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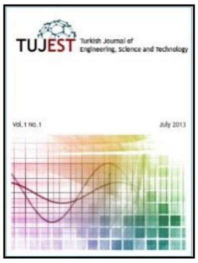

Comparative Analysis of QRR and AODV Based Relaying System

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Abstract

In Cooperative communication, multiple single-antenna relay terminals assist the source in transmitting information to the destination and provide a very effective strategy for improved spatial diversity of communication. A relay strategy, Quantized Reliability Relaying (QRR) is implemented in a semi blind scenario, considering multiple sources and destinations assisted by a set of relays. The reliability of the relays is partitioned into three levels in accordance with the log-likelihood ratio (LLR) of the received signal and forward regenerative symbol to the destination if quantized reliability falls within the "send +1" and "send-1" region. The assumption is that a relay gets the perfect channel state information (CSI) from the source and the destination node can obtain the perfect CSI from the other relays, which is a semi blind scenario. The CSI of the link between the source and the participating relays is not required by the destination receiver. The performance parameters of QRR namely delay, throughput and delivery ratio are plotted for various packet sizes. It is compared with the existing protocol, AODV. In order to enhance the performance, it is extended to higher order modulation schemes and compared using NS-2 tool.

1. Introduction

Cooperative communications methods have been proposed in wireless communication that enables a single-antenna transmitter which is limited in having a diversity antenna for want of space, to share their antennas and generate a virtual multiple-antenna transmitter thus enabling to achieve the effects of a good transmit diversity. Transmit diversity schemes generally requires more antennas at the transmitter for the purpose of increasing data rate. Cooperative communication has received great attention in recent years because it increases the signal coverage area and also higher spatial diversity. The Cooperative communication employs relays to meet the demand of coverage and diversity. Modern wireless devices are handheld which implies they are very small to provide space for more than one antenna. Even the hardware complexity to employ diversity is another challenge for the small devices. Cooperative communications with the help of relays proves to be a better solution for increased spectral and power efficiencies. The network coverage problem with reduced outage probability also finds a good solution through cooperative means. Like the multi-antenna transceivers, relays create multiple replication of the signal to be transmitted, thus providing a good diversity.

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Antenna diversity or space diversity is one of the several wireless diversity schemes where two or more antennas are employed to improve the quality and reliability of a wireless link. In case of urban and indoor environments, a clear line-of-sight (LOS) between transmitter and receiver is not possible. The signal is reflected transmitted reaches destination through multiple paths. Each of these reflections of signals has new phase shifts, time delays, attenuations, and distortions that can destructively interfere with each another at the receiving antenna.

Spatial diversity employs multiple antennas, where the antennas are of the same characteristics. These antennas are physically separated from one another. The expected incidence of the incoming signal, sometimes decides the space between the antennas used for diversity and at times it is in the order of few wavelengths. Many times a larger distance of separation between the antennas are needed. The concept of Cellularization and the sectorization is an example for spatial diversity, where the antennas or base stations are kept few miles apart. These techniques have benefited the mobile communication industry, as it can allow more users to share a limited communication spectrum and reduced co-channel interference. A virtual antenna array that can emulate the operation of a multi-antenna transceiver system can be synthesized through proper coordination between various users in the wireless system. On the other hand, many aspects of cooperative communications have open problems. Cooperative diversity systems consist of multiple nodes that share resources in order to create multiple diversity channels and thereby improve system performance, typically in terms of availability, range and throughput.

2. Background

A detailed study on Cooperative communications has been done from [1]-[5]. Cooperative communications contain multiple single-antenna relay terminals that assist the source in transmitting information to the destination. The cooperative method proves to be an effective means of increasing the spatial diversity of communication networks.

Many relay-based strategies have been studied for realizing cooperative diversity in wireless communication networks [6]–[9]. It is concluded that the Amplify-and-Forward (AF) is the best-relay selection scheme. The Amplify-and-Forward scheme proposed for a semi-blind scenario in [10] is studied for better understanding. The amplitude CSI of the source-to-relay is unknown to the destination and the relay with the best source-to-relay SNR transmits its amplified signal to the destination.

The Decode-and-Forward (DF) [11] scheme is studied in detail and concluded that in the DF scheme, each relay decodes the received information and generates a new message, which it then forwards to the destination. However, in many applications, the relays cannot perform channel decoding due to a lack of knowledge of the channel codebook or a limited transceiver capability. In such a scenario, the DF scheme is implemented simply by detecting or demodulating the received signals on a symbol-by-symbol basis.

