Improving QoS and energy efficiency of CRCN using optimal relay node selection scheme

Sribindu Sattu[1], Moparthy Gurunadha Babu[2]

[1] PhD Scholar, Shri Jagdishprasad Jhabarmal Tibrewala University, Jhunjhunu, Churela, Rajasthan, India
[2] Professor, Department of Electronics and Communication Engineering,, CMR Institute of Technology, Hyderabad, Telangana, India

Abstract: Due to the critical and extensive applications in defense and research systems, the research on MIMO-based Cognitive Radio Ad-Hoc Networks has considered. The cooperative communication-based wireless relay networks exploit as an effective technique to achieve the improved performance in wireless networks based on the transmission and lifetime. The MIMO based Cognitive Radio Ad-Hoc Networks have neither understood nor studied under the constraint of harsh environments with the power supply stringently. The scheme of optimal relay selection has proposed for decreasing the energy consumption and data error rate using bit-error-rate (BER) while ensuring the each link Quality of Service (QoS) than the MIMO-based networks. By implementing the finite-state Markov chain, the modeling of wireless channel has performed. In the relay selection, the methods of multiplexing-gain and diversity-gain have incorporated in MIMO systems for residual energy.

Keywords: Quality of Service, Finite-state Markov channel, energy-efficiency, MIMO-based Networks, Relay selection, Broadcast, Optimal selection.

I. INTRODUCTION

For transmission of data and significant gains, the communication of wireless nodes involve in the cooperative communication networks that ensures the overall throughput and energy efficiency [1]-[3]. The inherent diversity uses in the networks of multiple wireless links that are distributed spatially, and the nodes with single antennas are only required. A finite amount of energy can supply by the nodes of batteries in the networks. Energy efficiency is crucial in such networks because it impacts the network lifetime [4]. In fading channels, the outage probability should keep below a specified level for data delivery in a network. According to the varied relay data with the time, the cooperative communication schemes' energy consumption has assessed with the state changes in a channel. Due to the wireless channel broadcasting, the energy saves by transmitting the data over multiple relay nodes and decoding of a signal performs using some or all of the relays. From the relays to the destination, the transmitting energy saves by using cooperative beamforming algorithms [5]-[9]. The transmit signals with linearly weight add at the destination coherently in the approach where the relays are used based on the knowledge of required channel state information (CSI).

For cooperative beamforming, an additional challenge is the obtaining and exploitation of CSI in a distributed manner while maximal ratio transmission motivates the cooperative beamforming that incorporate with multiple antennas [14], [15]-[18]. In the above literature, the CSI retrieval for relay and its further consequences have not included. In [3], [7], [10], and [11], transmitter-side CSI was assumed without considering the cost of factoring. In [5], the authors consider the amplify-and-forward rather than the decode-and-forward and not involving the acquiring CSI cost.

In [6], the data retrieval of channel phase or channel fading at the transmitters was not involved in the model. In the above cited papers, the decoding of a signal using all relay nodes that support the beamforming. In [12], a method of fully distributed power allocation was described that decides the power at each relay node using the instantaneous channel gain for the destination. For example in [13], strategies have considered for allocating the Gaussian relay networks to improve the net throughput. Recently, a rapid growth has resulted with the improvements of underwater acoustic wireless sensor networks (UWA-WSN) [19] because of the high significance for military and commercial applications including tactical surveillance, offshore exploration, disaster prevention, oceanographic data collection, and pollution monitoring. The long-term monitoring of selected water areas include in the applications of underwater communications that costs a greater bandwidth and energy or power of UWA-WSN [20]. One of the essential features and challenges of the next generation UWA-WSN represents as the multimedia transmissions (ex: audio and video) with QoS requirements and further it demands both the consumptions of bandwidth and energy for ensuring the low-bit-error-rate, delay-tolerant, and high data rate requirements of QoS. The research community of UWA-WSN has explored and different advanced efficient wireless techniques applications, involving relay networks, cooperative communication, and MIMO. The MIMO [21] wireless communication has displayed as an effective wireless method which improve the spectral efficiency significantly based on the parallel transmission than the multiple transmitter or receivers over the underwater acoustic wireless channels. In the proposed technique, the issues of power saving didn't address. For prolonging the UWA wireless networks lifetime with the high data-rate transmissions, an efficient power saving technique was used as the cooperative communication based wireless relay networks. In [22], the authors were proposed the technique of cooperative communication for achieving the strategies of energy efficient scheduling for wireless networks. In the underwater environments, the provisioning of QoS didn't investigate. In [23], a wireless relay networks framework has improved based on the effective capacity and cross-layer operation theory and the corresponding algorithms of resource allocation for provisioning of QoS. The work can extend to the framework of UWA-WSN although it focuses on the wireless networks of radio frequency (RF). A number of recent research works [21], [24]-[26], the existed explicit schemes address the optimal relay selection critical design problem for QoS provisioning and power-saving over UWA-WSN with the requirements of QoS while the cooperative relay communications have utilized for high-data-rate and reliable UWAWSN that covers the large-area and long-range. However, the investigation or understanding of the energy-efficient relay selection has not discussed under the stringent power supply constraint in MIMO based UWA WSNs for analyzing the energy saving and QoS performances.

