International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 11, pp: 358-365 www.ijaem.net ISSN: 2395-5252

Delay and Bandwidth Enabled Quality of Service Routingfor MANET through Random Cast Technique

Suma R[1] and Dr. Siddaraju[2]

[1]*Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Visvesvaraya Technological University, Bengaluru, Karnataka, India.*

[2]*Professor, Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Visvesvaraya Technological University, Bengaluru, Karnataka, India.*

Date of Submission: 10-12-2020 Date of Acceptance: 25-12-2020

ABSTRACT:
Quality of Service (QoS) has a wide appeal in wired networks. In the recent past, we have seen attempts by the research community to address QoS issue in Mobile Adhoc Networks (MANET) too, but could not achieve the intended level. QoS enforces certain demands which needs to be satisfied by the network during data transmission. MANET require frequent broadcasting for route discovery which exhausts its precious battery energy. Energy conservation is an important aspect of MANET design. Hence, it is required that QoS module is integrated in route discovery of MANET and achieving reduction in energy usage is the need of the hour in these networks. In this work, fusion of Random Cast algorithm for MANET which aims at energy conservation with the QoS parameters such as maximum delay and required bandwidth that were recently developed is performed. A new Bernoulli probability mass function is used in randomized selective broadcasting. Empirical results in Network Simulator-3 demonstrate good energy conservation and effective route discovery for the new integrated approach.

KEYWORDS: Quality of Service, Probability Mass Function, Random Cast, Energy Conservation, Mobile Ad-hoc Networks.

I. INTRODUCTION

Mobile Adhoc Network (MANET) consists of collection of wireless nodes that have significantly lower capacity than wired networks [1]. MANET have become essential in establishing networking capabilities in military and civilian establishments where there is a need of mobility of the wireless systems. The major problem in MANET is the issue of energy conservation. This is because, the nodes have limited battery capabilities and exhausting battery energy can lead to poor communication in the network itself [2]. The current research effort is to reduce energy consumption of MANET [2, 3, 4, 5, 6, 7] with efficient routing so that messages can be delivered in an effective way. There are various numerous protocols developed for MANET [8]. These protocols must provide limitations of these networks, such as low bandwidth, high power consumption and high error rates. The reactive protocols [9] such as Dynamic Source Routing (DSR) [10] and Adhoc On demand Distance Vector (AODV) [11] for mobile networks maintains routes only between nodes which need to communicate.

MANET's are having limited storing and computational abilities [2]. So, maintaining routing tables for the entire network is infeasible. At best, every node can maintain its neighbor node list. Hence, in order to find a path between any two nodes, a route discovery algorithm called Dynamic Source Routing (DSR) is initiated by the source node in which the source node broadcasts the route request packets (RREQ) to its neighboring nodes. In turn, the nodes which receive the RREQ packets also perform broadcasting until the destination is reached. This route discovery process leads to a lot of redundant RREQ packets and loss of energy in the nodes. IEEE 802:11 which deals with wireless radio has an in-built energy management mode. It classifies the nodes as active mode and passive mode. In an active mode, the nodes are awake and remain in this state for all time. In passive mode, the nodes are asleep and remain in this state until they receive the Ad Hoc Traffic Indication Message (ATIM) during the ATIM window. This window is periodic and the passive nodes make a transition to active state and are ready to receive messages. If the node has to remain awake after the ATIM window then, it remains in the active state. This power saving mechanism was incorporated in MANET through the Random Cast Algorithm [13]. In this approach, a node broadcasts RREQ packets immediately after the ATIM window based on a probability. The probability was calculated on the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 11, pp: 358-365 www.ijaem.net ISSN: 2395-5252

number of neighbors of that particular node. So, the number of broadcasts was reduced and also the route discovery effectiveness was not compromised drastically.

