OFDM based SCM for Multicast Dual Amplify and Forward Relays

[1]Muhammad Adnan,[2]Irfan Ahmed,[3]Ishtiaq Ahmed,[3]Shaohua Chen,[3]Yafeng Wang,[3]DaCheng Yang
[1]University of Management and Technology , Lahore , Pakistan.
[2]Taif University, Taif , Saudi-Arabia.
[3]Beijing University of Posts and Telecommunication, Beijing , China.

Abstract – **In multihop OFDM relay systems the end-to-end throughput can be increased by incorporating subchannel mapping (SCM) at the relay nodes. This helps in achieving high data rate requirements for live streaming applications. Average Symbol Error Probability (SEP) is an important measurement for investigating wireless communication systems. This paper presents the statistical and symbol error performance analysis of the 2-hop OFDM based multicast strategy with Amplify and Forward protocol and subchannel mapping scheme. Closed Form expressions for probability density function (PDF) and well-approximated symbol error probability of the signal to noise ratio (SNR) for the *kth* mapped subchannel pair link are provided.**

Keywords – **OFDM, subchannel mapping (SCM), 2-hop network, virtual MIMO, dual AF relay, multicasting.**

I. Introduction

In recent years the co-operative relay transmission gain significant importance for extending radio coverage and capacity of the wireless network [1].Through the evolution of next generation wireless networks the key technology of multi-hop wireless networks is becoming more important to provide better services. Multi-hop networks with inherent multicast nature of wireless medium provides a way to exploit another form of diversity called multicast diversity. In such form of diversity, parallel transmission through multiple relays improves the performance of the wireless system. Unlike co-operative diversity schemes, there is no line of sight between source and destination. This is the more practical scenario in next generation wireless system for live streaming applications.

Orthogonal Frequency Division multiplexing(OFDM) has inherent property of combating frequency selective fading and inter-symbol interference and it provides high spectral efficiency in the area of its coverage. In 4G wireless networks OFDM transmission combining with relay network become a potential candidate for providing data services in femto-cell environment.In relay networks, multiple nodes dynamically reconfigured to provide multi-hop connectivity without the superfluous energy consumption of one node. During OFDM transmission over multi-hop network, subchannel mapping takes place in an un-ordered manner. This increased the chance of coupling the subchannel with strongest signal of the first hop into a weakest subchannel of the second hop. This result in a poor end-to-end signal to noise ratio, which in turn cause capacity minimization.To maximize capacity, however, it can be proven that the subchannels should be coupled into each other in a sorted way. This means that the strongest received subchannel signal has to be coupled into the strongest subchannel of the second hop, the second strongest received subchannel signal into the second strongest sub channel of the second hop.

In this paper we have considered the ordered subchannel mapping (SCM) for OFDM based dual relay network.The outage probability and closed form expression for our multicast scheme is also calculated here. So far, in literature, no such analysis is given for dual relay scheme with SCM. The analytical comparison of SCM with single relay is performed with two-relay SCM and significant improvement is being observed.

The remaining sections of this paper is organized as follows, system model is explained in Section II, Section III provides the problem formulation and closed form expressions, Section IV describes the simulation results and finally the conclusions & future work is presented in Section V.

II. System Model

In a simple multicast scenario in cellular environment a source S multicast the signal to a pair of mobile stations M_1 and M_2. A Pair of relay nodes contributes the signal in the second hop instead of a single relay to avoid the superfluous energy consumption of the single relay. The inherent multicast nature of the wireless medium also supports this configuration. We assume that there is no direct link transmission between source and a pair of destinations due to high shadowing caused by obstacles or long distance between them and all nodes are equipped with a single antenna and an OFDM transceiver with N subchannels. The CSI of both hops are available at the relay nodes R_1 and R_2 to make true SCM can be implemented. With the length of the cyclic prefix (CP) being long enough to accommodate the channel delay spread, the frequency selective fading channels are transformed to N parallel flat fading sub-channels for hops $S-R_1, S-R_2$ and $R_1-M_1, R_1-M_2, R_2-M_1$, R_2-M_2