II. LITERATURE SURVEY

For conflicting the induced fading by multipath propagation in WSNs, two variants introduce for an energy efficient cooperative diversity protocol. Based on classical relay channel, the underlying methods have developed and exploit the space diversity. They are implemented for any wireless setting and energy savings provide and network performance improved in capacity although they are designed for ad-hoc and peer-to-peer wireless networks [27], [28]. The data of theoretic upper bound has derived on the rate per communication pair in a large ad-hoc wireless network [29]. As the number of users are large, the maximum achievable rate per communication pair has to reduce to zero in a large extended ad-hoc network. To investigate the networks and their performance using algebraic methods, a new framework designs using the linear codes and implements for acyclic delay-free networks and cyclic networks with delays. Based on the results, the overhead of network management is not required for multicast connections, but the network management requires to initiate the codes change that becomes necessary [30].

Marjan Baghaie & Bhaskar Krishnamachari (2011) [31] have conveyed the information about delay constrained energy-efficient broadcasting problem in cooperative multi-hop wireless networks. The problem is NP complete and O (log (n)) is approximated. For this issue, the analytical lower-bound and approximation results derive. Three parts include in the NP hard problem such as power control, scheduling, and ordering. A novel algorithm integrates the linear and dynamic programming, the power-control and joint scheduling problem can solve in a polynomial time if the ordering is given for achieving minimum energy broadcast in a given delay constraint.

Sushant Sharma et al., (2011) [32] has described the advantages of utilizing Cooperative Communications (CC) in multi-hop wireless networks based on the multi-hop flow routing and joint optimization of cooperative relay not allocation for concurrent sessions. Because of the mixed-integer nature and large problem space, this optimization issue is difficult inherently. In addition to the various novel components, the branch-and-cut framework can resolve this problem using an efficient solution procedure for improving the computation.

Vishal K Shah et al., (2012) [33] has investigated various relay selection methods in cooperative communication. The author has discussed the exploitation of cooperative transmission protocols in the relay station such as detect and forward or amplify and forward. The mechanisms of relay selection can categorize as cooperative relay selection and opportunistic relay selection by relying on the relation between the entities of a network. However, these techniques have demonstrated briefly.

Rui Cao et al., (2012) [34] has proposed a decomposed LT codes which has two layers of random encoding for cooperative relay communications. But, the method has a single layer of decoding. Both relay-destination and source-relay links can ensure by the cooperative system based on the encoding of two layers at the relay nodes and the source that reduces the latency and computation cost. For construction of DLT code, a technique of general decomposition develops.

Bravo et al., (2009) [35] has proposed a cooperative relay communications in mesh networks. The decode-and-forward relay nodes use to address the mesh wireless networks for which the decision rules of optimal node derive for binary transmission. For the probability of bit error, the expression obtains. Compared to the multihop networks, the mesh networks performance is analyzed and the improvement achieves when both networks include the equal number of hops and the same number of nodes.

In [36], various researches have outlined for presenting the CR technology throughput. The overlay and inter weave methods of CR have focused specifically and describe these methods based on a conceptual framework for SUs. The used techniques of frequency selection in OSA have demonstrated. By considering the interference from PU, the system outage probability performance assesses using the method of amplify and forward relay selection in an underlay CR relay network [37]. Based on the criterion of merit index, the relay selection scheme has proposed. Because of huge increment in data access, Cognitive Radio becomes new paradigm that proposes for managing the spectrum scarcity. As long as the primary users don't utilize the band, the radio spectrum can sense by a CR, locate the spectrum holes, and access them. The network performance can increase by coupling of nodes using the cognitive functionalities and the capabilities of self-aware operation. The energy efficiency can achieve based on the data routing in a cognitive radio network based on the routing protocols. In CRN, an unexplored area is the routing method with the performance evaluation and efficient criterion is an open problem for analyzing the routing protocols performance [38].