Many diversity combining techniques [12], [13] have been studied for DF cooperative networks. It is concluded that in implementing such diversity combining schemes, each relay must know the source-to-relay channel CSI, while the destination must know not only the CSI of each relay-to-destination channel, but also the CSI of each source-to-relay. To satisfy this requirement, various assumptions are made.

The compress-and-forward scheme [14] is studied in detail. It is characterized as a block-encoded scheme where each node performs its operation over blocks of time symbols. The relay node quantizes (or compresses) the symbols it receives over a block of time to finite bits. These bits are then transmitted to the next block. The compression rate at a relay node is defined to be the rate of transmission of the compressed bits.

3. QRR Modeling

In the proposed QRR model each relay after receiving the source symbol partitions its reliability into three levels based on the log-likelihood ratio (LLR) of the received signal and forwards the regenerative symbol to the destination over orthogonal channels if the quantized reliability falls within the "send +1" or "send -1" region and remains silent otherwise. The QRR is implemented for the assumed system model shown below:

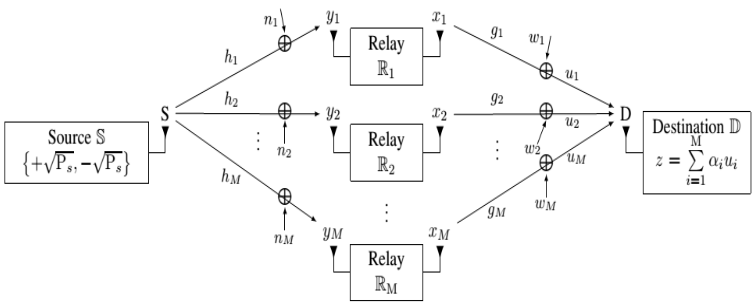

***Fig. 1** Cooperative Relaying*

Fig.1 illustrates a typical cooperative communication network consisting of M randomly placed relay nodes R_i, i= 1,2,…….,M, a source node S, and a destination node D .It is assumed that each node has only a single antenna, and thus simultaneous transmission and reception cannot be performed. In addition it is also assumed that the communication channel between each node pair is flat fading. Let the channel from the source S to relay R_i be denoted as h_i, and let the channel from relay R_i to the destination D be denoted as g_i. Furthermore, let the two sets of channels be denoted as h={h_1,...,h_M}and g={g_1,...,g_M} respectively. Assume that all the communication channels are drawn from a Rayleigh distribution with variances , σ_h^2 and σ_g^2, i.e.,

$$h_i \sim CN(0, \sigma_h^2) \text{ and } g_i \sim CN(0, \sigma_g^2) \tag{1}$$

It is assumed that S transmits symbols to D using the considered semi-blind model. As already mentioned in a semi-blind model destination does not know the CSI (Channel State Information) between sources and relays. The source uses BPSK modulation scheme and hence

$$S \in \{\sqrt{Ps}, -\sqrt{Ps}\} \tag{2}$$

where P_S is the power of the symbol transmitted by the source.

The transmission of symbols from source is accomplished through a two-phase process:

- Phase I, the source S broadcasts to all the relays in the network. Under the flat fading assumption, the received complex signal at R_i is expressed as

$$y_i = h_i . s + n_i \tag{3}$$

where n_i is a Zero Mean Circular Symmetric Complex Gaussian (ZMCSCG) variable with variance σ_n^2, i.e.,

$$n_i \sim CN(0, \sigma_n^2) \tag{4}$$

n_i, i=1,...,M are assumed to be independent.