In this scheme we have to consider the two propagation channels to a pair of mobile stations M_1 and M_2 , one from each relay R_1 and R_2. So the sub-channel coefficients of ($S-R_1$) hop 1 and hop 2 (R_1-M_1) are ;

$\mathbf{h}_{\mathbf{SR_1}} = (h_{SR_1,1}, h_{SR_1,2}, \ldots\ldots, h_{SR_1,N}), \mathbf{g}_{\mathbf{R_1M_1}} = (g_{R_1M_1,1}, g_{R_1M_1,2}, \ldots\ldots, g_{R_1M_1,N})$, and $\mathbf{g}_{\mathbf{R_2M_1}} = (g_{R_2M_1,1}, g_{R_2M_1,2}, \ldots\ldots, g_{R_2M_1,N})$ respectively .

For the second propagation channel through relay 2, we have sub-channel coefficients $\mathbf{h}_{\mathbf{SR_2}} = (h_{SR_2,1}, h_{SR_2,2}, \ldots\ldots, h_{SR_2,N})$ $\mathbf{g}_{\mathbf{R_1M_2}} = (g_{R_1M_2,1}, g_{R_1M_2,2}, \ldots\ldots, g_{R_1M_2,N})$ and $\mathbf{g}_{\mathbf{R_2M_2}} = (g_{R_2M_2,1}, g_{R_2M_2,2}, \ldots\ldots, g_{R_2M_2,N})$ respectively from hop1 and hop2 .

Furthermore, the entries of $\mathbf{h}_{\mathbf{SR_1}}, \mathbf{h}_{\mathbf{SR_2}}, \mathbf{g}_{\mathbf{R_1M_1}}, \mathbf{g}_{\mathbf{R_1M_2}}$, $\mathbf{g}_{\mathbf{R_2M_1}}, \mathbf{g}_{\mathbf{R_2M_2}}$ are independent identically distributed (i.i.d) zero-mean complex Gaussian random variables with unit variance and the correlation of the adjacent subchannels is ignored for simplicity.

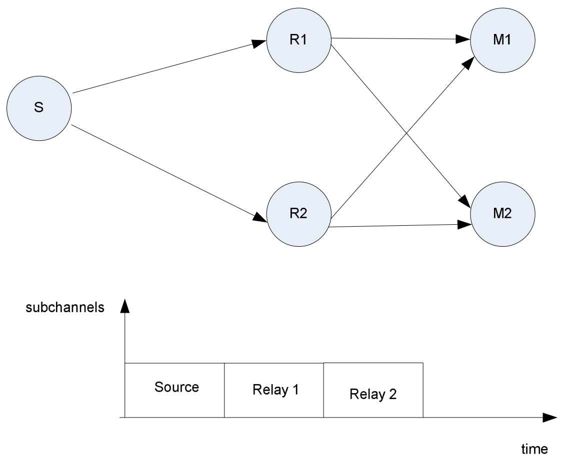

Figure 1 : System Model

III. Problem Formulation

In our scheme, the subchannel mapping is performed on the basis of minimum differential between sorted source-relay subchannel gain and the sorted relay-mobile subchannel gain, i.e.,

$$\Gamma_{R_i:k} = \arg\min_{R_i,n,m} \left| \frac{E_{R_i}}{N_0} g_{R_iM_j}^{(m)} - \frac{E_S}{N_0} h_{SR_i}^{(n)} \right|, i = 1,2$$

Where m belongs to set of subchannels at relay R_i and n belongs to the set of subchannels at source S. Subchannel mapping between first and 2[nd] hop at relay R_1 depends on the minimum differential gain. Subchannel n will map with subchannel m if and only if the channel gain between the relay R_i and mobile M_j is close to channel gain between source and relay R_i with subchannel n, for all values of j.

