International Journal of Future Generation Communication and Networking
Vol. 13, No. 1, (2020), pp. 1528-1538

Energy Efficient Co-operative Routing Mechanism for Mobile Ad-Hoc Networks

Srinivasa H P[1], Dr. Kamalesh V N[2]

Dept. of CSE, T. John Institute of Technology, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, India
E-mail: srinihp@yahoo.co.in, kamalesh.v.n@gmail.com

Abstract

Mobile Ad-Hoc Networks (MANETs) have become essential in various civilian and military applications. The mobility of the nodes is exploited to obtain required information in difficult and hostile terrain. The effectiveness of the collected information can also be increased by setting up communication between the mobile nodes. Since, these nodes depend upon limited power supply/battery backup, it is imperative that, energy conservation in the nodes should be given primal importance.

Due to the mobility of MANET nodes and limited energy supply, reactive routing protocols, which establish routes on-demand are preferred over proactive routing protocols, which continuously update routing information as soon as some changes occur in the network. Recently [1], Quality of Service (QoS) mechanism was built over reactive routing protocols. However, many MANET applications collect large volumes of data, which needs to be transmitted through the network by using these reactive routing protocols. Routing such large volumes of data can easily drain out the energy reserves in MANET nodes. It is essential that, QoS mechanism for MANET should be made highly energy efficient.

In this work, the QoS mechanism proposed in [1] is extended to achieve better energy efficiency. Co-operative Communication mechanism is introduced to achieve this goal. This mechanism utilizes the suitable neighbor nodes around the routing path to share the routing load, and achieve energy conservation. The proposed mechanism is implemented in Network Simulator 3. Empirical results demonstrate the excellent energy efficiency achieved by the proposed mechanism over the QoS mechanism described in [1].

Keywords: *Energy Efficiency, Cooperative routing, Lifetime of network, Throughput*

1. Introduction

MANET comprises a set of mobile nodes which interact with each other through shared wireless channel. MANET is a multi-hop and dynamic wireless network. The mobile nodes collect neighbor node information through Local Broadcasting. The nodes which are in the transmission range of a particular node are considered as neighbor nodes. Each node also serves as router for routing the data packets.

MANETs are extensively used in disaster recovery and in military applications. Also, MANETs are becoming increasingly popular in civilian applications. Due to the critical nature of many applications, implementing QoS becomes extremely important. For example, disaster management applications require the collected data to be sent in a particular time interval, otherwise, the data might become stale, and any counter actions taken may have little significance.

QoS is defined by United Nations consulative committee for International Telephony and Telegraphy as *The collective effect of service performance which determines the degree of satisfaction of a user of the service.*

In wired networks, QoS is implemented through various mechanisms such as-adding plenty of resources in the network, reserving the resources based on application QoS requirement, differentiating

QoS data traffic with normal data traffic etc. However, there are significant drawbacks in implementing these methods in MANETs, which are listed below:

1. MANETs suffer by poor bandwidth issues due to limited resources and node mobility.

2. Frequent disconnections between MANET nodes occur due to dynamic topology.

3. MANET nodes are plagued by limited computational resources, which reduce the scope of performing complex data processing.

4. Maintaining updated network state information is difficult due to the limited computational ability of MANET nodes.

5. Many QoS mechanisms require signaling packets to be transmitted, which will compete with data packets for network resources.

6. Lack of connection admission control mechanism makes QoS model to lose some effectiveness.

Recently, a computationally light QoS mechanism for MANET was proposed in [1]. This mechanism addressed 2 QoS parameters-minimum bandwidth and maximum delay. The first QoS parameter specifies the minimum required bandwidth that, every node in the routing path should provide, and the second QoS parameter specifies the maximum delay that, a data packet can experience from transiting between source node to destination node. The suitable route discovery was performed through the aid of Dynamic Source Routing (DSR) protocol.

One of the essential drawbacks in the QoS scheme described in [1], is the issue of Network Lifetime. Consider a scenario where a chosen route by the QoS scheme proposed in [1] satisfies all the specified QoS constraints, but, after transmitting considerable number of data packets, there is a high probability that, many nodes in the routing path might drain significant energy, this situation can lead to network disconnection. Hence, it is crucial that the QoS mechanism proposed in [1] is extended to achieve better network life time.

The following contributions are made in this work:

1. The QoS mechanism proposed in [1] is extended so that, a single route is not overburdened to perform data transmission. A set of feasible routes are selected, which share the data transmission load, along with satisfying the required QoS constraints.