III. PROPOSED SYSTEM

MIMO wireless communication has proved as effective wireless techniques as they show improvement in the spectral efficiency based on the parallel transmission at the multiple receivers or transmitters. The power saving issues didn't mention in the proposed method. The cognitive networks data transmission and lifetime improve using the cooperative communication based wireless relay networks. For analyzing the strategies for energy efficient scheduling in WSNs, the cooperative communication method proposes and the provisioning issue of QoS didn't investigate in the cognitive environments. The crucial design issue of the optimal relay selection addresses by the existing schemes for QoS provisioning and power saving than the CRCN with QoS requirements. For high data rate and reliable CRCN that ensures the covering of large area and long range using the cooperative relay communications. In the MIMO-based networks, the energy-efficient relay selection has neither investigated nor understood in the performances of QoS and optimization of energy or power under the constraints of stringent power supply. In MIMO-based UWA-WSN, a Hybrid Relay Selection Scheme proposes using the Bit Error Rate (HRS-BER) for limiting the aforementioned problems for QoS provisioning. The finite state Markov chain uses for channel modeling. The tradeoff between the multiplexing gain and diversity gain of MIMO is considered that need to design based on the random channel-state variations jointly. For maximizing the network lifespan and energy efficiency, the residual relay energy considers in the relay selection. The system formulates based on the functions of: (1) energy consumption of data packets that transmit from source node to the destination node; (2) the wireless link data rate between the relay node and the destination node; and (3) BER of the link between the source node and the relay node. The optimal relay selection models as the stochastic optimization problem for improving the reward function of system over the MIMO-based cognitive radio networks. The proposed scheme of optimal relay selection implements by using the technique of linear programming (LP) and figure 1 shows the flowchart of a system.

