wireless user is assumed to transmit data as well as act as cooperative agent for another user.

3. Cooperative relaying protocols

There are two phases for the transmission of data from source to destination. In first phase, source transmits data both to relay and destination. In the second phase, relay processes the receive data and retransmits it to destination.

3.1 Non-Regenerative Communication Protocol

In non-regenerative relaying, signal from source is first transmitted to destination and relay node in phase 1, whereas relay amplifies the received signal and retransmits it to destination during second phase [4]. Relay receives the information signal with channel gain and noise. At the receiver, it decodes the combined signal using Maximum Ratio Combiner (MRC).

Suppose that the source is transmitting its information m to relay and destination with transmission power Ps to destination and relays. Received signal at relay and destination is given by

$$y_{sd} = \sqrt{P_s}\, h_{sd}\, m + n_{sd} \quad (1)$$

$$y_{sr} = \sqrt{P_s}\, h_{sr}\, m + n_{sr} \quad (2)$$

where h_{sd} and h_{sr} is the fading amplitude of the channel between source and the relay and destination, respectively. In equation, n_{sd} and n_{sr} are the additive noise. In AF relaying scheme amplification factor is given by

$$amp = \sqrt{P_k}/(P_s|h_{sr}|^2 + P_s + N_0) \quad (3)$$

P_k is the transmit power of any relay. Then, all the relays will forward the scaled versions of the received signal to D in the matched phases. So at the destination terminal, the received signals from the relay R can be written as

$$y_{rd} = amp\ h_{rd}\, y_{sr} + n_{rd} \quad (4)$$

$$= amp\ h_{rd}\,(\sqrt{P_s}\, h_{sr}\, m + n_{sr}) + n_{rd} \quad (5)$$

where h_{rd} is the fading amplitude of the channel between the relay and destination. In the case of Multi-relay cooperation based amplify and forward relaying, each relay applies an MRC detector on the signals that it receives from the source and all previous relays. There will be N + 1 phases for a system with N relay nodes.

3.2 Regenerative communication protocol

Instead of amplifying the signal received from source, another possibility for the relay is to decode the received signal from source and then retransmit to destination. DF scheme can be used to avoid error propagation if the channel between relay and destination is reliable. But, if the decoded signal at the relay is incorrect then forwarding incorrect signal to destination is meaningless. Here, performance of system is limited by worst link from source-relay and source-destination.

4. Fading in wireless communication

Due to multipath propagation of waves, rapid fluctuations in amplitude and phase occurs. This random fluctuations in received signal is called fading. In small scale fading, signal amplitude has a short term fluctuation due to local multipath propagation.

4.1 Flat fading

A received signal is said to undergo flat fading if the mobile radio channel has a constant gain and a linear phase response over a bandwidth larger than the bandwidth of the transmitted signal [5]. When the transmit signal experience flat fading, the received signal consist of pulses at irresponsible delays. That is the received signal consists of multipath with delays much smaller than symbol duration.

4.2 AWGN Channel model

The simplest wireless channel is the AWGN channel where the transmitted signal is added with noise and is given by

$$y = x + n \quad (6)$$

where, x is the signal transmitted and n is the additive white gaussian noise with mean zero and power spectral density $N_0/2$. Here, transmitted signal is added with noise. For deep space communication between earth stations and satellites, AWGN channel is an accurate model. To predict path loss in typical wireless environment, different path loss models have been developed.

4.3 Rayleigh fading

Rayleigh fading is used to model statistics of signals that reaches the receiver by multipath [6]. In this model, signal transmitted through a communication channel will fade according to Rayleigh distribution. If the mobile antenna receives the transmitted signal through number of multiple paths, Rayleigh fading is used. Rayleigh fading model is used as a model that is reasonable for ionospheric and tropospheric signal propagation. It is also used to model the effect of heavily built-up urban environments on radio signal. There is no direct path or Line Of Sight (LOS) component for Rayleigh fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution. Its probability density function is given by

$$f(r) = \frac{r}{\sigma^2} \exp\left[\frac{-r^2}{2\sigma^2}\right], \quad r \geq 0 \quad (7)$$

4.4 Rician fading

Rician fading occurs when there exists a line of sight signal, which is much stronger than the others. Amplitude gain in rician fading is characterized by Rician distribution. When there is no line of sight signal, specialised model for stochastic fading is the Rayleigh fading. It is sometimes referred as a special case of the more generalised concept of Rician fading. The probability density function of rician distribution can be written as

$$f(r) = \frac{r}{\sigma^2} \exp\left[\frac{-r^2+B^2}{2\sigma^2}\right] I_0\left(\frac{rB}{\sigma^2}\right), r \geq 0 \qquad (8)$$

Where $I_0(\ )$ is the zeroth-order modified Bessel function of the first kind, B is the strength of the direct component.