2. The applications are prioritized, such that, the critical or highest priority applications are given the best available resources, and the selected routes always satisfy the specified QoS constraints. The lower priority applications are provided with those routes which almost satisfy the specified QoS constraints.

3. The above mentioned goals are achieved through cooperative communication mechanism. Every node, which is part of the routing path of one or many applications, will maintain a suitable neighbor list, such that, these neighboring nodes can almost satisfy the required application QoS constraints. Two node energy thresholds are defined. The first threshold when reached, the respective node will stop providing data routing service to lower priority applications, and will only cater to the highest priority applications. In this situation, the neighbor node which can provide alternate path is selected and will replace the old node in the routing path.

The second threshold when reached, the respective node intimates the source and destination node that, it no longer can be part of the routing path, and requests a new route discovery for the highest priority application. This distributed load sharing mechanism achieved through cooperative communication philosophy will aid in extending the network lifetime.

4. The proposed scheme is implemented in Network Simulator 3, and it is compared with the QoS scheme proposed in [1]. The empirical results demonstrate the superior network lifetime conservation advantage of the proposed scheme over the QoS scheme proposed in [1]. This paper is organized as follows: section 2 describes the related work in the area. Section 3 presents the proposed technique. Section 4 presents the empirical results. Section 5 concludes the work with future direction in this area.

2. Related Work

MANET node energy conservation has been one of the important design goals [2-16]. Due to limited energy supply for MANET nodes, it is important to design routing protocols which conserve node energy. Many innovative energy conserving routing protocols have been presented [17-22].

In [17], an energy aware routing protocol was designed at the transport layer. This protocol, conserves node energy by making the nodes idle for long durations. The nodes are made active only if, there are data packet routing responsibilities.

It was observed in [18] that, large number of neighbors can lead to excess energy drainage. Hence, a mechanism was presented in [18], which provided the flexibility to nodes for controlling the number of neighbors.

In [19], it was shown that, the shortest path routing provides maximum benefits in conserving node energy. The cost of the path also included energy consumption metrics which were specially designed to achieve the said goal.

In [20], a new routing protocol called Local Energy Aware Routing (LEAR) protocol was proposed. This protocol achieves beneficial tradeoff between node energy expenditure and routing delay. It was shown that, this protocol achieves better energy conservation than Dynamic Source Routing (DSR) protocol.

The CDMA networks, utilize power control loop technique for conserving energy. In [21], this technique was applied on MANET, and energy conservation merits were demonstrated. Heterogeneous MANETs contain nodes with different structure and responsibilities. These MANETs create new challenges in conserving node energy [22]. Clustering based routing protocols were proposed in [22] to conserve node energy.

The reactive routing protocols such as AODV and DSR require flooding of route request packets in the network to identify suitable routes. In [23], it was observed that, this flooding technique can cause significant node energy drainage. Hence, a new technique for route discovery was presented, which replaced flooding with selective broadcasting. Here, every node which receives route request packets will randomly identify some neighbors for forwarding the route request packets. Empirical results demonstrated, the energy conserving merits of the proposed selective broadcasting scheme.

The Denial of Service (DoS) attack can cause significant node energy drainage [3-14]. A cooperative technique was proposed in [4] to detect and filter possible DoS attacks.

2.1 QoS Mechanism [1]

In [1], QoS mechanism was developed for MANETs. The application specifies 2 QoS constraints maximum delay and minimum tolerable bandwidth that should be satisfied by the nodes of the routing path. This QoS mechanism is integrated inside the route discovery stage of DSR algorithm. The DSR technique employs flooding mechanism to identify suitable paths. The proposed QoS scheme ensures that, the identified paths satisfy the specified QoS constraints.