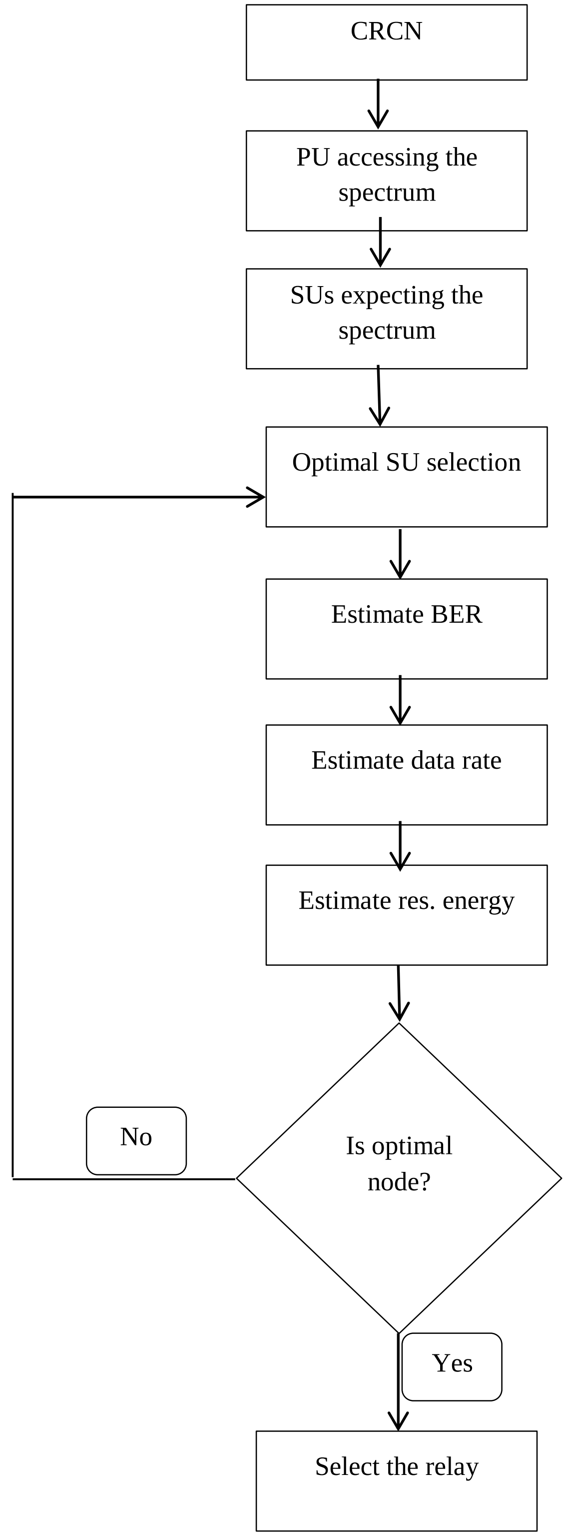

Figure1: Flowchart of Proposed system

IV. RESULTS AND DISCUSSIONS

Based on the extensive simulations, the proposed scheme HRS-BER-CRCN performance analyzes using the NS-2 network simulation. The performances of five existing schemes such as CRCN, ESUS-CRCN, OENC-CRCN, RBS-CRCN, and SNR-RS-CRCN have compared with the proposed method HRS-BER-CRCN to prove the effectiveness. The methods have designed according to the principle of on-demand distance vector (AODV) for routing in Mobile Ad-Hoc Networks. By considering the routing, the cognitive feature integrates in AODV and the assignment of joint node-channel performs. The proposed method compares with existing schemes based on the throughput, energy consumption, and end-to-end packet delay. Table 1 shows the simulation parameters.

The random distribution of 10 mobile nodes over a 1000*1000 m2 area is considered in the simulation setup. Each node communicates with other nodes over a 250m transmission range and 500m interference range. Here, the traffic sources consider as File Transfer Protocol (FTP) that sends 512-byte packets at a rate of 15 packets per sec. Based on the standard of IEEE 802.11 and DCF medium access mechanism, all nodes communicate each other over a single radio channel with a data rate of 54 Mbps.

PARAMETER	VALUE
Application Traffic	FTP
Transmission rate	512 bytes/0.01ms
Radio range	250m
Packet size	512 bytes
Maximum speed	30m/s
Simulation time	150s
Number of nodes	10
Area	1000x1000
Window Size	32
Methods	SNR-RS-CRCN, RBS-CRCN, OENC-CRCN, ESUS-CRCN, and CRCN