- Phase II, having received y_i, relay R_i generates an output x_i in accordance with a pre-defined relaying approach. In the regular uncoded DF scheme, the relays make hard decisions based on the signal received from S, and then transmit these decisions to the destination. The output of the relay has the form

$$x_i = \begin{cases} \sqrt{Pr}, & if \gamma_{DF}(y_i) > \eta_{DF} \\ -\sqrt{Pr}, & else \end{cases} \tag{5}$$

where P_r is the power of the symbol transmitted by the relays

The relays transmit or mute their signals in accordance with their reliability, as determined by, the LLR of the relay observations, y_i. Under the considered assumptions, the density function of yi given h_i and s can be expressed as

$$P(yi|hi, s) = \frac{1}{2\pi\sigma^2} \exp\{\frac{(yi - hi.s)*(yi - hi.s)}{\sigma_n^2}\} \tag{6}$$

Thus, LLR of y_i is given by,

$$\mathcal{L}(yi) = log \frac{P(\frac{yi}{hi}, s = +\sqrt{Ps})}{P(\frac{yi}{hi}, s = -\sqrt{Ps})} \tag{7}$$

$$\mathcal{L}(yi) = \frac{4\sqrt{Ps}\Re(hi * yi)}{\sigma_n^2} \tag{8}$$

where $\Re(c)$denotes real part of complex variable c

Thus,

$$Rel(yi) = \Re(hi * yi) \tag{9}$$

Thereby $-\infty < Rel(yi) < \infty$

In the QRR scheme, the real-valued reliability given in (3) is partitioned into three regions by means of the following detector:

$$x_i = \delta_{Q,i} s_i(y_i) \tag{10}$$

$$s_i(y_i)=\begin{cases} 1, & if\Re(h_i^* y_i) > \eta_u \\ 0, & if \eta_l < (h_i^* y_i) < \eta_u \\ -1, & if\Re(h_i^* y_i) < \eta_l \end{cases} \quad (11)$$

In which η_u and η_l are upper and lower threshold values, respectively. In the above equation if $x_i = 0$ indicates that R_i mutes its decision.

The received signal corresponding to the signal x_i from R_i will be

$$u = g_i.x_i + w_i \quad (12)$$

where, w_i is a ZMCSCG variable with varianceσ_w^2, i.e.,

$$w_i \sim CN(0, \sigma_w{}^2) \quad (13)$$

The received signal at the destination is

$$Z = \sum_{i=1}^{M} \alpha_i u_i \quad (14)$$

where α_i is optically determined for the QRR scheme.

4. Simulation Results

It is The QRR scheme is implemented in NS-2.34 by generating 10 nodes for the scenario and its performance is compared with the existing AODV routing protocol. The QRR described in the above section uses BPSK modulation scheme. The QRR is modified for higher order modulation schemes namely QPSK,QAM 16, 64, 128, 256. The graphs are plotted for comparison of its performance parameters.

Table I. Simulation Parameters

PARAMETERS	SPECIFICATIONS
Tool used	NS 2.34
No. of nodes	10
Source nodes	3
Destination nodes	2
Packet size	500-2000 bytes
Sending rate	20 packets per second

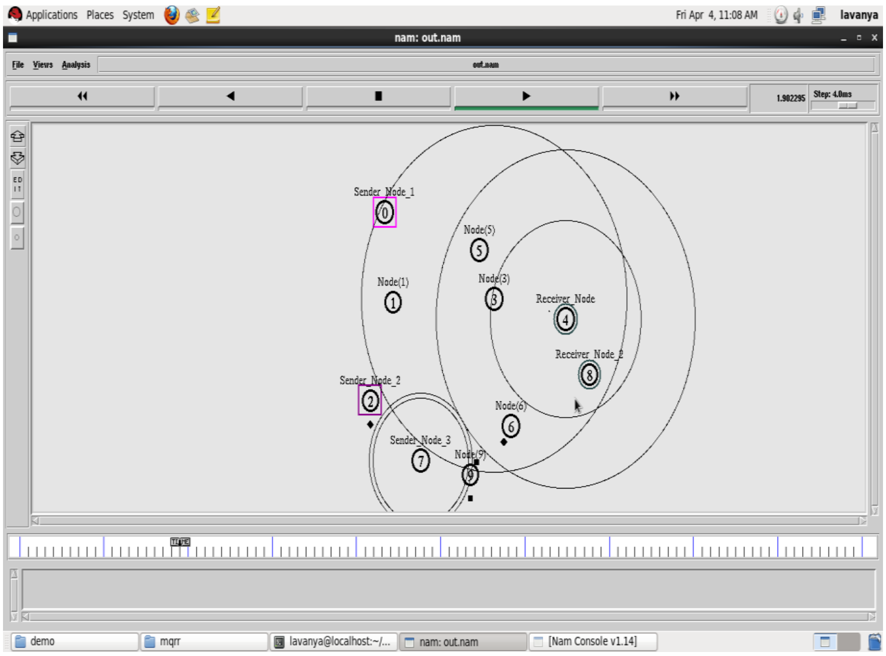

Figure 2. *Relaying Scenario Simulated Through NS2*

Fig.2 illustrates the animator file of the scenario generated. It consists of 10 nodes of which 3 act as source nodes (0-2) and 2 act as destination nodes (4,8) and the remaining 5 act as relay nodes. The source nodes are selected based on the user's interest and the selected source nodes transmit packets to the relays. Once the relay has received the packet it computes log likelihood ratio if this value is within the CST then the packet will be forwarded to destination else it will be dropped. The following are the simulation results obtained.