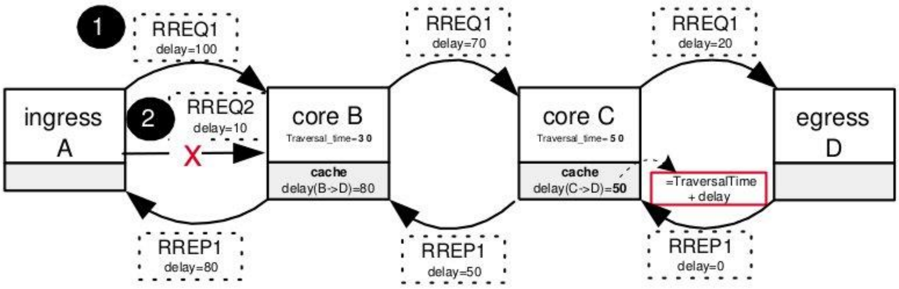

Figure 1: QoS Constraint-Maximum Delay

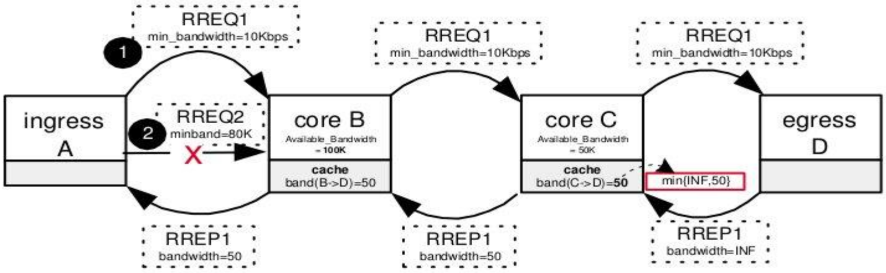

Figure 2: QoS Constraint-Minimum Bandwidth

Figure 3 illustrates the QoS oriented route discovery process for maximum delay constraint. This constraint information is added into the route request packet (RREQ) by the source node and broadcasted. The intermediate nodes after receiving the RREQ packets, subtract their individual delay with maximum delay and replace the maximum delay value with this new value. If the new value is negative, then, the node will drop the RREQ packet.

Figure 2 illustrates the QoS oriented route discovery process for minimum bandwidth constraint. Along with the maximum delay information, the source node adds the constraint information into RREQ packets before broadcasting. The intermediate nodes drop the RREQ packets if they are unable to provide the requested bandwidth, otherwise, the RREQ packet is rebroadcasted. The ultimate goal of the QoS oriented route discovery process is to identify those routes which satisfy both the QoS constraints.

The importance of QoS in MANETs was described in [24, 25]. In [25], QoS mechanism for stateless wireless ad-hoc networks was presented. The QoS was provided through rate control for UDP and traffic management for TCP.

3. Cooperative Routing Technique

3.1 Application Priority Analysis

Assuming that, there are r applications being executed inside a given MANET. The applications are denoted by a_1, a_2,…,a_r. Each routing path will correspond to a single application. The priority levels of the applications are represented in Equation 1. Here, $priority(a_i)$ indicates the priority level of application a_i and $1 \leq i \leq r$.

$$priority(a_1) \geq priority(a_2) \geq \ldots \geq priority(a_r) \qquad (1)$$

Each application is associated with 2 QoS limiting factors, which are basically used in the routing stage to decide the degree of satisfying the application QoS requirements. These factors, which are defined for application ai, are represented in

Equations 2 and 3. Here, $0 \leq \alpha(a_i)$ and $0 \leq \beta(a_i)$. The first limiting factor is related to maximum delay constraint, and the second limiting factor is related to minimum bandwidth constraint.

$$\textit{first limiting factor} = \alpha(a_i) \quad (2)$$

$$\textit{second limiting factor} = \beta(a_i) \quad (3)$$

3.2 Node Cooperative Table

Let, n_j be a MANET node which is part of multiple routing paths. The node n_j, reactively builds a cooperative table to be used in routing stage, and which is updated in predefined intervals. This table is represented in Table 1, which is the cooperative table for nj . Here, nj_i is one of the neighbor nodes of n_j , bw (nj_i) is the bandwidth offered by nj_i , md(nj_i) is the delay induced to a data packet by nj_i and ec(nj_i) is the energy cost of transmitting a data packet from nj_i.

3.3 Neighbor Node Scoring Function

To achieve node cooperation during routing stage, a scoring function is designed to score each neighbor node of n_j, and select the suitable neighbor node for routing cooperation. This scoring function is represented in Equation 4. Here, score (nj_i) indicates the score of neighbor node nj_i. Higher the score, more beneficial will be the node for establishing cooperative routing.

$$\boxed{score(n_{j_i}) = \frac{bw(n_{j_i})}{ec(n_{j_i}) + md(n_{j_i})}} \quad (4)$$

3.4 Algorithm

The cooperative routing algorithm is presented in Algorithm 1. The Algorithm flow diagram is illustrated in Figure 3. Consider an instance, where the MANET node n_j is part of r routing paths [$p_1, p_2, \ldots p_r$], where each $p_k (1 \leq k \leq r)$ belongs to the application a_k, and the priority of all these applications are represented in Equation 1.