Until recently, Quality of Service (QoS) was an alien concept to MANET. The main reason in this alienation was dynamic topology, limited processing capabilities and limited availability of band width. But, QoS has become an important necessity in MANET [14, 15, 16]. In [14], this issue was addressed through QoS parameters namely, maximum delay and required bandwidth. The first parameter indicates the maximum delay a source can withstand in the data transmission path from source to destination. The second parameter indicates the required bandwidth for the source between any pair of adjacent nodes in the data transmission path. These two parameters were incorporated into the route discovery process of DSR algorithm. If any node did not satisfy either of these two parameters that node would prevent broadcasts for further route discovery. The task now is to integrate both the QoS component of[14] and random cast algorithm[13] to achieve lesser redundant messages, more passive nodes in the DSR algorithm execution and conservation of energy. In this work, the following contributions are made:

1. The fusion of QoS approach of [14] and the Random Cast algorithm [13] is performed. This new Random Cast algorithm achieves reduction in redundant broadcast messages, increases the number of passive nodes and implements QoS procedure in MANET.
2. A new Bernoulli distribution mass function is defined for selective broadcast. In the classical Random Cast algorithm only the neighboring nodes are considered for the mass function. But, there are other important parameters which should be incorporated such as distance of the neighbor node and current battery capacity. The new probability mass function incorporates all the above mentioned parameters to obtain better efficiency in selective broadcasting.
3. The new Random Cast algorithm is empirically evaluated in Network Simulator-3 (NS3) [24].
4. This new approach achieves better results in number of passive nodes and energy conservation compared to the classical QoS approach [14].

The rest of the paper is organized as follows. In section II, we have reviewed energy efficient and QoS aware routing protocols. In Section III, QoS through Random Cast is described briefly. Section IV discusses about experimental setup and simulation results are shown. Finally conclusion is presented in Section V.

II. RELATED WORKS

Wireless adhoc networks handle a wide variety of energy saving techniques. In Dynamic Power Saving Mechanism (DPSM) [17] method, the ATIM window length is adjusted dynamically related to current network conditions. A NPSM [18] (New Power Saving Mechanism) initiates few parameters, which indicates the amount of data in each station. In ODPM [19] (On Demand Power Management) technique, soft state timers are set or refreshed based on demand over control messages and data transmission. Nodes that are not involved in transmission of data enters into doze state to save energy. Further in this method energy is saved by integrating the MAC layer functionality and route discovery process. The protocol discussed in [20] extends the sleep time of the nodes and reduces the contention, retransmission and improves the utilization of channel, hence providing the quality of service support. In [21] uses backbone probability which reduces the number of AM (Active Mode) nodes in the network, thus increases the lifetime of the network. TITAN (Traffic-Informed Topology-Adaptive Network) is an improvement over ODPM, in which PS (Power Saving) nodes sleep for longer time and saves energy [22]. The 802:11 standard [23] deals with wireless radio transmission. It has incorporated power saving scheme in which there are basically 2 modes of operation for nodes, active mode and passive mode. To achieve efficiency in power management, every node will be in passive mode. Periodically, a window is created for a specific node through internal clock timers called the ATIM window. This window will create a transition of passive mode to active mode for all the nodes in the neighborhood. In this time interval, any broadcast message has to be intimated to the neighboring nodes by the transmitting node. After getting the intimation message the neighboring nodes will remain active after the ATIM window and until the end of data transmission window (This window starts after ATIM window and ends after the designated time interval). During this data transmission period the nodes wait and receive the broadcast message. After the data transmission window, all the receiving nodes go back to the passive state and remain until the next ATIM window. The Figure 1 describes a typical scenario for 802:11 as given in [7]. The ATIM window activates all the 5 nodes in the network. The node S2 sends a broadcast ATIM frame to its neighbors (the remaining nodes in the Figure 1). All the nodes will remain active during the data transmission period to receive the broadcast message.

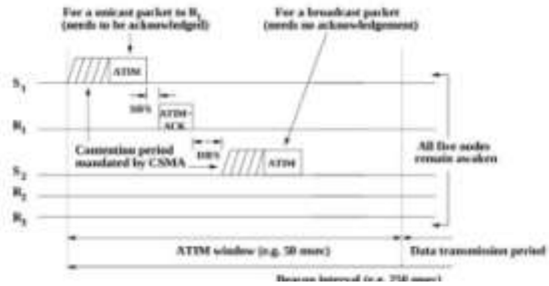

Figure 1. 802.11 ATIM window.