It proves in [4] that in order to maximize capacity, the subchannels of two hops should be coupled into each other in a sorted way,i.e., ordered subchannel coupling. In order to provide subchannel mapping from two relays, the source multicast the information to two relays by using N subchannels. The carrier with best received SNR on relay 1 is mapped into the carrier with best transmitted SNR at relay 1 and so on at relay 2.Specifically, the sub-channel with the *k*-th smallest channel gain denoted by h_{SR_i} of hop-1 maps to the subchannel with the *k*-th smallest channel gain denoted by $g_{R_iM_j}$ of hop-2 where the subscript *i* and *j* represents the number of relays and number of mobile station respectively,i.e., $h_{R1:k} \rightarrow g_{R1:k}$ is the *k*-th mapped subchannel pair link (*k*-MSPL) at relay 1 and $h_{R2:k} \rightarrow g_{R2:k}$ is the *k*-th mapped (*k*-MSPL) at relay 2, where *k*=1,2,…….,N. At the receiver side, the maximal ratio combining method is used to achieve the highest possible SNR by combining *k*-MSPL in slot 2 and 3. The overall received SNR of *nth* subchannel at *jth* mobile station is the sum of SNR received from *k*-MSPL.

After implementing ordered SCM based on both relays and variable-gain power constraint [5] at both relays, the overall E2E SNR before the MRC combination can be approximated as [5];

$$\Gamma_{SR_iM_j:k} = \frac{\Gamma_{SR_i:k}\Gamma_{R_iM_j:k}}{\Gamma_{SR_i:k} + \Gamma_{R_iM_j:k} + 1} \quad for\ i, j = 1,2 \qquad (1)$$

Here we define $\Gamma_{SR_1} = \frac{E_s\left|h_{SR_1}\right|^2}{N_{01}}, \Gamma_{SR_2} = \frac{E_s\left|h_{SR_2}\right|^2}{N_{02}}, \Gamma_{R_1M_1} = \frac{E_{R_1}\left|g_{R_1M_1}\right|^2}{N_{03}}$, $\Gamma_{R_1M_2} = \frac{E_{R_1}\left|g_{R_1M_2}\right|^2}{N_{04}}, \Gamma_{R_2M_1} = \frac{E_{R_2}\left|g_{R_2M_1}\right|^2}{N_{05}}$ and $\Gamma_{R_2M_2} = \frac{E_{R_2}\left|g_{R_2M_2}\right|^2}{N_{06}}$. E_s , E_{R_1} and E_{R_2} denote the average transmit power equally located at each subchannel at S , R_1 and R_2 respectively; N_{01} & N_{02} denote the average power of AWGN component of each sub channel in hop-1 through source to relay 1, N_{03} & N_{04} represents through relay 1 to mobile stations in hop-2 and N_{05} & N_{06} represents the same through relay 2 in hop-2 .

The cumulative distribution function (CDF) and the average symbol error probability to resort the asymptotic expression of SEP at high SNRs of our scheme can be derived in the same way as in [8] for *k*-MSPL OFDM relaying system. To the best of our knowledge, analytical evaluation of CDF for Γ_v defined in (1) is truly complicated. As we used maximal ratio combining to combine k-MSPL in slot 2 and 3 so Γ_v is the sum $\sum_{i=1}^{2} \Gamma_{SR_iM_j:k}, \forall j$. Here $\Gamma_{SR_iM_j:k}$ represents the end to end SNR of *k*-MSPL link. Making it more tractable, Γ_v can be approximated by two widely used upper bounds as [5],[6],

$$\Gamma_v = \frac{\Gamma_{1,:v}\Gamma_{2,:v}}{\Gamma_{1,:v} + \Gamma_{2,:v}} \qquad (2)$$

and

$$\Gamma_v = \min\left(\Gamma_{1,:v}, \Gamma_{2,:v}\right) \qquad (3)$$

The first upper bound (2) can provide a relatively exact approximation in medium and high SNR regimes and the second upper bound (3) is useful for asymptotic analysis.