4.5 Nakagami fading

Probability distribution which is related to the gamma distribution is the Nakagami distribution or the Nakagami-m distribution [7]. Two parameters of nakagami distribution are shape parameter, m and controlling spread, Ω.

Its probability density function (pdf) is

$$f(x; m, \Omega) = \frac{2m^m}{\Gamma(m)\Omega^m} x^{2m-1} \exp\left(-\frac{m}{\Omega}x^2\right) \qquad (9)$$

The parameters m and Ω are

$$m = \frac{E^2[x^2]}{Var[X^2]} \qquad (10)$$

and

$$\Omega = E[X^2] \qquad (11)$$

Rayleigh and Rician can be considered the special cases of Nakagami distribution. In the special case m=1, Nakagami tends to Rayleigh distribution. For m>1, Nakagami reduces to Rician distribution.

5. Results and discussions

To assess the performance of a system transmitting a signal from source to destination, key parameter used is BER. There are different parameters for determining performance of system. For the time being, BER is taken as a parameter to assess the performance of a system.

Table 1: System parameters

Parameters	*Specification*
Number of bits	10e6
Total transmitted power	1
SNR vector	0 to 40dB
Modulation scheme	QPSK
Number of relays	2, 3
Combining technique	MRC
Channels	Rayleigh, rician, nakagami, flat fading and AWGN channel

Figure 1 gives the BER vs Signal-to-Noise-Ratio (SNR) graph of multihop relays deploying QPSK modulation over Rayleigh fading channel for AF relaying scheme. For evaluating the BER performance of Multi-hop relays, considered two and three relays. From the graph, it is noticeable that BER for three relay system is higher than two relay system. Even though the deployment of three hop increases the BER compared to two relay, it increases the performance due to increased network coverage.

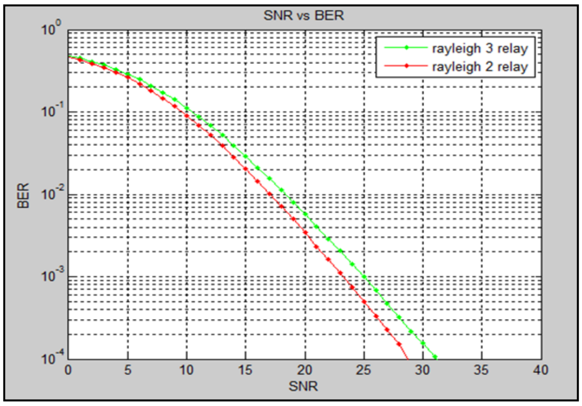

Figure 1: Simulated BER vs SNR graph for Rayleigh fading

Figure 2 shows the BER vs SNR graph of Rician fading which gives almost the same results as that described for Rayleigh distribution.

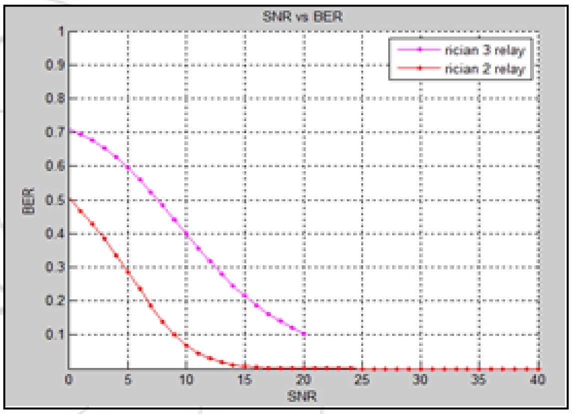

Figure 2: Simulated BER vs SNR graph for Rician fading

Figure 3 and Figure 4 illustrates that both AWGN and flat fading is expected to have approximately same BER performance. But for flat fading BER converges to zero at low values of SNR.

