. Generalized-$\mathcal{K}$ Fading

This is a generic composite model that emerges when a mixture of multi-path fading and shadowing affect the relay communication. Herein, we assume that only the relay desired links are subject to independent and non identically distributed generalized-$\mathcal{K}$ fading. Nevertheless, for the sake of simplicity, all interfering links are assumed to undergo i.i.d Nakagami-m fading. In this case, we show that the MGFs of the SNR γ_1 and the inverse SINR U can be expressed as follows

$$M_{\gamma_1}(s) = \frac{\mathrm{G}_{1,2}^{2,1}\left(\frac{\lambda_1 m_1}{\bar{\gamma}_1 s} \middle| \begin{matrix} 1 \\ \lambda_1, m_1 \end{matrix}\right)}{\Gamma(m_1)\Gamma(\lambda_1)}, \quad (28a)$$

$$M_U(s) = \frac{\mathrm{G}_{3,2}^{2,3}\left(\frac{\lambda_{Z_I} m_{Z_I} \bar{\gamma}_2}{\bar{Z}_I \lambda_2 m_2 s} \middle| \begin{matrix} 1, 1-m_2, 1-\lambda_2 \\ \lambda_I, L_2 m_I \end{matrix}\right)}{\Gamma(L_2 m_I)\Gamma(\lambda_I)\Gamma(m_2)\Gamma(\lambda_2)}, \quad (28b)$$

where m_1, m_2 and λ_1, λ_2 are the shaping parameters of the distributions pertaining on the first and second hops, and $\mathrm{G}_{c,d}^{a,b}(\cdot)$ denotes the Meijer's G function [13, Eq. (9.301)]. Substituting (19), (28a), and (28b) into (7) yields the ergodic capacity of interference-impaired two-hop relaying under generalized-$\mathcal{K}$ fading, which can be efficiently evaluated with a single numerical integration.

IV. Numerical Results

The aim of this section is to illustrate the expressions derived in Sections III using numerical examples and examine the detrimental effects of interference, multipath and shadowing on the system's capacity.

Fig. 1 shows the ergodic capacity performance in Nakagami-m fading when the number of interferers at both the relay and the destination increases from 1 to 4, and the average strength of the interfering links varies between 10 and 20 dB lower than that of the useful link so that $\bar{Y}_I(\text{or } \bar{Z}_I) = \bar{\gamma}_1(\text{or } \bar{\gamma}_2) - \{10, 20\}$ dB. We can see that as the number of interferers increases, the ergodic capacity relatively

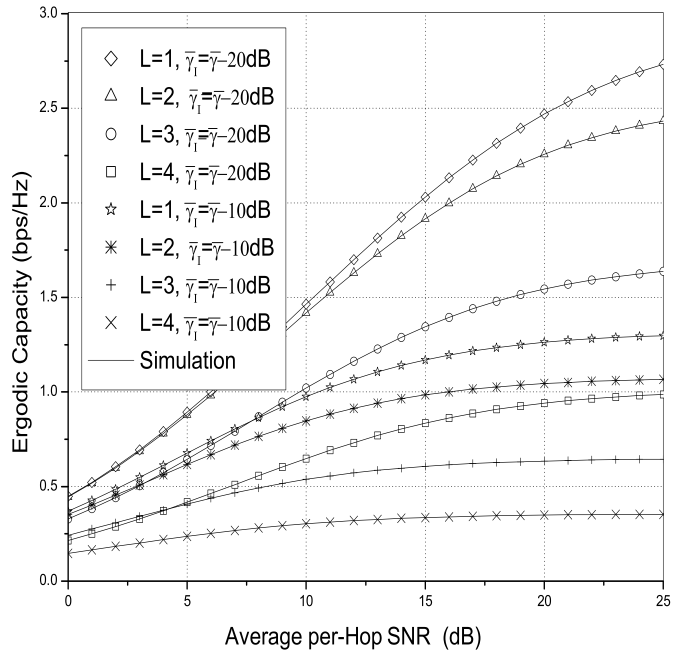

Fig. 1. Ergodic capacity for different numbers of interferers at the relay and the destination when $L_1 = L_2 = L$, $m_1 = m_2 = 1.5$, $m_I = 1$, and $\bar{Y}_I = \bar{Z}_I = \bar{\gamma}_I$ and $\bar{\gamma}_1 = \bar{\gamma}_2 = \bar{\gamma}$

improves very slowly with increasing SNR. Moreover, the ergodic capacity attains a saturation level which is more noticeable when the difference between the received powers of the useful and interfering signals decreases. Hence, interference imposes severe constraints on the system's capacity, thereby highlighting the significance of using interference cancelation techniques in interference-impaired relay systems in order to attain the beneficial effects of relaying.