For the convenience of derivation, $\overline{\gamma_1} = \frac{E_s}{N_{01}}, \overline{\gamma_2} = \frac{E_s}{N_{02}}$ being the average SNR from source to relay1 and relay 2 , $\overline{\gamma_3} = \frac{E_{r_1}}{N_{03}}, \overline{\gamma_4} = \frac{E_{r_1}}{N_{04}}$ being the average SNR of hop-2 from relay 1 to mobile stations, respectively. Similarly, $\overline{\gamma_5} = \frac{E_{r_2}}{N_{05}}$ and $\overline{\gamma_6} = \frac{E_{r_2}}{N_{06}}$ being the average SNR from relay 2. Thus, $\Gamma_{SR_1,:k} = \overline{\gamma_1}\left|h_{SR_1:k}\right|^2$ and $\Gamma_{R_1M_1:k} = \overline{\gamma_3}\left|g_{R_1M_1:k}\right|^2, \Gamma_{R_1M_2:k} = \overline{\gamma_4}\left|g_{R_1M_2:k}\right|^2$ are the *k*-th smallest SNR among all subchannels of hop-1 and hop-2 of first relay. Similarly , $\Gamma_{SR_2:k} = \overline{\gamma_2}\left|h_{SR_2:k}\right|^2$ and

$\Gamma_{R_2M_1:k} = \overline{\gamma}_5 \left| g_{R_2M_1:k} \right|^2, \Gamma_{R_2M_2:k} = \overline{\gamma}_6 \left| g_{R_2M_2:k} \right|^2$ are the k-th smallest SNR of hop-1 and hop-2 of second relay. According to order statistics [7], the CDF of single hop $\Gamma_{:k}$ is given by

$$F_{\Gamma_{:k}}(x) = \sum_{j=k}^{N} \binom{N}{j} \left(1 - e^{-x/\overline{\gamma}}\right)^j e^{-(N-j)x/\overline{\gamma}} \qquad (4)$$

and the corresponding PDF is given by

$$f_{\Gamma_{:k}}(x) = \frac{N\binom{N-1}{k}}{\overline{\gamma}} \sum_{m=0}^{k-1} \binom{k-1}{m} (-1)^m e^{-(N+m-k+1)x/\overline{\gamma}} \quad (5)$$

Next, we firstly use the first upper bound (2) to calculate a well approximated CDF of $\Gamma_{R_iM_j,:k} (i, j = 1, 2)$ with the details as shown follows [8, Eq.(30)].

$$\begin{aligned} F_{\Gamma_{R_iM_j:k}}(z) &= P_r\left(\frac{\Gamma_{SR_i:k}\Gamma_{R_iM_j:k}}{\Gamma_{SR_i:k} + \Gamma_{R_iM_j:k}} < z\right) \\ &= 1 - \int_0^\infty \overline{F}_{\Gamma_{SR_i}:k}(z + z^2/t) f_{\Gamma_{R_iM_j}}(z+t)dt \end{aligned} \qquad (6)$$

where $\overline{F}_{\Gamma_{SR_i:k}}(\bullet) = 1 - F_{\Gamma_{SR_i:k}}(\bullet)$. We then proceed by substituting (5),(4) and (6) and solving the resultant integral with [9,Eq.(3.471.9)], yielding

$$F_{\Gamma_{SR_iM_j:k}}(z) = 1 - 2z\sum_{p=0}^{k-1}\sum_{q=0}^{k-1} \frac{a_p c_q}{\sqrt{b_p d_q}} e^{-(b_p+d_q)z} \kappa_1(2\sqrt{b_p d_q} z) \quad (7)$$

where

$a_p^{(SR_i)} = N\binom{N-1}{k-1}\binom{k-1}{p}(-1)^p/\overline{\gamma}_{SR_i}, b_p^{(SR_i)} = (N-k+p+1)/\overline{\gamma}_{SR_i}$,

$c_q^{(R_iM_j)} = N\binom{N-1}{k-1}\binom{k-1}{q}(-1)^q/\overline{\gamma}_{R_iM_j}, d_q^{(R_iM_j)} = (N-k+q+1)/\overline{\gamma}_{R_iM_j}$;

$\kappa_v(\bullet)$ is the v *th*-order modified Bessel function of the second kind [9, Eq.(8.432.3)]. After taking derivative with the respect to z, the PDF of $\Gamma_{SR_iM_j:k}$ can be obtained as

$$\begin{aligned} f_{\Gamma_{SR_iM_j:k}}(z) &= 2z\sum_{p=0}^{k-1}\sum_{q=0}^{k-1} a_i c_j e^{-(b_p+d_q)z} \\ &\times \left[\frac{b_p + d_q}{b_p d_q}\kappa_1(2\sqrt{b_p d_q} z) + 2\kappa_0(2\sqrt{b_p d_q} z)\right] \end{aligned} \qquad (8)$$

For a simple check, when N=1, k=1, our (8) reduces to [5, Eq.(19)].