Algorithm 1: Cooperative Routing Algorithm

```
Let, the node $n_j$ be part of routing paths $p_1, p_2, \ldots p_r$.
Let, $p_k$ $(1 \leq k \leq r))$ belong to application $a_k$.
The priority level ordering of applications $a_1, a_2, \ldots, a_r$ is represented by Equation 1.
The current energy level of $n_j$ is indicated by energy level($n_j$).
if energy level($n_j$) $\geq T1(n_j)$ then
        Continue providing data packet routing for all the routing paths.
end if
if energy level($n_j$) $< T1(n_j)$ then
        cooperative table($n_j$) indicates the cooperative table for $n_j$.
        Continue routing data packets for $p_1$ corresponding to application $a_1$.
        for Each path $p_k \in (p_2, p_3 \ldots p_r)$ do
                Let, next hop($n_j \mid p_k$) indicate the next hop node for $n_j$ wrt path $p_k$.
        for Each node $nj_i \in$ cooperative table of $n_j$ do
                Let, neighbor list($nj_i$) indicate the list of neighbors for $nj_i$.
                if $md(nj_i) \leq md(nj) + \alpha(a_k)$ and $bw(nj_i) \geq bw(nj) - \beta(a_k)$ and next_hop($n_j|p_k$) $\in$
                neighbor_list($nj_i$) then
                        Calculate score($nj_i$) by using Equation 4
                end if
        end for
        Select that neighbor node $nj_i$ which has the highest score.
        Assign the incoming data traffic for path $p_k$ towards $nj_i$.
```

```
    Intimate the source node of path $p_k$ about this traffic migration and $n_j$ will get isolated
    from path $p_k$.
    if No suitable neighbor nodes available in cooperative table of $n_j$ for data traffic
    migration then
        Intimate the source node of path $p_k$ to discover new route.
        if Suitable new routes are not available then
            The source node can use the same path for data routing.
        end if
    end if
    end for
end if
if energy level($n_j$) < T2($n_j$) then
    for Each node $nj_i \in$ cooperative table of $n_j$ do
        if $md(nj_i) \geq md(n_j)$ and $bw(nj_i) \geq bw(n_j)$ and $next\_hop(n_j \mid p_1) \in neighbor\_list(nj_i)$
        then
            Calculate score($nj_i$) by using Equation 4
        end if
    end for
    Select that neighbor node $nj_i$ which has the highest score.
    Assign the incoming data traffic for path p1 towards $nj_i$.
    Intimate the source node of path $p_1$ about this traffic migration and $n_j$ will get isolated
    from path $p_1$.
    if No suitable neighbor nodes available in cooperative table of $n_j$ for data traffic
    migration then
        Intimate the source node of path $p_1$ to discover new route.
        if Suitable new routes are not available then
            The source node can use the same path for data routing.
        end if
    end if
end if
```

Two node energy thresholds are defined. The first energy threshold for node n_j is indicated by T1(n_j) and the second energy threshold for node n_j is indicated by T2(n_j). Here, T1(n_j) > T2(n_j).

If the current node energy level of n_j falls below the first energy threshold, then, n_j continues to provide routing service for p_1, but, comes out of all the low priority paths p_2, p_3, …., p_r. There are two options available for n_j to get isolated from low priority paths. The first option, for each low priority path p_k, suitable neighbors are searched, which can directly communicate with the next hop of n_j in the low priority path. Also, these suitable neighbors should satisfy the QoS conditions $md(nj_i) \leq md(n_j) + \alpha(ak)$ and $bw(nj_i) \geq bw(n_j) - \beta(ak)$. Here, $bw(nj_i) > \beta(ak)$. If such suitable neighbors are found, then, by using scoring function represented in Equation 4, n_j will divert the incoming traffic for low priority paths to such selected and suitable neighbors, and n_j will get isolated from all low priority paths. This implies that, the low priority application will now get a new routing path which approximately satisfies the QoS conditions. For any particular low priority path, if suitable neighbors are not available for data traffic migration, then, n_j intimates the source node of that particular path to perform fresh route discovery, which will not include the node n_j . If the source node is unable to discover suitable new routes, it can use the previous registered routing paths.