Fig. 2 illustrates the ergodic capacity of the TB/MRC system in the presence of one and four i.i.d interferers with $\bar{\gamma}_I = \bar{\gamma} - 10$dB at the relay and the destination, respectively. Large improvement of performance can be observed by using the multi-antenna techniques. Besides, it is interesting to notice that increasing antennas at the source side can achieve more gains than at the destination side at the low and medium SNR regions. Fig. 2 also shows that, the capacity loss due to the increased interference remains almost the same for different antenna numbers; which suggests that the impact of CCI on the ergodic capacity is not sensitive to the number of antennas.

Fig. 3 plots the ergodic capacity of composite generalized-$\mathcal{K}$ fading against the average SNR per hop. With the increase of the interference power, we observe that the impact of the channel fading parameter λ on the ergodic capacity decreases gradually. Fig. 3 also shows that better performance is attained when severe fading conditions (small λ) characterize the R-D link. This is because the gain applied to the signal depends on the statistics of the first hop only.

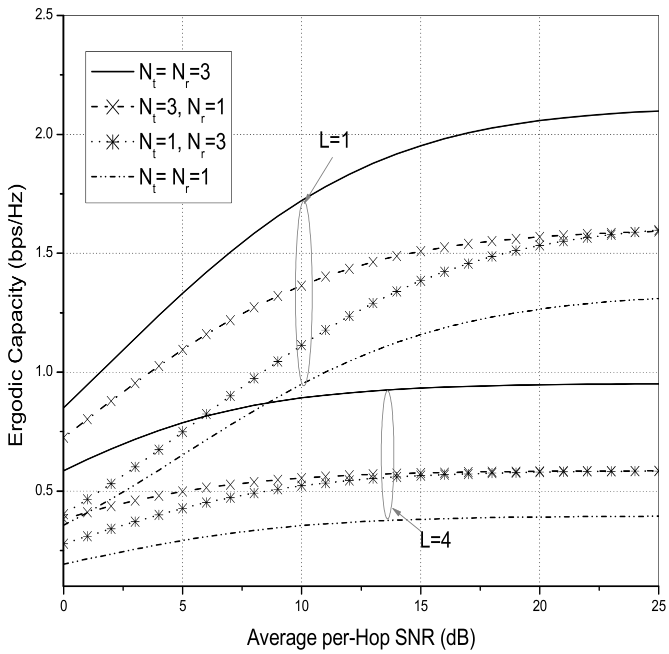

Fig. 2. Ergodic capacity versus the average per hop SNR for different numbers of interferers and antennas. $L_1 = L_2 = L$, $m_{t_i} = m_2 = 1.5$, $m_I = 1$, and $\bar{Y}_I = \bar{Z}_I = \bar{\gamma} - 10$ dB.

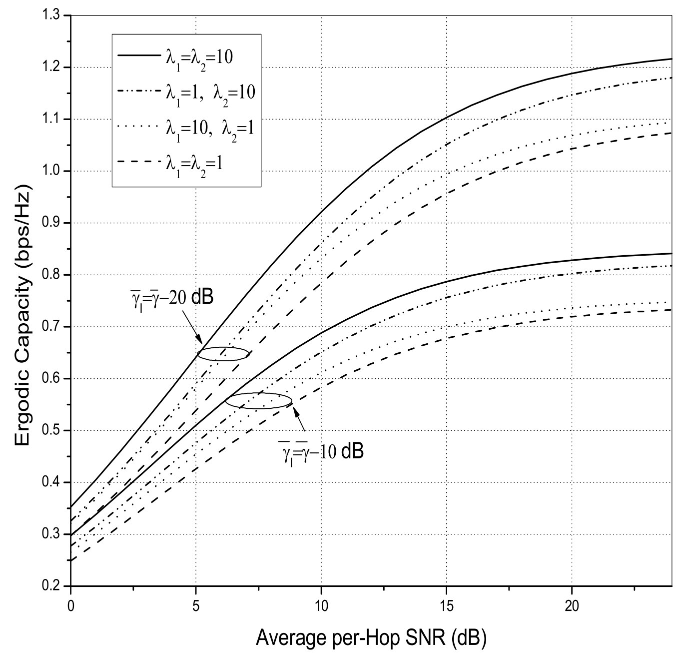

Fig. 3. Ergodic capacity in composite generalized-$\mathcal{K}$ fading, $m_1 = m_2 = 2$, $m_I = 1$.

V. CONCLUSION

A unified capacity analysis framework of fixed-gain two-hop AF relaying when the relay and the destination nodes undergo independent sources of CCI was developed and shown to be able to encompass most of the existent fading models. Indeed, this analysis framework considered the Nakagami-m and generalized-$\mathcal{K}$ distributions to model the relay and interference links in multipath and composite multipath/shadowing environments, respectively, with non identically distributed hops. The derived exact expressions stemming from this new unified analysis framework allow for fast and accurate computation of capacity and insight into its behavior with respect to various key environments parameters. The new capacity expressions are applicable with arbitrary numbers of interfering users at the two nodes, asymmetric fading conditions [16], and over multi-antenna relay channels using beamforming.

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