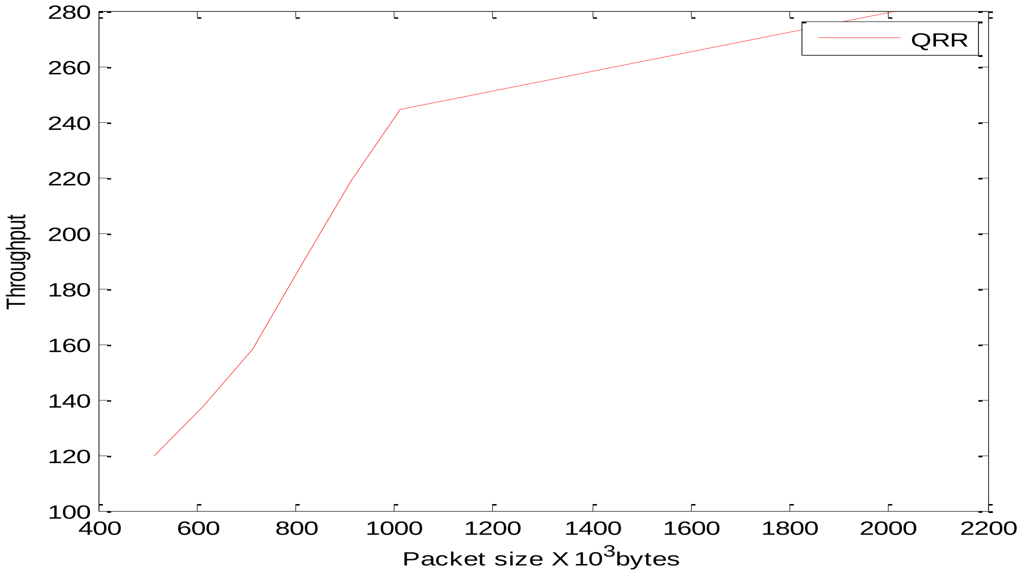

Figure 3. Throughput Vs Packet Size

From the Fig.3 it is inferred that with increase in packet size throughput increases. The throughput is measured in bytes per second, when packets of bigger size are sent the destination, node receives packets of bigger size. Thus, throughput increases. Fig.4 illustrates that average delay increases with increase in the packet size due to limited capacity in the queue.