If the current node energy level of n_j falls below the second threshold, then, suitable neighbor nodes which have the same QoS capacity, and which can directly communicate with the next hop of n_j for p_1 are searched. If such neighbors are available, then, by using scoring function represented in Equation 4, n_j will select the most beneficial neighbor node and divert the incoming traffic of p_k to the selected neighbor. This implies that, the highest priority application will get a new routing path, which exactly satisfies the QoS constraints. If such neighbors are available, n_j intimates the source node of that particular path to perform fresh route discovery, which will not include the node n_j. The source node can use the previously registered routing path, if new suitable route is not available.

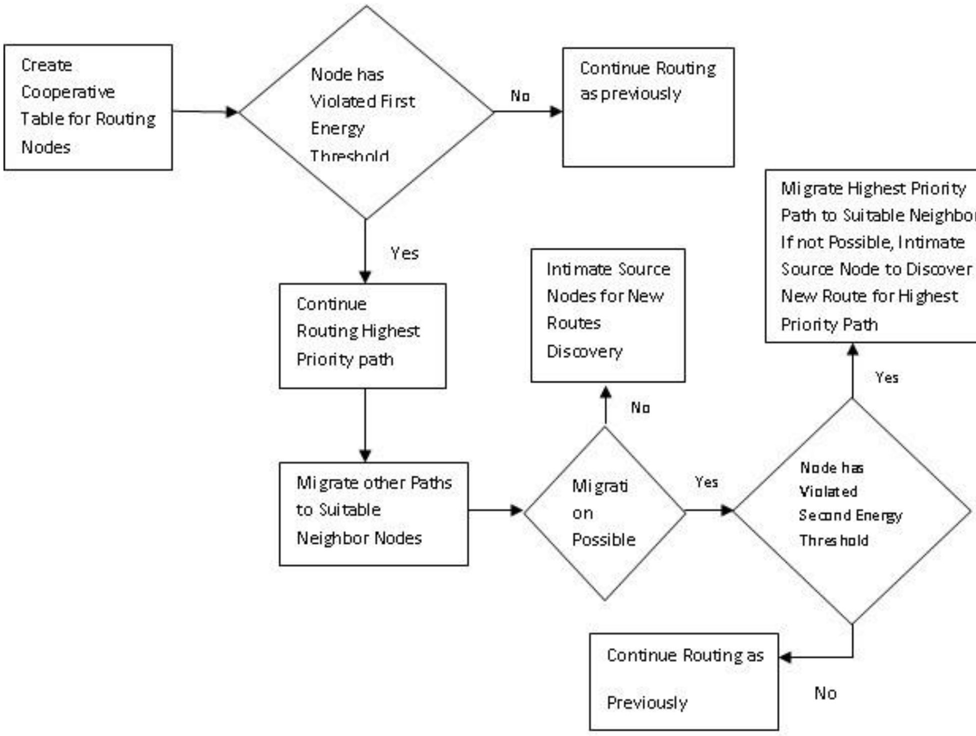

Figure 3: Algorithm Flow Diagram

4 Results and Discussions

The proposed cooperative routing protocol is implemented in Network Simulator 3. The simulation parameter settings are presented in Table 2. For the ease of referring, the proposed cooperative routing protocol will be referred as CQRP. This CQRP is compared against the QoS mechanism proposed in [1], which will be referred as NQRP. In NQRP, new route discovery is invoked, when any node in the routing path looses all its energy reserves.

To perform empirical analysis on CQRP and NQRP, a metric called avgcp is defined, which is represented in Equations 5 and 6. Here, n_i is one of the node which was involved in data packet routing for application a_k, and this application might have used multiple paths due to cooperative routing technique, energy_expense(n_i) is the total energy cost incurred by n_i to route all the data packets of application a_k, $N(a_k)$ indicates the total number of nodes involved in routing all the data packets for a_k and $avgcp(a_k)$ indicates the average node energy consumption for a_k.

$$\boxed{avgcp(a_k) = \sum_{n_i \in a_k} \frac{energy\_expense(n_i)}{N(a_k)}} \qquad (5)$$

$$avgcp = \sum_{a_k} avgcp(a_k) \qquad (6)$$

The first experiment analyzes the performance of CQRP and NQRP wrt avgcp metric, when the total number of MANET nodes is varied. The result of this experiment is presented in Figure 4. As the number of nodes increase, the cooperative tendency of nodes also increase, due to increase in the number of neighbors, hence, the performance of CQRP improves. The second experiment analyzes the performance of CQRP and NQRP wrt avgcp metric, when the total number of data packets of all the applications is varied, and this result is presented in Figure 5. Increase in data packets, will result in more nodes reaching their energy thresholds, which invariably results in more node cooperation, hence, the performance of CQRP also improves.