Rcast [12] implements only randomized overhearing but not randomized rebroadcasting. Random Cast algorithm [13] is a probabilistic modification of the DSR algorithm used in route discovery for MANET. This algorithm is built over the power saving scheme of 802:11. The route discovery between a pair of nodes in DSR is initiated by the source. The source node transmits a broadcast packet called the RREQ packet to its neighbors during the data transmission period after the ATIM window. The neighboring nodes retransmit the same packet by using broadcasting. The destination node when it receives the RREQ packet registers the route and sends back Route Reply Packet (RREP) back to the source. The Random Cast Algorithm assigns a probability for the broadcast of the RREQ packet for a given node (except the source). The probability mass function is given by Equation 1.

$$P_{broadcast} = \frac{cn}{m^2} \ldots\ldots\ldots\ldots\ldots (1)$$

Here, n is the number of neighbors for the broadcasting node, m is the average number of neighbors neighbor, and c is a tunable constant.

To achieve Random Cast in MANET, the ATIM frame format requires entry of certain predetermined values as shown in the Figure 2.

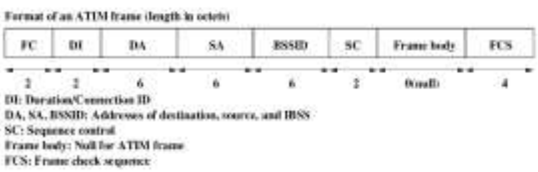

Figure 2. ATIM Frame for MANET

The DA field indicates the receivers Medium Access Control(MAC) address. If the receiver is the intended destination then it will stop broadcasting and gets ready to transmit RREP packets. Otherwise, it is assumed that it is a broadcast message and the receiving node will execute Random Cast algorithm described in Algorithm 1.

Algorithm 1 Random Cast for RREQ Packets

ifThe node Receives a ATIM frame then
if DA==Broadcast then
Continue to be active in the Data Transmission interval and receive the broadcast message.
end if
ifrand(0,1) ≤ $P_{broadcast}$then
Send an RREQ packet to neighbors.
end if
if DA==Intended Destination then
Stop Broadcasting and prepare the RREP packet.
end if
end if

Currently, Random Cast only applies for route discovery but, it does not have a provision to integrate QoS inside the core of the algorithm. Since, route discovery by using QoS constraints also suffers from redundant broadcast and energy loss problems. It is highly essential that QoS component gets integrated with Random Cast. Also, the Bernoulli probability mass function Pbroadcast considers only the number of neighboring nodes. It is also important to consider other performance parameters in designing a new probability mass The QoS techniques in wired networks have been instrumental in offering on demand service for the network users. But, these techniques also utilize complex algorithms for implementing QoS. These techniques are infeasible for MANET because:

1. The MANET have limited processing capabilities and hence heavier computational task will drain out their precious energy reserve.
2. The existence of dynamic topology in MANET makes things more complicated because the original QoS algorithms were designed for a static network.

By overcoming these two constraints, a novel QoS technique for MANET has been proposed [14]. This technique provides 2 parameters in QoS design namely, maximum delay and required bandwidth. Every MANET node has a processing time for a packet. In order to set up a communication link between 2 nodes,the source will demand the maximum delay it can withstand during transmission. Similarly, the source also demands the minimum required bandwidth between any pair of adjacent nodes in the communication link to the destination. This technique is tailor made for the limiting processing capabilities present in MANET nodes. In mobile adhoc networks, few authors suggested solutions

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 11, pp: 358-365 www.ijaem.net ISSN: 2395-5252

for improving the accuracy of available bandwidth and incorporating a QoS aware into the route discovery and also limiting the energy consumed by nodes [24]. The execution of the QoS approach with respect to maximum delay is described in Figure 3.