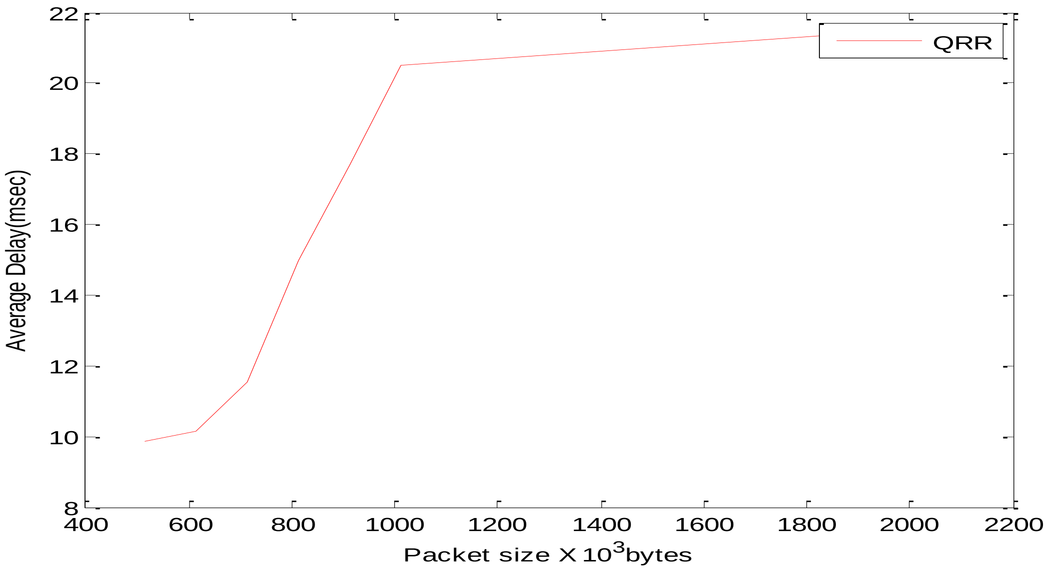

Figure 4. *Average Delay Vs Packet Size*

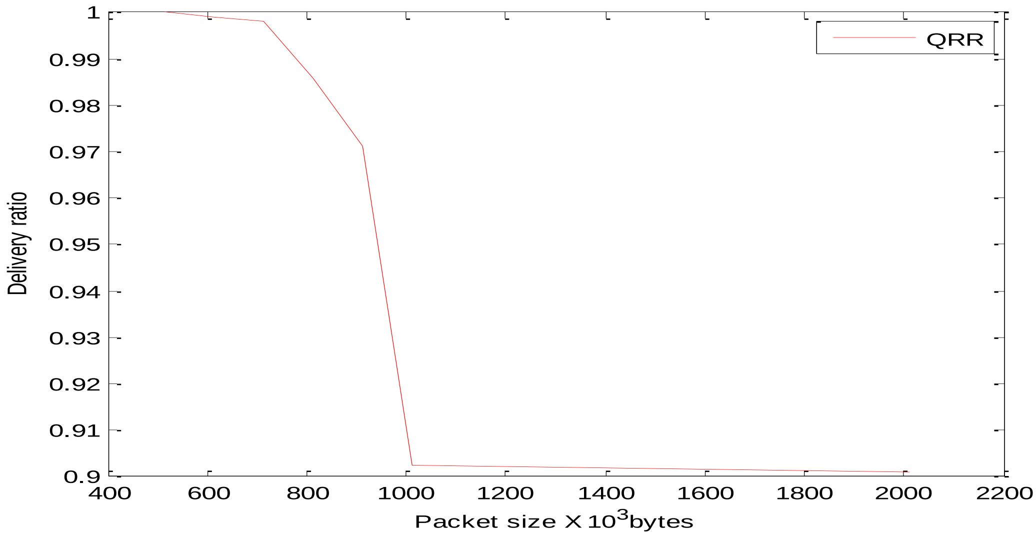

Figure 5. *Delivery Ratio Vs Packet Size of QRR Scheme*

Fig. 5 illustrates that delivery ratio decreases with increase in packet size. The delivery ratio is the ratio of number of packets received to number of packets sent. As the packet size increases with buffer of constant size, more number of packets will be lost, hence delivery ratio decreases. Fig.6 depicts that the average delay is low for QRR compared to AODV for a given packet size.