Table 1: Simulation table

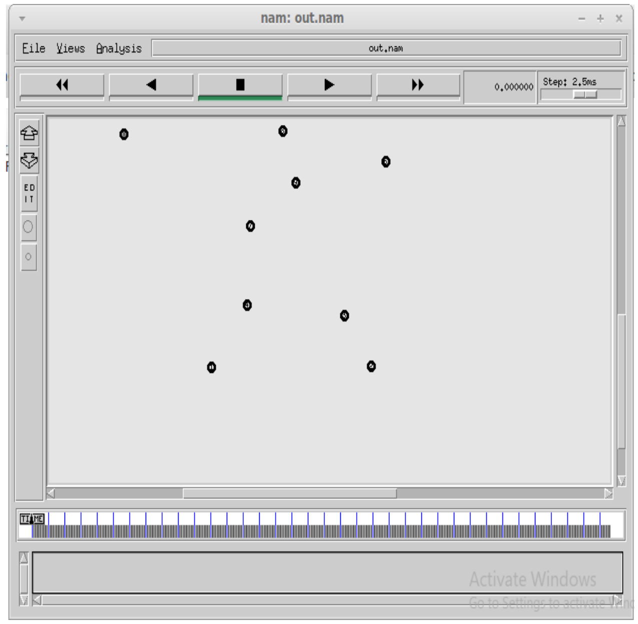

Fig 2: Network Deployment

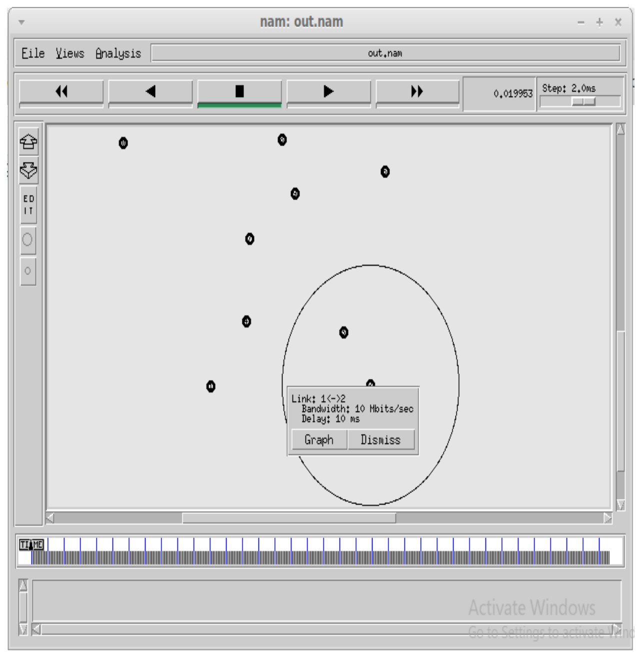

Fig 3: Broadcasting in the network

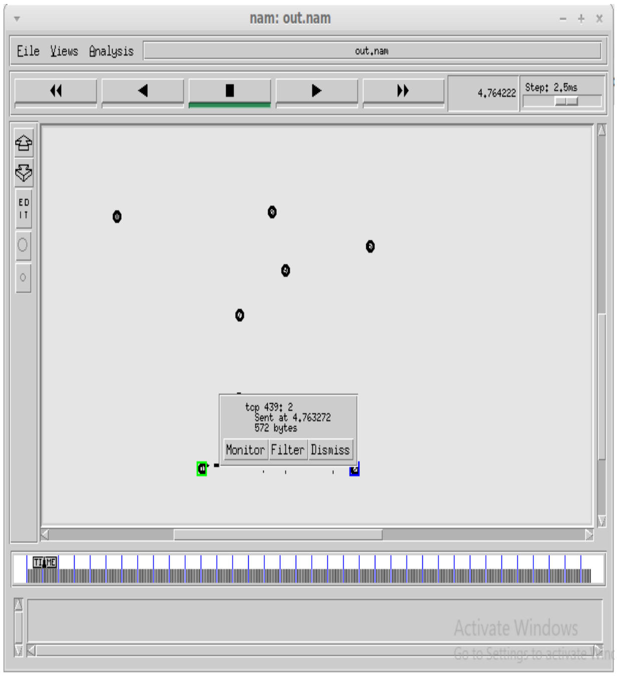

Fig 4: PU's Data Transfer

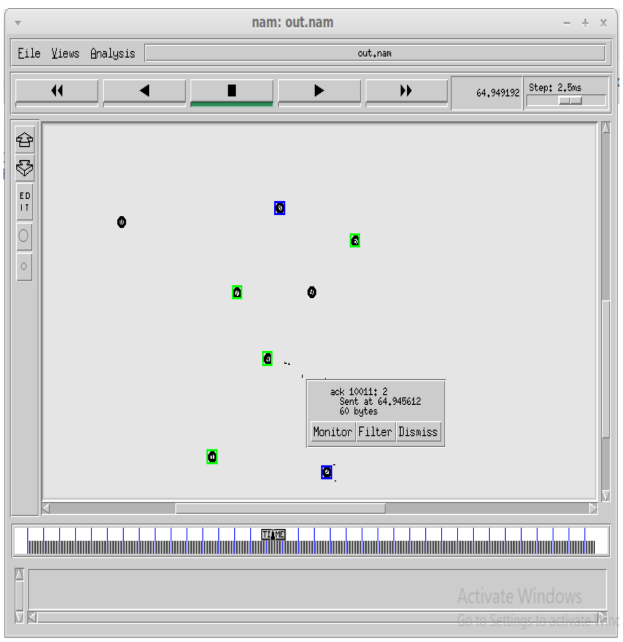

Fig 5: Acknowledgement

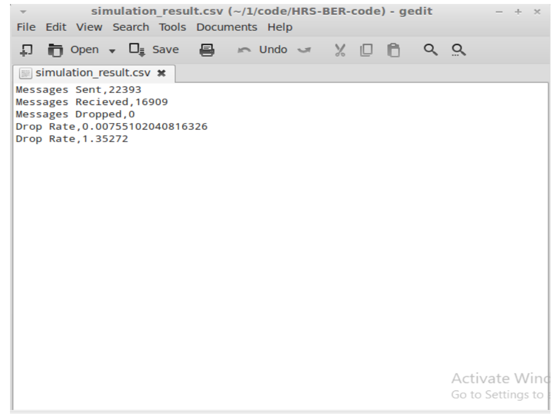

Fig 6: Simulation Results

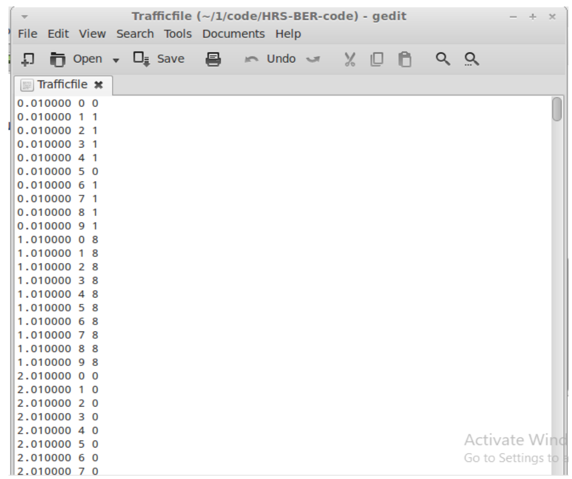

Fig 7: Trace File

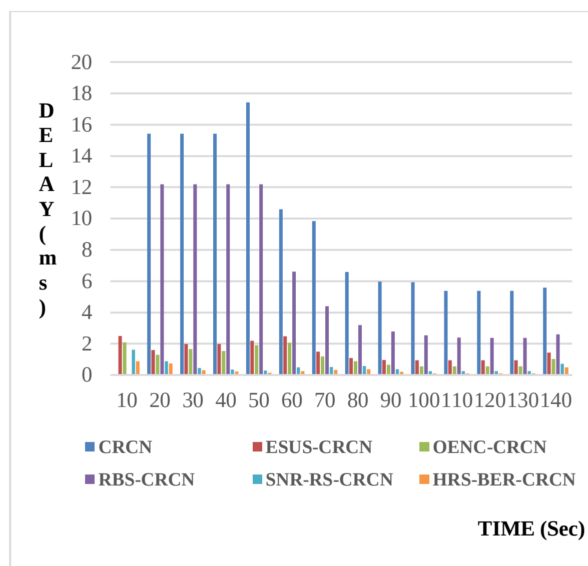

Fig 8: End-to-End Delay

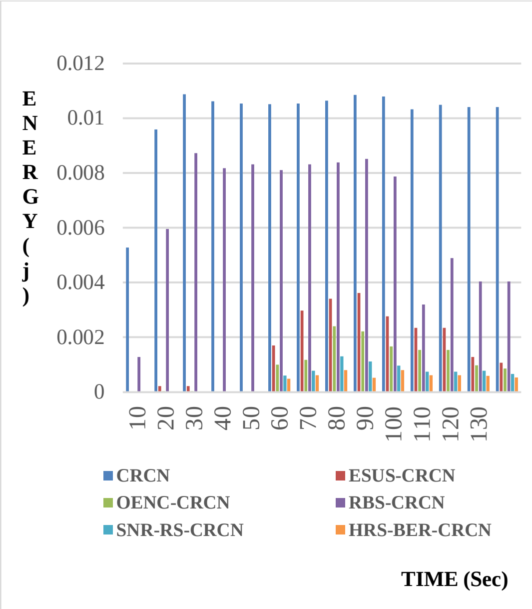

Fig 9: Energy Consumption

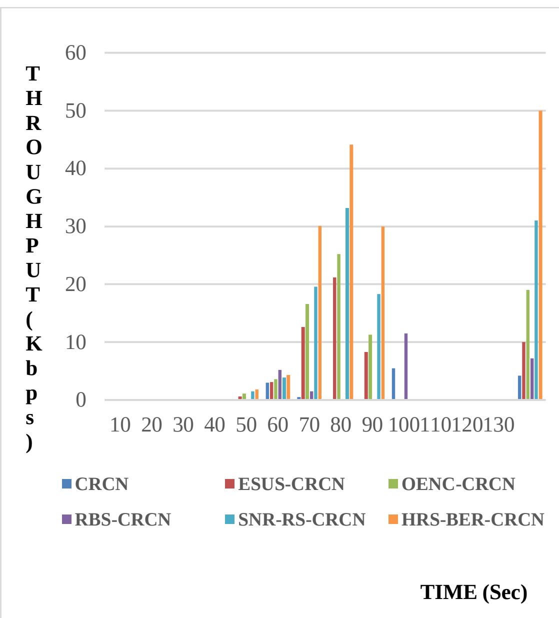

Fig 10: Throughput

Figure 2 represents the network deployment where all node deploy at the initial phase. Figure 3 shows the broadcasting process of a network after completing the nodes deployment and verifies whether the node is within the range or not. Figure 4 illustrates the accessing of a link by primary users and communicate with each other. Figure 5 describes the acknowledgement of transmission among the primary users.

Figure 6 shows the simulation results for determined overall performance in terms of information about sent, dropping, and received packets. Figure 7 displays the network trace file for routing and it observes the nodes values that is called trace file. Figure 8 describes the results of end-to-end delay of a network and the proposed scheme HRS-BER-CRCN reduces the delay compared to the previous methods such as CRCN, SNR-RS-CRCN, ESUS-CRCN, RBS-CRCN, and OENC-CRCN. Figure 9 displays the energy consumption results and performs well than the existing methods. Figure 10 shows the throughput or network performance and the proposed work increases the throughput than the ERCR, CRCN, ESUS-CRCN, RBS-CRCN, SNR-RS-CRCN, and OENC-CRCN.