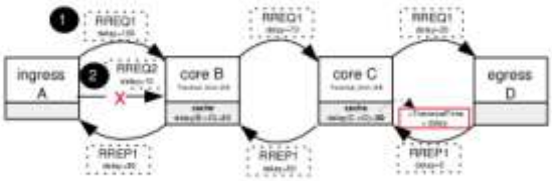

Figure 3. MANET QoS Maximum Delay.

The source node A broadcasts a RREQ packet to its neighbors. It also mentions in the packet about the maximum delay. Every node which receives this packet will retransmit it through broadcasting and also subtracts the maximum delay field with its own maximum processing time. If a node is unable to meet the maximum delay constraint (RREQ2 and node B), it will drop the packet. Otherwise it will reach the destination for the production of RREP packet (RREQ1). In Figure 4, QoS approach with respect to required bandwidth is described.

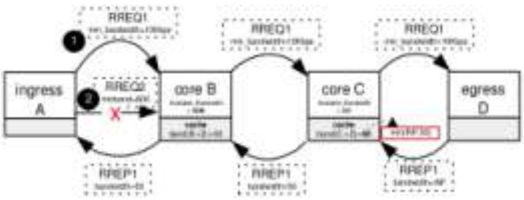

Figure 4. MANET QoS Required Bandwidth.

Again, the source node A initiates a RREQ broadcast packet indicating the minimum required bandwidth. If a node cannot provide that bandwidth, it will drop the packet (RREQ2 and node B). Otherwise, the packet will reach the destination (RREQ1). The cause of concern is that this QoS technique performs complete broadcasting of RREQ packets which can be detrimental to energy conservation. So, in this work, the above described QoS technique is merged with Random Cast algorithm for achieving dual goal of effective route discovery and energy conservation.

III. QOS THROUGH RANDOM CAST

To perform fusion of Random Cast with QoS technique requires an efficient Bernoulli probability mass function. Consider a situation where a particular node has got very limited remnant battery capacity. In this scenario, let us assume probability mass function described in Equation 1 is used. Since, the broadcast probability only considers the number of neighbors, if due to favorable probability outcome, the node broadcasts its RREQ packet which will lead to complete drainage of battery energy and would make the node isolated in the network. So, the Bernoulli probability mass function needs to be designed by considering other crucial parameters.

$$P(\text{connect}_{ij} = 1 | k, r) = \frac{\frac{b_j}{\max\ \text{battery}} + \frac{(1-d_j)}{\max\ \text{distance}} + 1 - \frac{k+n_i}{r+n_i}}{3} \quad \text{.... (2)}$$

Equation 2 describes the new Bernoulli probability mass function designed for performing QoS through Random Cast. Consider node i which needs to perform selective broadcasting and node j is its neighbor, $\text{connect}_{ij} = 1$ indicates that node i will send RREQ packet to node j, otherwise $\text{connect}_{ij} = 0$, bj is the current battery capacity of node j, max battery is the maximum battery capacity of the MANET nodes, dj is the distance of node j from node I (it is estimated through signal strength ratio[4]), max distance is the maximum allowed distance to form MANET node connection, n_i is the number of neighbors of node i, k and r are the number of successful connections established and the number of neighbor nodes considered for connection until node j is considered (every neighbor node is sequentially considered once for establishing connection). In Equation 2, the current battery power of the MANET node j determines the probability for successful connection with node i. Larger the current battery capacity, higher will be the probability of successful connection. Similarly, longer the distance of the node j from node i, lower will be the successful connection probability. This is because, at longer distances more battery power is exhausted by the MANET node for transmission of packets. Also, every neighbor node for node i is considered sequentially for establishing connection. Before node j, if r nodes were considered and k successful connections were established where $k \le r$. Then, connection success probability of node j is penalized as kincreases. This is because, in a dense node neighborhood establishing connection with few nodes is quite effective for route discovery process [13].