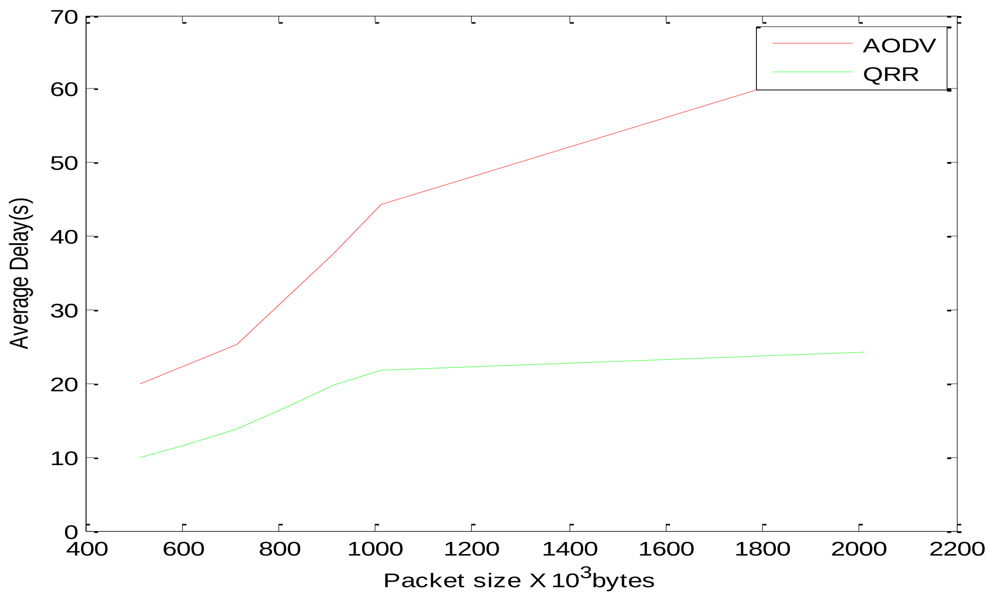

Figure 6. *Average Delay Vs Packet Size Comparison*

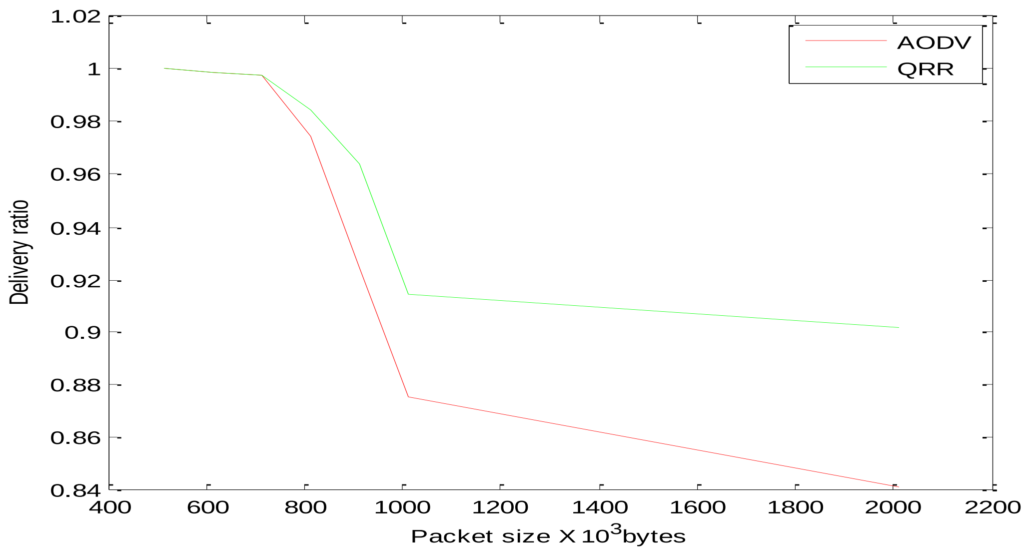

Figure 7. *Delivery Ratio Vs Packet Size Comparison*

Fig.7 depicts that the delivery ratio of QRR is better compared to AODV for a given packet size. Fig. 8 depicts that throughput is higher for QRR compared to AODV for given packet size Thus from Fig.6,7 and 8 it can be concluded that QRR gives a better performance when compared to AODV.