Let the SNR after the MRC combination at mobile station M_j is $\Gamma_{M_j:k}$ and given by

$$\Gamma_{M_j:k} = \Gamma_{SR_1M_j:k} + \Gamma_{SR_2M_j:k}$$

Thus the resultant SNR at mobile station M_j is the sum of two independent random variables. From the elementary statistics, we now that the CDF of the sum of two independent variables $W = X + Y$ is given by

$$\begin{aligned} F_W(w) &= \int_{-\infty}^{\infty} F_Y(w-x) f_X(x)dx \\ &= \int_{-\infty}^{\infty} F_X(w-y) f_Y(y)dy \end{aligned}$$

Thus, the CDF of combined SNR at mobile station M_j, $\Gamma_{M_j:k}$ is given by

$$F_{\Gamma_{M_j:k}}(w) = \int_{-\infty}^{\infty} F_{\Gamma_{SR_1M_j:k}}(w-x) f_{\Gamma_{SR_2M_j:k}}(x)dx$$

Since $F_{\Gamma_{SR_1M_j:k}}, f_{\Gamma_{SR_2M_j:k}}$ are causal functions, using integration by parts, we get

$$F_{\Gamma_{M_j:k}}(w) = \frac{1}{2} F_{\Gamma_{SR_1M_j:k}}(w-x) F_{\Gamma_{SR_2M_j:k}}(x)\Big|_{x=0}^{w}$$

$$\begin{aligned} F_{\Gamma_{M_j:k}}(w) = w\Bigg[&\sum_{p=0}^{k-1}\sum_{q=0}^{k-1} \frac{a_p^{(SR_1)} c_q^{(R_1M_j)}}{\sqrt{b_p^{(SR_1)} d_q^{R_1M_j}}} e^{-(b_p^{(SR_1)} + d_q^{(R_1M_j)})z} \kappa_1\left(2\sqrt{b_p^{(SR_1)} d_q^{(R_1M_j)}} w\right) \\ &- \sum_{p=0}^{k-1}\sum_{q=0}^{k-1} \frac{a_p^{(SR_2)} c_q^{(R_2M_j)}}{\sqrt{b_p^{(SR_2)} d_q^{R_2M_j}}} e^{-(b_p^{(SR_2)} + d_q^{(R_2M_j)})z} \kappa_1\left(2\sqrt{b_p^{(SR_2)} d_q^{(R_2M_j)}} w\right)\Bigg] \end{aligned}$$

The PDF of received SNR after the MRC combination at mobile station M_j is given by either the convolution of $f_{\Gamma_{SR_1M_j:k}}(x)$ and $f_{\Gamma_{SR_2M_j:k}}(y)$, i.e.,

$$f_{\Gamma_{M_i:k}}(w) = f_{\Gamma_{SR_1M_j:k}}(x) * f_{\Gamma_{SR_2M_j:k}}(y)$$

$$f_{\Gamma_{M_i:k}}(w) = \int_0^w f_{\Gamma_{SR_1M_j:k}}(w-x) f_{\Gamma_{SR_2M_j:k}}(y)dy$$

or by taking derivative of above CDF w.r.t w.