Protocol Version	Type	Subtype	To DS	From DS	More Frag	Retry	Pwr Mgt	More Data	WEP	Order

Figure 5. ATIM Frame FC Field.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 11, pp: 358-365 www.ijaem.net ISSN: 2395-5252

To perform the integration of QoS module in Random Cast algorithm, it is necessary to add information about the new technique in the ATIM frame. So, for the frame in Figure 2, the FC field is used for filling up this information. The Type field in Figure 5 is filled with 1011 to indicate that it is an ATIM frame for Random Cast with QoS. The RREQ packet will contain information about the QoS parameters, maximum delay and minimum requested bandwidth. The QoS through Random Cast technique is described in Algorithm 2. The source node considers each node in its neighborhood sequentially. For each neighborhood node, RREQ packet is sent based on the probability described in Equation 2. The RREQ packet will contain information about both QoS parameters, maximum delay and minimum required bandwidth. The source node waits for d > 0 ATIM frame intervals and if it does not receive RREP packet from the destination, normal broadcasting is used for route discovery. The intermediate node after receiving the RREQ packet performs QoS check on the two parameters. If these parameters can be satisfied then, it performs random casting of RREQ packets in its neighborhood. If the destination node receives the RREQ packet then, it prepares the RREP packet to be transmitted back to the source. The main aim of this new technique is to conserve battery energy for QoS route discovery process. Since randomized algorithms also have a possibility of not connecting to the destination (with less probability) [13], the source node will opt for route discovery through normal broadcasting if the destination node could not be reached in specified time interval.

IV. EXPERIMENTAL RESULTS

The performance experiments were executed on NS3 simulator. This simulator does not provide inbuilt facility for selective broadcasting. Hence, this module had to be implemented inside the simulator. The maximum neighbor distance was set to 100 meters, maximum battery capacity was set to 100 Kilo Joules (KJ). Two important performance metrics were used in the experiments:

1. Energy Consumption Ratio (ErgCp) is the ratio of remnant battery energy of the network after route discovery to battery energy of the network before route discovery. This metric is quantified in Equation 3, expense(bi) is the left over energy after performing selective/complete broadcasting of RREQ packet by node i whose remnant energy is bi, Ii is the indicator random variable whose value is 1 if node i is active and receives the RREQ packet otherwise, it is zero.

$$\mathrm{ErgCp} = \frac{\sum_{i=1}^{n} \mathrm{expense}\ (b_i) I_i}{\sum_i^n b} \ .....(3)$$

2. Energy Goodput (ErgGt) [13] is the ratio of bytes delivered to the energy consumed for that delivery. This metric is quantified in Equation 4, size_r is the size in bytes of each RREQ packet.

$$\mathrm{ErgGt} = \frac{\mathrm{size}_{\,r}}{\sum_{i=1}^{n} (b_i - \mathrm{expense}\ (b_i)) I_i} \ .... (4)$$

Algorithm 2 QoSThrough Random Cast Algorithm

Let max delay be the maximum delay tolerated by the source node in the transmission path.

Let min bandwidth be the minimum bandwidth required between 2 adjacent nodes of the transmission path.

Let delay_i and $\mathrm{bandwidth}_i$ indicate the maximum processing delay of packets and bandwidth offered at node i.

Let $\mathrm{neighbor}_i$ be the list of neighbors of node i.
if node i=source then
for each node j $\in \mathrm{neighbor}_i$ do
Calculate $P(\mathrm{connect}_{ij})$ given in Equation 2.
if $\mathrm{rand}(0,1) \leq P(\mathrm{connect}_{ij})$ then
Send an RREQ packet to node j which contains information about both parameters max delay and min bandwidth.
end if
end for

if RREP packet is not received in d ATIM frame intervals then
Perform normal broadcasting for route discovery.
end if
end if

if node i=intermediate node and RREQ packet is received then
if $\max \mathrm{delay} - \mathrm{delay}_i \geq 0$ and $\mathrm{bandwidth}_i - \min \mathrm{bandwidth} \geq 0$ then
for each node j $\in \mathrm{neighbor}_i$ do
Calculate $P(\mathrm{connect}_{ij})$ given in Equation 2.
if $\mathrm{rand}(0,1) \leq P(\mathrm{connect}_{ij})$ then
Send an RREQ packet to node j which contains information about both parameters
$\max \mathrm{delay} = \max \mathrm{delay} - \mathrm{delay}_i$ and min bandwidth.
end if
end for
end if
end if
if node i=destination and RREQ is received then
Prepare the RREP packet.