V. CONCLUSION

In MIMO-based UWA-WSN, an energy-efficient relay selection scheme proposes for QoS provisioning. The channel models using the finite state Markov chain. It's require to design the MIMO system based on the random state variations of a channel with the consideration of tradeoff between multiplexing gain and diversity gain of MIMO. In relay selection, the residual relay energy considers for improving the network lifespan and energy efficiency. Based on the function of link data rate between the relay node and the destination node, the link BER between the relay node and the source node, and the data packets energy consumption while transmitting from source to the destination node, the system formulates. We have observed that the algorithm achieves energy-efficient relay selection for the constraints of power supply based on the evaluations of MIMO-based networks.

VI. REFERENCES

[1] A. Nosratinia, T. Hunter, and A. Hedayat, "Cooperative communication in wireless networks," *IEEE Commun. Mag.*, vol. 42, pp. 68–73, 2004.

[2] A. Sendonaris, E. Erkip, and B. Aazhang, "User cooperation diversity–part I: system description," *IEEE Trans. Commun.*, vol. 51, pp. 1927–1938, 2003.

[3] J. N. Laneman, D. N. C. Tse, and G. W. Wornell, "Cooperative diversity in wireless networks: efficient protocols and outage behavior," *IEEE Trans. Inform. Theory*, vol. 50, pp. 3062–3080, 2004.

[4] Y. Chen and Q. Zhao, "On the lifetime of wireless sensor networks," *IEEE Commun. Lett.*, vol. 9, pp. 976–978, Nov. 2005.

[5] A. Wittneben, I. Hammerstroem, and M. Kuhn, "Joint cooperative diversity and scheduling in low mobility wireless networks," in *Proc. Globecom*, pp. 780–784, 2004.

[6] A. E. Khandani, J. Abounadi, E. Modiano, and L. Zheng, “Cooperative routing in wireless networks,” in *Proc. Allerton Conf. on Commun., Control and Computing*, 2003.

[7] B. Rankov and A. Wittneben, “Distributed spatial multiplexing in a wireless network,” in *Proc. Asilomar Conf. on Signals, Systems, and Computers*, pp. 1932–1937, 2004.

[8] G. Barriac, R. Mudumbai, and U. Madhow, “Distributed beamforming for information transfer in sensor networks,” in *Proc. 3rd International Symposium on Information Processing in Sensor Networks (IPSN)*, 2004.

[9] H. Ochiai, P. Mitran, H. V. Poor, and V. Tarokh, “Collaborative beamforming for distributed wireless ad hoc sensor networks,” *IEEE Trans. Signal Processing*, vol. 53, pp. 4110–4124, Nov. 2005.

[10] M. M. Abdallah and H. C. Papadopoulos, “Beamforming algorithms for decode-and-forward relaying in wireless networks,” in *Proc. Conf. on Inform. Sciences and Systems (CISS)*, 2005.

[11] P. Larsson, “Large-scale cooperative relay network with optimal coherent combining under aggregate relay power constraints,” in *Proc. Future Telecommun. Conf. (FTC)*, 2003.

[12] M. Chen, S. Serbetli, and A. Yener, “Distributed Power Allocation for Parallel Relay Networks,” in *Proc. IEEE Globecom*, pp. 1177–1181,2005.

[13] I. Maric and R. D. Yates, “Forwarding strategies for Gaussian parallelrelay networks,” in *Proc. ISIT*, pp. 269–275, 2004.

[14] A. F. Molisch, *Wireless Communications*. Wiley/IEEE Press, 2005.

[15] S. A. Jafar, S. Srinivasa, “The Optimality of Transmit Beamforming: A Unified View,” *IEEE Trans. Inform. Theory*, vol. 53, pp. 1558–1564, 2007.

[16] T. K. Y. Lo, “Maximum ratio transmission,” *IEEE Trans. Commun.*, vol. 47, pp. 1458–1461, 1999.

[17] D. Gesbert, M. Shafi, D.-S. Shiu, P. J. Smith, and A. Naguib, “From theory to practice: an overview of MIMO space-time coded wireless systems,” *IEEE J. Select. Areas Commun.*, vol. 21, pp. 281–302, 2003.

[18] J.B. Andersen, “Array gain and capacity for known random channels with multiple element arrays at both ends,” *IEEE J. Select. Areas Commun.*, vol. 18, pp. 2172–2178, 2000.

[19] E. Sozer, M. Stojanovic, and J. Proakis, “Underwater acoustic networks,” *IEEE Journal of Oceanic Engineering*, vol. 25, no. 1, pp. 72–83, 2000.