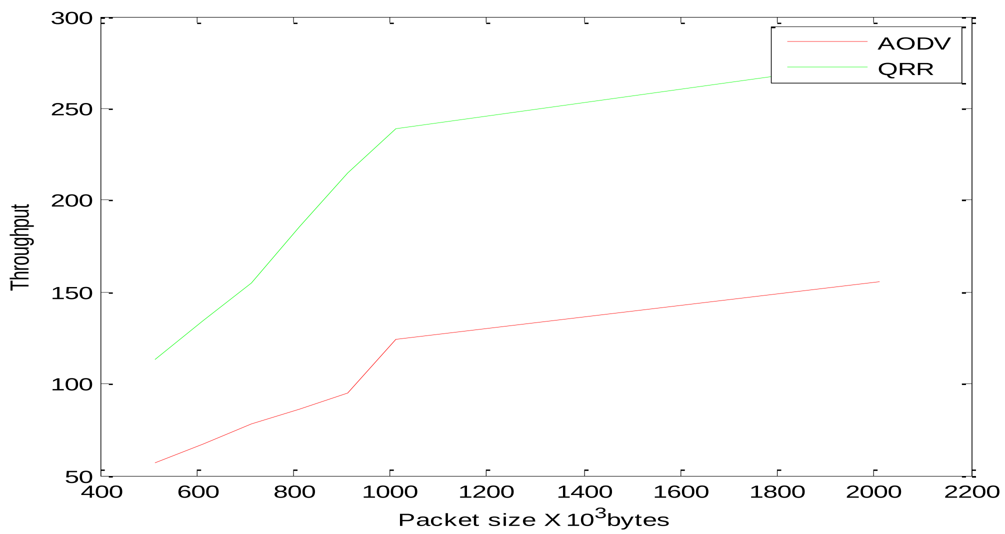

Figure 8. *Throughput Comparison*

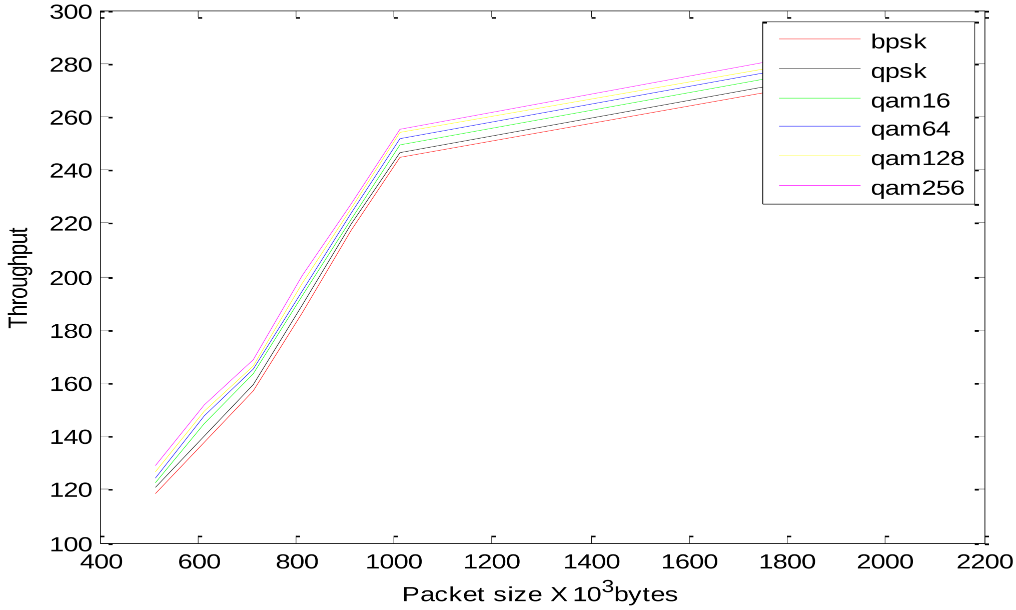

Figure 9. *Throughput comparison For Various modulation Schemes*

Fig.9 depicts that QAM 256 provides highest throughput when compared to other modulation schemes. Fig.10 depicts that QPSK provides maximum delay when compared to other modulation schemes.