end if

The metric, Energy Consumption Ratio measures the efficiency of the route discovery algorithm and Energy Good-put measures the effectiveness. The performance experiments compare Classical QoS (CQoS) technique with QoS through Random Cast (RQoS) technique. Figure 6 demonstrates the Energy Consumption Ratio (ErgCp) performance of these 2 techniques wrt number of nodes in the network. The QoS parameters were kept static. RQoS has a facility (Equation 2) wherein, if the node neighborhood density is large then, with the presence of few active nodes the route discovery process can be accomplished. This is clearly demonstrated in Figure 6.

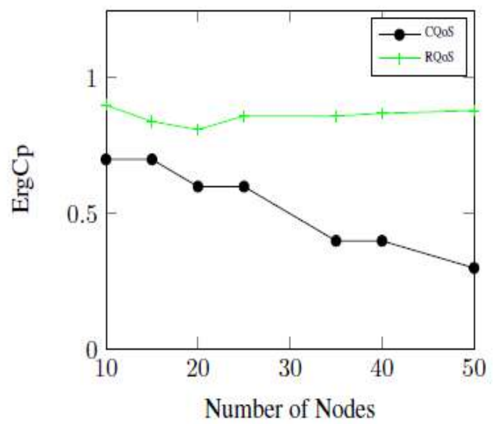

Figure 6. ErgCp vs Number of Nodes.

In Figures 7 and 8, Energy Consumption Ratio performances of RQoS and CQoS are evaluated by varying the QoS parameters, minimum required bandwidth and maximum delay. RQoS performs exceedingly well when QoS parameters are low. This is because at low values of QoS parameters, chances of multiple paths to reach the destination will be high and RQoS selective broadcasting will be largely successful in finding the route. But, in higher values of QoS parameters, very few routes might be available so, RQoS converts into CQoS after waiting the specified time interval.

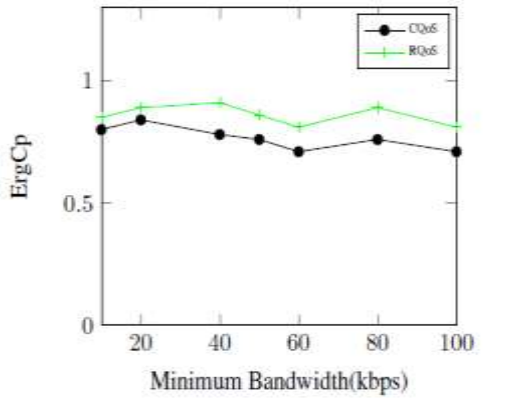

Figure 7. ErgCp vs Minimum Bandwidth

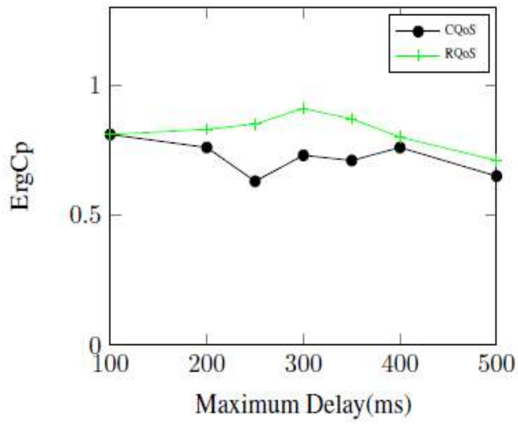

Figure 8. ErgCp vs Maximum Delay

The same 3 experiments described above were performed for Energy Good-put (ErgGt) metric. As seen in Figures 9, 10 and 11, similar result was obtained which were seen for Energy Consumption Ratio metric.