Table 2: Simulation Parameter Settings

Simulation Parameter	Values
Number of nodes in MANET	200
Average number of neighbors per node	26
Number of applications	10
Path per application	1
$\alpha(ai)(1 \leq i \leq 10)$	Varied between 0 ms to 30 ms
$\beta(ai)$	Varied between 0 kbps to 30 kbps
Node delay	Varied between 10 ms to 100 ms
Node bandwidth	Varied between 20 kbps to 150 kbps
Node data packet energy cost	Varied between 50 kj to 150 kj
Node energy reserve	Varied between 50 mj to 150 mj
First node energy threshold	40% of the total node battery energy
Second node energy threshold	70% of the total node battery energy
Application bandwidth requirements	Varied between 60 kbps to 130kbps per node
Application maximum delay requirements	Varied between 100 ms to 400 ms

The third experiment varies the average number of neighbors per node, and analyzes the performance of CQRP and NQRP. The result of this experiment is presented in Figure 6. It is obvious that, increase in neighbors will increase cooperative tendency, and will improve the performance of CQRP.

The fourth experiment varies the minimum bandwidth parameter to analyze the performance of CQRP and NQRP. Here, the term min(bw) refers to the minimum value for bandwidth requirement among all the applications. The result of this experiment is presented in Figure 7. As the min(bw) value increases, there will be few nodes, which are eligible for cooperation, hence, the performance of CQRP reduces.

The fifth experiment varies the maximum delay requirement to analyze the performance of CQRP and NQRP. Here, the term min(md) refers to the minimum value for the maximum delay requirement among all the applications. The results of this experiment is presented in Figure 8. As the min(md) value decreases, due to lesser node availability to perform cooperation, the performance of CQRP reduces.

The sixth experiment varies the first node energy threshold values to analyze the performance of CQRP and NQRP. The result of this experiment is presented in Figure 9. When the value of T1is less, frequency of node cooperation increases, hence, at such low values of T1, the performance of CQRP is better.

In all the above experiments, due to the absence of node cooperation in NQRP, it always suffers much more than CQRP wrt avgcp metric.