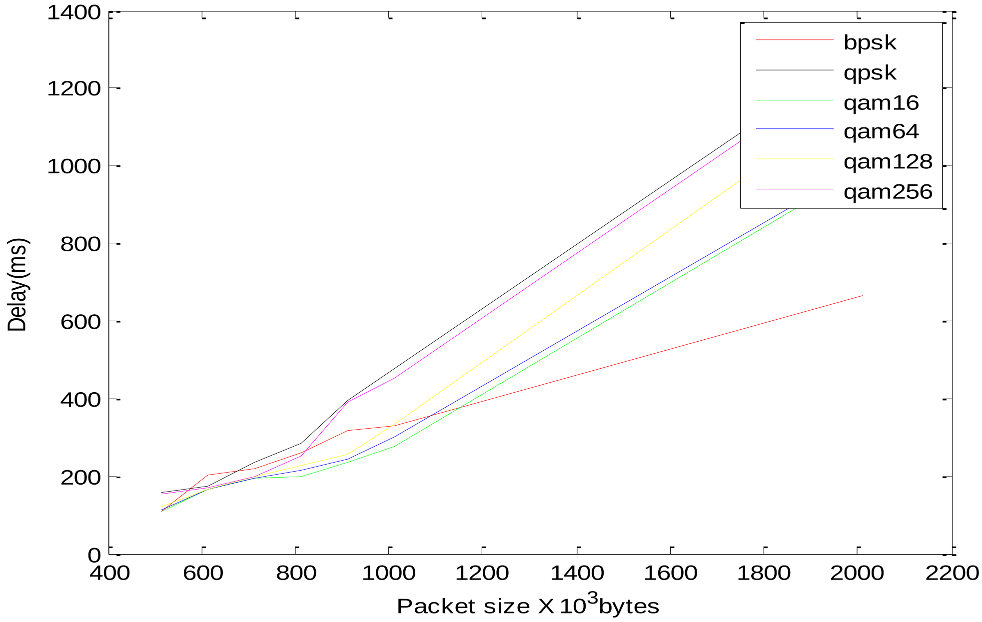

Figure 10. *Delay performance of Modulation Schemes*

5. Conclusion

QRR is implemented in the generated scenario consisting of ten nodes of which three acts as source nodes and two destination nodes and remaining act as relay nodes. For the same scenario the implemented QRR and the existing routing protocol, AODV are compared and from the results it is obtained that QRR gives a better performance when compared to AODV. The implemented QRR is further extended for higher order modulation schemes namely QPSK, QAM 16, QAM 64, QAM 128, QAM 256 and their performance parameters are compared and from the results it is obtained that QAM 256 gives the highest throughput where as delay is maximum for QPSK.

References

[1] J. N. Laneman, D. N. C. Tse and G. W. Wornell, "Cooperative diversity in wireless networks: efficient protocols and outage behaviour," *IEEE Transactions on Information Theory*, vol 50, no.12, pp.3062–3080, Dec. 2004.

[2] G. Kramer, M. Gastpar and P. Gupta, "Cooperative strategies and capacity theorems for relay networks," *IEEE Transactions on Information Theory*, vol 51, no.9, pp.3037–3063, Sep. 2005.

[3] J. N. Laneman and G. W. Wornell, "Distributed space-time-coded protocols for exploiting cooperative diversity in wireless networks," *IEEE Transactions on Information Theory*, vol 49, no.10, pp.2415–2425, Oct. 2003.

[4] T. E. Hunter, S. Sanayei and A. Nosratinia, "Outage analysis of coded cooperation," *IEEE Transactions on Information Theory*, vol 52, no.2, pp.375–391, Feb. 2006.

[5] A. Sendonaris, E.Erkip and B.Aazhang, "User cooperation diversity- part I and part II," *IEEE Transactions on Communications*, vol 51, no.11, pp.1927– 1948, Nov.2003.

[6] T. M. Cover and A. Gamal, "Capacity theorems for the relay channel," *IEEE Transactions on Information Theory*, vol 25, no.5, pp.572–584, Sep. 1979.

[7] A.Sendonaris, E.Erkip, and B.Aazhang,"User cooperation diversity-partI: system description," *IEEE Transactions on Communications*, vol 51, no.11, pp.1927–1938 Nov. 2007.

[8] A.Bletsas, H.Shin, and M.Z.Win, "Cooperative communications with outage-optimal opportunistic relaying," *IEEE Transactions on Wireless Communications*, vol 6, no.9, pp.3450–3460, Sep. 2007.

[9] S.Yang and J.-C.Belfiore, "Towards the optimal amplify-and-forward cooperative diversity scheme," *IEEE Transactions on Information Theory*, vol 53, no.9, pp.3114–3126, Sep 2007.

[10] A.Nosratinia, T.E.Hunter and A.Hedayat, "Cooperative communication in wireless networks," *IEEE Communication Magazine*, vol 42, no.10, pp.74–80, Oct 2004.

[11] D.B.da Costa and S. Aissa, "End-to-end performance of dual-hop semi-blind relaying systems with partial relay selection," *IEEE Transactions on Wireless Communications*, vol 8, no.8, pp.4306–4315, Aug. 2009.

[12] T.Wang, A.Cano, G.B.Giannakis, and J.N.Laneman, "High performance cooperative demodulation with decode-and-forward relays," *IEEE Transactions on Communications.*, vol 55, no.7, pp.1427–1438, Jul. 2007.

[13] T.Wang, G.B.Giannakis, and R.Wang, "Smart regenerative relays for link-adaptive cooperative communications," *IEEE Transactions on Communications*, vol 56, no.11, pp.1950–1960, Nov. 2008.

[14] Adnan Raja and Pramod Viswanath "Compress-and-Forward Scheme for Relay Networks: Backword Decoding and Connection to Bi sub modular Flows", *ACM Transactions on Algorithms*.[Online], Available: http://arxiv.org/pdf/1012.0416 Jun. 2012.