$$\begin{aligned} f_{\Gamma_{Mi:k}}(w) = w\Bigg[&\sum_{p=0}^{k-1}\sum_{q=0}^{k-1} a_p^{(SR_1)} c_q^{(R_1M_j)} \exp\left(b_p^{(SR_1)} + d_q^{(R_1M_j)}\right) w \\ &\times\left(\frac{b_p^{(SR_1)} + d_q^{(R_1M_j)}}{\sqrt{b_p^{(SR_1)} d_q^{(R_1M_j)}}} \kappa_1(2\sqrt{b_p^{(SR_1)} d_q^{(R_1M_j)}} w) + 2\kappa_0(2\sqrt{b_p^{(SR_1)} d_q^{(R_1M_j)}} w)\right) \\ &- \sum_{p=0}^{k-1}\sum_{q=0}^{k-1} a_p^{(SR_2)} c_q^{(R_2M_j)} \exp\left(b_p^{(SR_2)} + d_q^{(R_2M_j)}\right) w \\ &\times\left(\frac{b_p^{(SR_2)} + d_q^{(R_2M_j)}}{\sqrt{b_p^{(SR_2)} d_q^{(R_2M_j)}}} \kappa_1(2\sqrt{b_p^{(SR_2)} d_q^{(R_2M_j)}} w) + 2\kappa_0(2\sqrt{b_p^{(SR_2)} d_q^{(R_2M_j)}} w)\right)\Bigg] \end{aligned}$$

Approximated Symbol Error Rate :

A uniform average symbol error probability for several modulations with Gray bit mapped constellations can be expressed in the form: $SEP = E_w[AQ(\sqrt{2B_w})]$, where

$Q(x)=\frac{1}{2\pi}\int_x^\infty \exp(-t^2/2)dt$ and $E_w[\bullet]$ denotes the expectation over the distribution of w. The parameters A and B are determined by specific modulation, e.g., for BPSK modulation, A=B=1; for QPSK, A=1, B=0.5; for M-PSK, A=2 and B=$\sin^2$ (Π/M) [10]. For further derivation, we rewrite the SEP expression of the k-MSPL as [8.Eq.(24)]

$$SEP_k=\frac{A}{2}\sqrt{\frac{B}{\pi}}\int_0^\infty \frac{e^{-bw}}{\sqrt{w}}F_{\Gamma_{M_j:k}}(w)d_w \quad (9)$$

Substituting the value of $F_{\Gamma_{M_j:k}}(w)$ in Eq.(9), we get the expression .

$$F_{\Gamma_{M_j:k}}(w)=\frac{A}{2}\sqrt{\frac{B}{\pi}}\left[\begin{array}{l}\left[\int_0^\infty e^{-bw}w^{1/2}\sum_{p=0}^{k-1}\sum_{q=0}^{k-1}\frac{a_p^{(SR_1)}c_q^{(R_1M_j)}}{\sqrt{b_p^{(SR_1)}d_q^{(R_1M_j)}}}e^{-(b_p^{(SR_1)}+d_q^{(R_1M_j)})z}\kappa_1\left(2\sqrt{b_p^{(SR_1)}d_q^{(R_1M_j)}}w\right)dw\right]-\\ \left[\int_0^\infty e^{-bw}w^{1/2}\sum_{p=0}^{k-1}\sum_{q=0}^{k-1}\frac{a_p^{(SR_2)}c_q^{(R_2M_j)}}{\sqrt{b_p^{(SR_2)}d_q^{(R_2M_j)}}}e^{-(b_p^{(SR_2)}+d_q^{(R_2M_j)})z}\kappa_1\left(2\sqrt{b_p^{(SR_2)}d_q^{(R_2M_j)}}w\right)dw\right]\end{array}\right]$$

Therefore, using [9,Eq.(6.621.3)] one can get the analytical SEP expression of the k-MSPL as