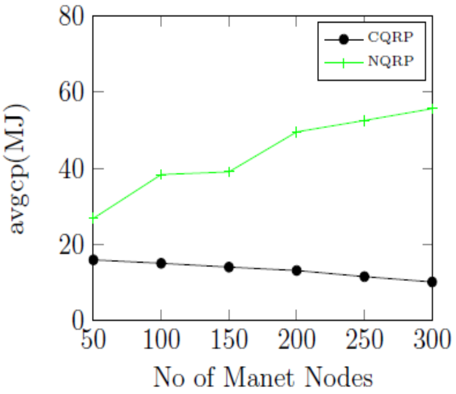

Figure 4: avgcp vs No of MANET Nodes

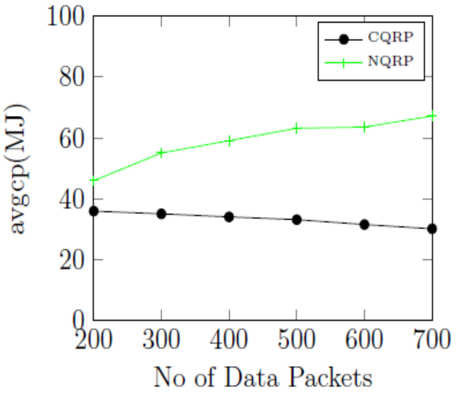

Figure 5: avgcp vs No of data packets

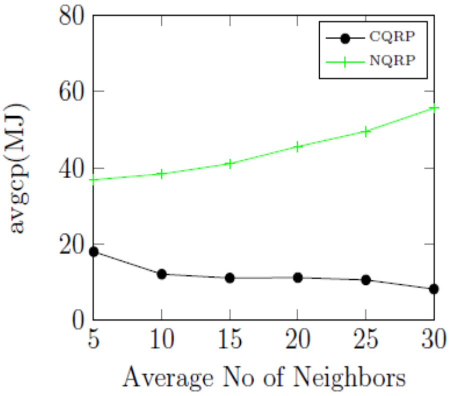

Figure 6: avgcp vs Avg No of Neighbors

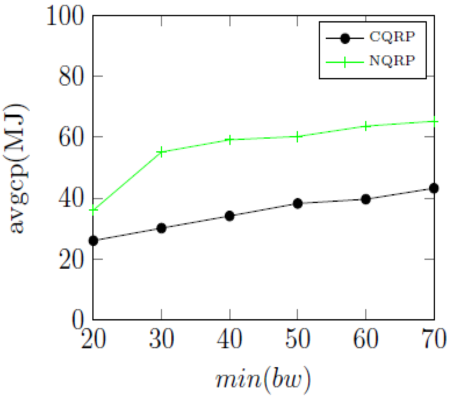

Figure 7: avgcp vs min(bw)

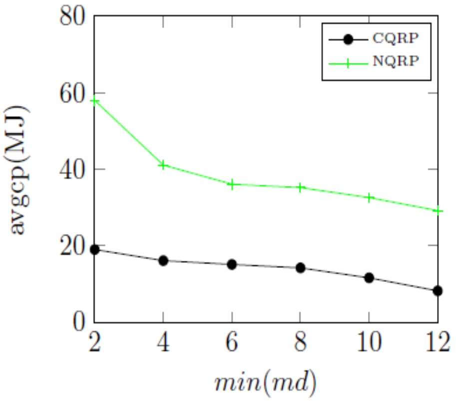

Figure 8: avgcp vs min(md)

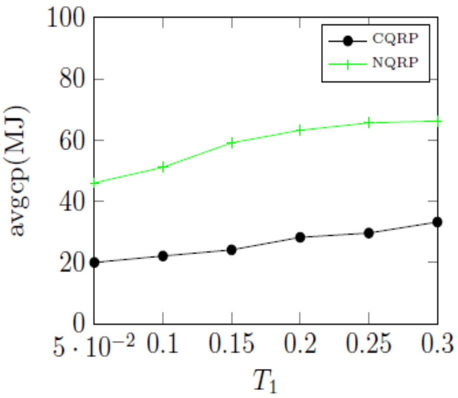

Figure 9: avgcp vs T1

5 Conclusion

In this work, a node cooperative routing technique was presented, which was extended from the routing protocol in [1]. This proposed scheme achieves application priority oriented QoS mechanism through the aid of two QoS parameters. Mathematical framework was presented and utilized to design the proposed routing protocol. Empirical results were analyzed on Network Simulator 3, which exhibited the merits of this proposed routing protocol over the competing technique [1]. In future, better mathematical frameworks need to be investigated for achieving better energy conservation results that were obtained in this work.

References

[1] Zeinalipour-Yazti Demetrios, A Glance at Quality of Services in Mobile Ad-Hoc Networks, Technical Report, http://alumni.cs.ucr.edu/csyiazti/courses/cs260/html/ manetqos.html.

[2] X. Zeng et al., Glomosim: A library for parallel simulation of large-scale wireless networks, In Workshop on Parallel and Distributed Bibliography 65 Simulation; Canada, May 1998, pp. 154-161.

[3] Shafiullah Khan et al, Denial of Service Attacks and Challenges in Broadband Wireless Networks, International Journal of Computer Science and Network Security, Vol. 8, No. 7, pp.1-6, July 2008.

[4] Xiao Bin et al, A novel approach to detecting DDoS Attacks at an Early Stage, The Journal of Supercomputing, Springer, Volume 36, Number 3, June 2006 , pp. 235-248(14).

[5] Shigang Chen et al, Stateful DDoS attacks and targeted filtering, Journal of Network and Computer Applications, Volume 30, Issue 3, August 2007, pp. 823-840.

[6] Xiaobo Zhou et al, Distributed denial-of-service and intrusion detection, Journal of Network and Computer Applications, Volume 30, Issue 3, August 2007, pp. 819- 822.

[7] Vasilios A. Siris et al, Provider-based deterministic packet marking against distributed DoS attacks, Journal of Network and Computer Applications, Volume 30, Issue 3, August 2007, pp. 858-876.

[8] Yaar Abraham et al StackPi: New Packet Marking and Filtering Mechanisms for DDoS and IP Spoofing Defense, IEEE Journal on Selected Areas in Communications 24, no. 10 (October 2006): 1853-1863.