[20] J. Catipovic, D. Brady, and S. Etchemendy, “Development of underwater acoustic modems and networks,” *Oceanography*, vol. 6, pp. 112–119, 1993.

[21] C. H. Song, P. Roux, S. W. Hodgkiss, A. W. Kuperman, T. Akal, and M. Stevenson, “Multiple-input/multiple-output coherent time reversal communications in a shallow water acoustic channel,” *IEEE Journal of Oceanic Engineering*, vol. 31, no. 1, pp. 170–178, 2006.

[22] H. Li, N. Jaggi, and B. Sikdar, “Relay scheduling for cooperative communications in sensor networks with energy harvesting,” *IEEE Transactions on Wireless Communications*, vol. 10, pp. 2918–2928, 2011.

[23] J. Tang and X. Zhang, “Cross-layer resource allocation over wireless relay networks for quality of service provisiioning,” *IEEE Journal on Selected Areas in Communications*, vol. 25, no. 4, pp. 645–656, 2007.

[24] M. Vajapeyam, S. Vedantam, U. Mitra, J. Preisig, and M. Stojanovic, “Distributed space-time cooperative schemes for underwater acoustic communications,” *IEEE Journal of Oceanic Engineering*, vol. 33, no. 4, pp. 489–501, 2008.

[25] P. Wang, W. Feng, L. Zhang, and V. Li, “Asynchronous cooperative transmission in underwater acoustic networks,” in *IEEE Symposium on Underwater Technology (UT) and Workshop on Scientific Use of Submarine Cables and Related Technologies (SSC)*, April 2011.

[26] R. Cao, F. Qu, and L. Yang, “On the capacity and system design of relayaided underwater acoustic communications,” in *In Proc. of Wireless Communications and Networking Conference*, April 2010.

[27] Laneman, J. Nicholas, Gregory W. Wornell, and David NC Tse. "An efficient protocol for realizing cooperative diversity in wireless networks." In *Proceedings. 2001 IEEE International Symposium on Information Theory (IEEE Cat. No. 01CH37252)*, p. 294. IEEE, 2001.

[28] Kong, Hyung Yun. "Energy efficient cooperative LEACH protocol for wireless sensor networks." *Journal of Communications and Networks* 12, no. 4 (2010): 358-365.

[29] Lévêque, Olivier, and I. Emre Telatar. "Information-theoretic upper bounds on the capacity of large extended ad hoc wireless networks." *IEEE transactions on information theory* 51, no. 3 (2005): 858-865.

[30] Bavirisetti, Teja D., Abhinav Ganesan, Krishnan Prasad, and B. Sundar Rajan. "A transform approach to linear network coding for acyclic networks with delay." In *2012 IEEE International Symposium on Information Theory Proceedings*, pp. 1902-1906. IEEE, 2012.

[31] Baghaie, Marjan, and Bhaskar Krishnamachari. "Delay constrained minimum energy broadcast in cooperative wireless networks." In *2011 Proceedings IEEE INFOCOM*, pp. 864-872. IEEE, 2011.

[32] Sharma, Sushant, Yi Shi, Y. Thomas Hou, Hanif D. Sherali, Sastry Kompella, and Scott F. Midkiff. "Joint flow routing and relay node assignment in cooperative multi-hop networks." *IEEE Journal on Selected Areas in Communications* 30, no. 2 (2012): 254-262.

[33] Vishal K. Shah, Anuradha P. Gharge, “A Review on Relay Selection Techniques in Cooperative Communication” IJEIT Volume 2, Issue 5, November 2012.

[34] Cao, Rui, and Liuqing Yang. "Decomposed LT codes for cooperative relay communications." *IEEE Journal on selected areas in communications* 30, no. 2 (2012): 407-414.

[35] A. Bravo and P. M. Djuri´c. Cooperative relay communications in mesh networks. In IEEE Proceedings of SPAWC, Perugia, Italy, July 2009.

[36] Goh, P. S., A. F. Ismail, S. M. Sanip, B. C. Ng, and M. Aziz. "Recent advances of inorganic fillers in mixed matrix membrane for gas separation." *Separation and Purification Technology* 81, no. 3 (2011): 243-264.

[37] Chen, Gaojie, Ousama Alnatouh, and Jonathon Chambers. "Outage probability analysis for a cognitive amplify-and-forward relay network with single and multi-relay selection." *IET Communications* 7, no. 17 (2013): 1974-1981.

[38] Zhang, Zhongshan, Keping Long, and Jianping Wang. "Self-organization paradigms and optimization approaches for cognitive radio technologies: a survey." *IEEE Wireless Communications* 20, no. 2 (2013): 36-42.