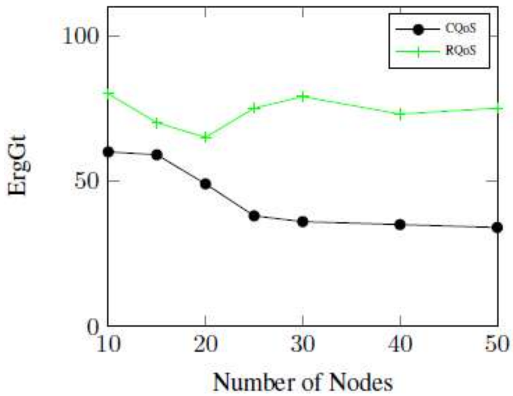

Figure 9. ErgGt vs Number of Nodes

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 11, pp: 358-365 www.ijaem.net ISSN: 2395-5252

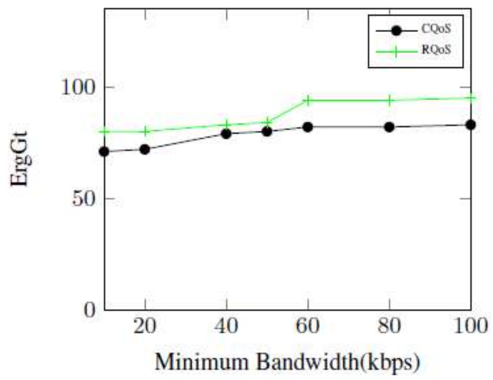

Figure 10. ErgGt vs Minimum Bandwidth.

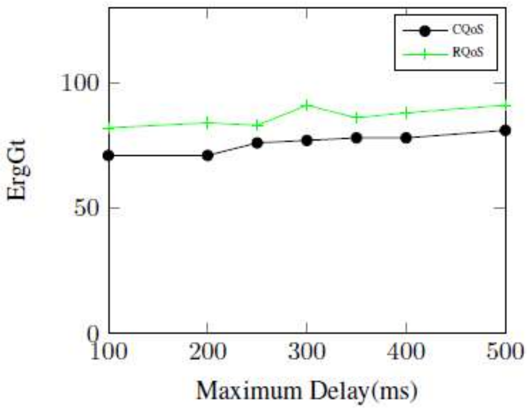

Figure 11. ErgGt vs Maximum Delay.

V. CONCLUSION

In this work, the fusion of Random Cast approach with the QoS techniques for MANET has been achieved. This new approach not only conserves energy but also exhibits its effectiveness in route discovery process. In future there are two major goals: 1. The Bernoulli probability mass function can be improved further to restrict excess broadcasting. Typically, a node needs to transmit to a single neighbor so that efficient energy conservation can be achieved. The future work is to achieve this ambitious goal. 2. This new approach needs to be adaptable in the presence of link errors. This adaptability will give the much required robustness for MANET route discovery process.

REFERENCES

[1] L. Chen and W. Heinzelman, QoS-aware Routing Based on Bandwidth Estimation for Mobile Ad Hoc Networks?, IEEE Journal on Selected Areas of Communication, Vol 23, No.3, 2005.

[2] Kravets, Robin and Krishnan, P., Power Management Techniques for Mobile Communication, Proceedings of the 4th Annual ACM/IEEE International Conference on Mobile Computing and Networking, 1998, 1-58113-035-X, Dallas, Texas, USA.

[3] Jae-Hwan Chang and L. Tassiulas, Energy conserving routing in wireless ad-hoc networks, INFOCOM 2000. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE, 2000.

[4] Singh, Suresh and Woo, Mike and Raghavendra, C. S., Power-aware Routing in Mobile Ad Hoc Networks, Proceedings of the 4th Annual ACM/IEEE International Conference on Mobile Computing and Networking, 1998, 1-58113-035-X, Dallas, Texas, USA.

[5] Kyungtae Woo and Chansu Yu and Dongman Lee and Hee Yong Youn and B. Lee, Non-blocking, localized routing algorithm for balanced energy consumption in mobile ad hoc networks, Modeling, Analysis and Simulation of Computer and Telecommunication Systems, 2001. Proceedings. Ninth International Symposium on.

[6] S. Agarwal and R. H. Katz and S. V. Krishnamurthy and S. K. Dao, Distributed power control in ad-hoc wireless networks Personal, Indoor and Mobile Radio Communications, 2001 12th IEEE International Symposium on.