[9] Yi-an Huang et al., A Cooperative Intrusion Detection System for Ad Hoc Networks, In Proceedings of the ACM Workshop on Security of Ad Hoc and Sensor Networks (SASN '03), Fairfax VA, October 2003.

[10] M. Just, E. Kranakis, T. Wan, Resisting Malicious Packet Dropping in Wireless Ad-Hoc Networks, In proceedings of 2nd Annual Conference on Adhoc Networks and Wireless (ADHOCNOW' 03), Montreal, Canada, Oct 09- 10, 2003, pp. 151-163, LNCS, S. Pierre, M. Barbeau, E. Kranakis, eds., Vol. 2865.

[11] Xianjun Geng and Andrew B. Whinston; Defeating Distributed Denial of Service Attacks; February, 2000.

[12] Mukesh Kumar and Naresh Kumar Study of Attack prevention methods for DDOS Attacks in Manets IJARCSSE Volume 2, Issue 8, Aug. 2012 pp. 224-228.

[13] Kamanshis Biswas and Md. Liakat Ali; Security Threats in Mobile Ad Hoc Network; Master Thesis; Thesis no: MCS- 2007:07; March 22, 2007.

[14] Stephen M. Specht and Ruby B. Lee; Distributed Denial of Service: Taxonomies of Attacks, Tools, and Countermeasures; Proceedings of the 17th International Conference on Parallel and Distributed Computing Systems, 2004 International Workshop on Security in Parallel and Distributed Systems, pp. 543-550; September 2004.

[15] Vesa Karpijoki; Security in Ad Hoc Networks; Helsinki University of Technology; HUT TML 2000.

[16] Yogesh Chaba, Yudhvir Singh, Preeti Aneja, Performance Analysis of Disable IP Broad-cast Technique for Prevention of Flooding-Based DDoS Attack in MANET, JOURNAL OF NETWORKS, VOL. 4, NO. 3, MAY 2009 ACADEMY PUBLISHER.

[17] 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.

[18] 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.

[19] 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.

[20] Kyungtae Woo and Chansu Yu and Dongman Lee and Hee Yong Youn and B. Lee, Nonblocking, 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.

[21] 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.

[22] Vikas Kawadia,P.R. Kumar, Power control and clustering in ad hoc networks, IEEE INFOCOM, 2003.

[23] 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.

[24] 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.

[25] Magula, Peter and Kotocova, Margareta, Quality of Service Models for Mobile Ad-hoc Networks, Proceedings of the 12th International Conference on Computer Systems and Technologies, 2011, 978-1-4503-0917-2, Vienna, Austria.

Authors

Srinivasa H P currently working as Associate Professor in the Department of Computer Science and Engineering at T. John Institute of Technology, Bengaluru. He has BE and M. Tech Degrees in

Computer Science & Engineering. He has 17 years of experience in Teaching and Administration. His area of Research includes Computer Networks, Wireless Networks and Cloud Computing. He has published more than 10 papers both National and International Journals. He is a member of many professional bodies like ISTE, IACSIT, IAENG, IFERP. He has designed, developed and maintained the State of art Gigabit LAN and also the CCI Technology of HP Pvt Ltd in the college. Currently working on Automation of Examination and Digital Valuation System.

Dr. Kamalesh V N has M. Tech and Ph D in the field of Computer Science & Engineering. Presently working as Professor and Dean in the Department of Computer Science and Engineering, T. JOHN Institute of Technology, Bangalore, affiliated to Visvesvaraya Technological University, Karnataka, India. He has published more than 45 research publications in reputed journals. He has rendered services as Consultant in IT & e-Learning, Rajiv Gandhi University of Health Sciences, Govt. of Karnataka, Bengaluru. He also worked as Professor and Special Officer, E-Learning Centre, VISVESVARAYA TECHNOLOGICAL UNIVERSITY Regional Office, Mysuru and as Director IT, Computer Science and School of Science & Technology, Karnataka State Open University, Mysore. He has received 24 MRC & IBN 7 Television Broadcast has confirmed 2015 leader award for achieving e – Learning consultant of the year and Indo-US National Award for Teaching Excellence by Indo-US Foundation. Recipient of Young Mathematician Best Research Paper Award of the year 1995-96 from Ramanujam Mathematical Society. Asian Education Leadership Award - Best Director, awarded by Asian Confederation of Business with CMO Asia as its strategic partner and Stars of the Industry Group as a research partner, Dubai.