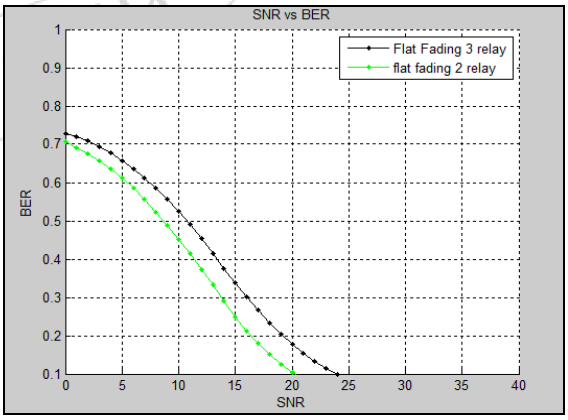

Figure 3: Simulated BER vs SNR graph for flat fading

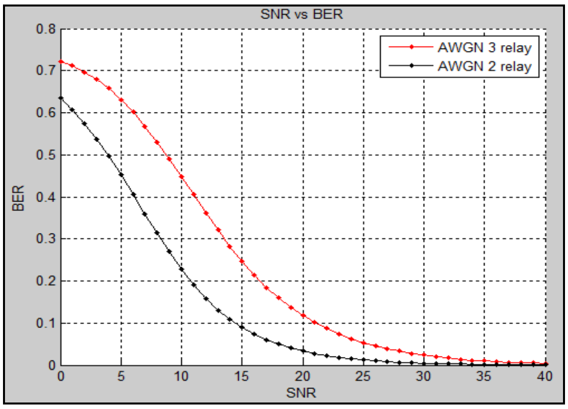

Figure 4: Simulated BER vs SNR graph for AWGN fading

Rayleigh and rician fading channels are the special cases of Nakagami fading channel. BER vs SNR graph of nakagami fading channel is shown in the Figure 5.Here also, obtained the similar results as that of other fading channels. As the number of relay increases, performance improves due to coverage extension even though there is an increase in BER.

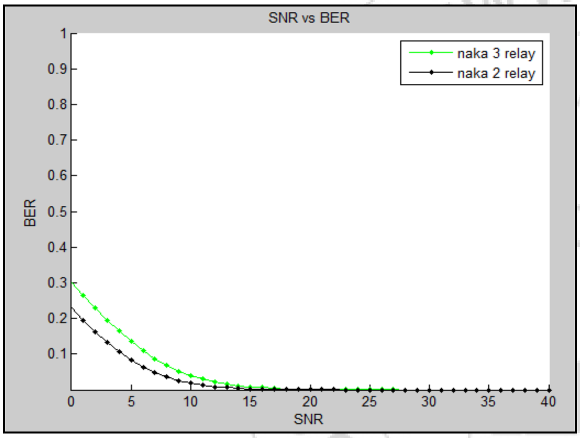

Figure 5: Simulated BER vs SNR graph for Nakagami fading

Rayleigh and Rician can be considered the special cases of Nakagami distribution. In the special case of m=1, Nakagami reduces to Rayleigh distribution. For m>1, Nakagami tends to Rician.

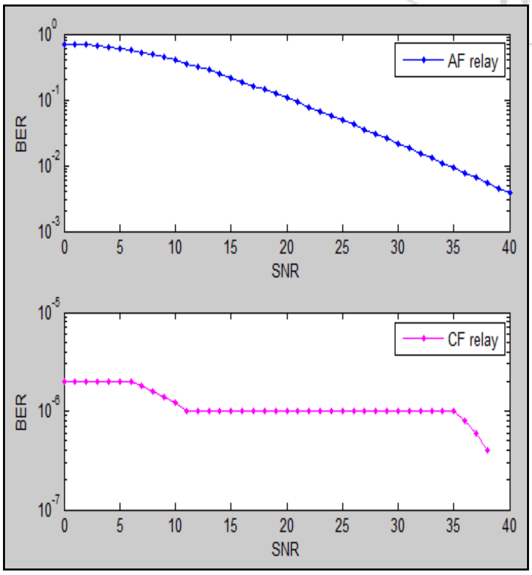

Figure 6: Comparison of AF and CF relay channel

Figure 6 illustrates the comparison of non-regenerative (AF) and CF relay channels. From the graph, it is noticeable that BER for AF is higher than CF. In an AF relaying scheme, the relays simply amplify and forward a received noisy signal to the destination node which results in increased noise level. But, this has an advantage over eavesdropper assisted relay channel as they amplifies the noise along with the signal. Relays in a CF relaying scheme map the received signal and only forward the compressed signal to the destination node. Because of simplicity, AF relaying scheme is widely used.

6. Conclusion

In communications theory, different distributions can be used to model the signals that reaches the receiver by multipath. In this paper, BER performance of Multi-hop non-regenerative communication protocol over different fading channels deploying QPSK modulation for 3 hop and 2 hop cases are evaluated and simulated. Fading channels such as Rayleigh, Rician, Nakagami, AWGN and Flat fading is considered. The simulated results show that as the number of relay increases, performance of the system improves due to extended network coverage even though there is an increase in BER. It is also analyzed and concluded that increasing number of relays in non-regenerative communication protocol have the same effect on BER performance of different fading channels. The performance of system in CF relaying protocol is also examined. Even though the BER for AF is higher than CF, due to simplicity, AF relaying protocol is widely used and it also has an advantage over eavesdropper assisted relay channel as they amplifies the noise along with the signal.

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Author Profile

Sumayya Ali received her B.Tech degree in Electronics and communication engineering from Mahatma Gandhi University, Kottayam, India, in 2013. Currently obtaining MTech degree in Communication Engineering from KMEA Engineering College, Edathala, Aluva. Her research interests include cooperative communication, wireless communication and computer networks.