$$SEP_k=\frac{A}{2}-4A\sqrt{B}\left[\begin{array}{l}\sum_{p=0}^{k-1}\sum_{q=0}^{k-1}\frac{\Gamma(5/2)\,\Gamma(1/2)\,a_p^{(SR_1)}c_q^{(R_1M_j)}}{\left(b_p^{(SR_1)}+d_q^{(R_1M_j)}+B+2\sqrt{b_p^{(SR_1)}d_q^{(R_1M_j)}}\right)^{5/2}}\times F\left(\frac{5}{2},\frac{3}{2};2;\frac{b_p^{(SR_1)}+d_q^{(R_1M_j)}+B-2\sqrt{b_p^{(SR_1)}d_q^{(R_1M_j)}}}{b_p^{(SR_1)}+d_q^{(R_1M_j)}+B+2\sqrt{b_p^{(SR_1)}d_q^{(R_1M_j)}}}\right)-\\ \sum_{p=0}^{k-1}\sum_{q=0}^{k-1}\frac{\Gamma(5/2)\,\Gamma(1/2)\,a_p^{(SR_2)}c_q^{(R_2M_j)}}{\left(b_p^{(SR_2)}+d_q^{(R_2M_j)}+B+2\sqrt{b_p^{(SR_2)}d_q^{(R_2M_j)}}\right)^{5/2}}\times F\left(\frac{5}{2},\frac{3}{2};2;\frac{b_p^{(SR_2)}+d_q^{(R_2M_j)}+B-2\sqrt{b_p^{(SR_2)}d_q^{(R_2M_j)}}}{b_p^{(SR_2)}+d_q^{(R_2M_j)}+B+2\sqrt{b_p^{(SR_2)}d_q^{(R_2M_j)}}}\right)\end{array}\right]$$

where $\Gamma(z)=\int_0^\infty t^{z-1}e^{-t}dt$ is the gamma function and $F(\bullet,\bullet;\bullet;\bullet)$ is the Gauss hyper geometric function defined in [9]. Although the analytical expression of SEP(10) can provide a relatively exact approximation in all SNR regimes. The average symbol error probability of *k*-MSPL with a single relay is derived in [7,Eq(10)].It provides an exact approximation in all SNR regimes. Furthermore, the traditional SEP of OFDM relaying system without SCM is given as [7],

$$SEP_{1-relay(non-SCM)}=\frac{A(1+\eta^{-1})}{4B\overline{\gamma}_1}=\frac{1}{N}ASEP_1$$

The diversity gain of the *k*-MSPL with single relay is *k* times more than the non-SCM based OFDM for single relay and it is calculated as [7].

$$SEP_{1-relay(SCM)}=\frac{1}{N}\sum_{k=1}^{N}ASEP_k$$

The SEP at M1 with two relays is given by

$$\begin{aligned}SEP_{2-relays}&=1-\left[2SEP_{1-relay(SCM)}\left(1-SEP_{1-relay(SCM)}\right)+\left(1-SEP_{1-relay(SCM)}\right)\left(1-SEP_{1-relay(SCM)}\right)\right]\\&=SEP^2_{1-relay(SCM)}\end{aligned}$$

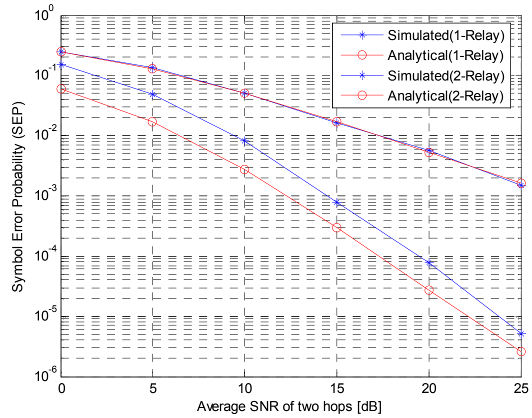

Figure 2: Comparison of Symbol Error Probability of the *k*-MSPL with single relay SCM and multicast relay SCM using BPSK modulation with N=16.

IV. Numerical Results

In the Monte Carlo simulations , we have assumed that both relays are transmitting at equal power level with non-symmetrical fading scenarios to study symbol error performance.Fig.2 depicts the simulation results, the well-approximated and analytical expressions of SEP for N=16 . For the convenience of comparison, the SEP of dual hop with single relay and dual relay are plotted. A significant performance gain is observed with multicast relay strategy. The results of simulation are quiet close to the well-approximated analytical expression.

V. Conclusion and Future Work

The one-way multicast strategy presented in this paper is suitable for live-streaming applications at downlink in Beyond 3G (B3G) wireless networks. Our dervied well-approximated SEP is better as compared to the earlier derived with single relay[7].As a result,a performance gain (high received SNR) is achieved at the edges of the cell with the help of dual relay and it avoids superfluous energy consumption of the single relay. Further, this scheme can be extended for Multi-user OFDM networks for high throughput applications like multicast real-time applications in 4G networks.

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