[7] VikasKawadia,P.R. Kumar, Power control and clustering in ad hoc networks, IEEE INFOCOM, 2003.

[8] T. Bheemarjun Reddy, I Karthigeyan, B.S. Manoj, C. Siva Ram Murthy, Quality of Service provisining in ad hoc wireless networks: a survey of issues and solutions, Ad Hoc Networks, pp.83-124(Elsevier), June 2004.

[9] N.Sumathi, Dr. Antony SelvadossThanamani, Evaluation of Energy Efficient Reactive Routing Protocols in QoS Enabled Routing for MANETS, International Journal of Computer Applications(0975-8887), Vol 14, No.2, January 2011.

[10] D.B. Johnson and D.A. Maltz, Dynamic Source Routing in Ad Hoc Networks Mobile Computing, pp.153-181, Kluwer, 1996.

[11] PerumalSambasivam, Aswin Murthy, E. M. Belding-Royer, Dynamically Adaptive Multipath Routing based on AODV, Proc. 3rd Annual MAHN, 2004.

[12] S.Lim, C. Yu, and C. Das, Rcast: A Randomized Communication Scheme for Improving Energy Efficiency in Mobile Ad Hoc Networks, Proc. 25th IEEE Int?l Conf. on Distributing Computing Systems 9ICDCS ?05, pp. 123-132, 2005.
[13] Sunho Lim, Chansu Yu, Chita R Das, Random cast: An energy efficient communication scheme for mobile ad hoc networks, IEEE Transactions on Mobile Computing, 2009.
[14] Zeinalipour-YaztiDemetrios, A Glance at Quality of Services in Mobile Ad-Hoc Networks, Technical Report, http://alumni.cs.ucr.edu/ csyiazti/courses/cs260/html/manetQoS.html.
[15] Priya, R. Lakshmi and Chaki, Nabendu, A Study on QoS Issues for Mobile Ad-hoc Networks, Proceedings of the 2nd International Conference on Interaction Sciences: Information Technology, Culture and Human, 2009, 978-1-60558-710-3, Seoul, Korea.
[16] Magula, Peter and Kotocova, Margareta, Quality of Service Models for Mobile Ad-hoc Networks, Proceedings of the 12th International Conference onComputer Systems and Technologies, 2011, 978-1-4503-0917-2, Vienna, Austria.
[17] Eun-Sun Jung and Nitin H. Vaidya, An Energy Efficient MAC Protocol for Wireless LANs, IEEE INFOCOM 2002, New York, U.S.A., June 2002.
[18] Eun-Sun Jung and Nitin Vaidya., A Power Saving MAC Protocol for Wireless Networks, Technical Report, July 2002.
[19] R. Zheng and R. Kravets, On-Demand Power Management for Ad hoc Networks, Adhoc Networks (Elsevier), pages 51-68, Nov 2003.
[20] TanomsakKhacharoen, Anan Phonphoem, A Power Saving Mechanism in Ad Hoc Network with Quality of Service Support, International Conference on Information and Communication Technologies (ICT 2003), Bangkok, Thailand, April 2003, pp.119-124.
[21] Z. Li and B. Li, Probabilistic Power Management for Wireless AdHoc Networks, Mobile Networks and Applications, Vol. 10, No. 5, pp. 771-782, 2005.
[22] C. Sengul and R. Kravets, Conserving Energy with On-Demand Topology Management, Proc. Second IEEE Int'l Conf. Mobile Ad Hoc and Sensor Systems (MASS '05), pp. 10-19, 2005.
[23] IEEE 802.11 Standard (IEEE Computer Society LAN MAN Standards Committee), Wireless LAN Medium Access Control and Physical Layer Specifications, Aug 1999.
[24] N. Sumathi and Dr. C. P. Sumathi, Energy and Bandwidth Constrained QoS Enabled Routing for MANETs, International Journal of Computer Networks and Communications (IJCNC) Vol.5, No.2, March 2013.
[25] NS-3 Manual:-https://www.nsnam.org/docs /release/3.9/manual.pdf.