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Accomplishing Consummate Throughput with Delay and Power Control in MANET

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Abstract

Mobile Ad Hoc Network is a self-configuring, autonomous, infrastructure less network of movable nodes which will be automatically connected by wireless connection with no access point. The nodes are free to move anywhere in the set of connections and the topology of MANET remains unpredictable. The major complexity with the available two hop relay protocols in MANET environment is to achieve the optimized throughput with reduced packet delivery delay. A generalized collection based two-hop relay and redundancy of the packet is used to attain the reduced delay. The complex process of packet delivery in MANET utilizes Routine Response Control and Modified Markov chain model. Tuning carefully the parameters, the transmission range, the packet redundancy and the group size help to achieve the optimized throughput with the reduced packet delivery delay. Transmission power of a node is controlled which helps in achieving the optimized throughput and reduced delay.

Keywords

Capacity, Mobile Ad Hoc Networks, Power Control, Throughput

1. Introduction

The mobile devices have path to the internet technology that reduces an outlay with consenting us to utilize Mobile Ad Hoc Wireless Network. Mobile devices are free to move anywhere and they detect the presence of other nodes in the network and they communicate with each other in the absence of a central administration. The field of MANET has experienced an exceptional growth in many applications that embraces military troop communication, disaster recovery, information exchange, e-commerce, multiuser games, etc. The fundamental per-

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formance limits like throughput capacity and packet delay are major distresses to settle on since the topology is unreliable. The mutual interference of concurrent transmission between nodes is the major hindrance to achieve the reduced packet delivery delay and optimized throughput with the available two hop relay protocols in MANET environment [1] [2].

The capacity theory for the wireless network is an exigent obstruction that stunts the development of MANET. Using the efficient two-hop routing scheme and its variants, the throughput capacity has been improved appreciably [3]. In two-hop routing scheme, initially the source no deal ways transmits the specified packet to a destination node if it is within the hearing range. When the destination node is not within one hop region, the source transmits the packet to the nearest neighbour node (relay) and the relay node in turn transmits it to the destination as soon as it comes in contact with the destination. They suggest that rather than fixed nodes mobile nodes increases the throughput capacity of the wireless network. Their work on two hop relay protocols supports applications with loose delay constraints such as electronic mail, database synchronization but does not hold up applications like video streaming, real time monitoring that are sensitive to delay. **Figure 1** illustrates the Mobile Ad Hoc Network model.

Two hop communication protocols do not reflect on the packet redundancy. The exposed order of two hop relay and acknowledged redundancy as suggested by [4] shows that the packets have more than one (multiple) copies while transmitting the packets from source to destination through relay nodes. In case of out of order reception, the reception occasion takes full advantage but the mobile nodes have to carry in buffer with contains very big used to accommodate all the arrived packets, which is not practically possible in MANET [5]. Another disadvantage with this case of reception incorporates the early arrival of packets, which becomes expired after the meticulous interval of time [6].

2. Proposed Work

The main purpose of our proposed work compared to existing work is used to attain the exact optimum throughput for every node capacity with reduced delay in accordance with packet redundancy and power control [8]. To accomplish this throughput for every node capacity with delay control a general theoretical framework based on Routine Response Control and the Modified Markov chain model is initially developed [9]. The generalized group based routing scheme for two-hop with r-cast (2HR-(r, g)) algorithm is worn where limited number of copies for each packet is dispatched to different relay nodes (*i.e.*, each packet has a restricted redundancy r) and all packets are inward bound in order in the destination if it is among the group, the destination is requesting. The optimum setting of the transmission range and packet redundancy limit is initially determined. Once the above factors are decided the next step is to determine the group size of the packets [10]-[13].

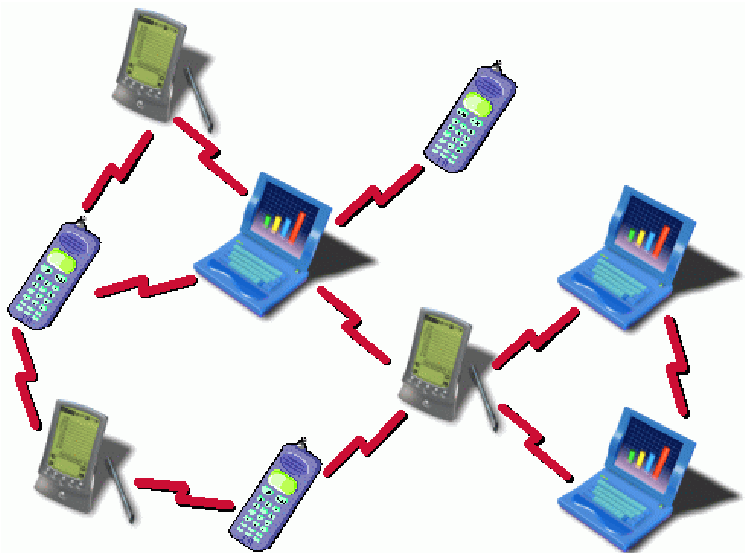

Figure 1. Mobile Ad Hoc network [7].

2.1. Node Creation

The network includes mobile nodes that can move in a random fashion. The mobile node communicates with each other in the absence of a fixed infrastructure [14]. The mobile nodes are able to detect the presence of other nodes in the network. Connections between the mobile nodes are established only when there are requests from other mobile nodes in the network. Transmission of a packet is made only when the node is within the audible range of one another [15]. The mobile node includes various parameters like channel type, propagation model, network interface type, MAC type, link layer type, antenna model, number of mobile nodes, maximum queue length, dimension of the topology, etc.. The topology of the network is initially constructed with a boundary and the mobile nodes are restricted to move within this boundary. A topological object termed General Operations Director (GOD) is used to track the mobile nodes within this boundary area. GOD object incorporates various information like the total number of mobile nodes in the network, circumstances of the environment, the details about the number of hops from one node to other node in order to reach the destination [16]-[19]. The mobile nodes are created and configured only when the GOD object encumbers the next hop Information from the movement pattern file before the commencement of simulation.

2.2. Transmission Scheduling

The vocation of this paper embraces the Time slotted system and protocol interference model which is absolutely contrasted from DCF. According to DCF (distributed coordination function), packets can be circulated at any end, and whether the packets are successfully received or not depends on the actual SINR at the receiver, which is completely dissimilar from the time slotted system and the Protocol obstruction model. The obstruction model suggests that the packet transmission can be made through multiple links concurrently if the nodes are suitably far away from each other. A simple transmission-group based scheduling scheme is used to shore up abundant simultaneous link transmissions. A transmission-group is a detachment of cells, where any two of them have a perpendicular and parallel distance of some manifold of δ cells and all of them could conduct transmissions at the same time as the previous transmission. At the commencement of each time slot every node is supposed to judge whether it is inside a current live cell or not. All the cells which are in the same transmission-group can simultaneously shore up a transmitting node in it without interfering. It is major issue for the transmission-group based scheduling with parameter δ, there will be in total δ^2 distinct transmission-groups. If all the transmission-groups alternatively become live (*i.e.*, obtain the transmission opportunity), then each transmission-group (each cell) becomes active in every δ^2 time slots.

2.3. Modified Markov Chain Model and Routine Response Control

At the source S, to denote the transient state for a tagged packet group a three state tuple (i, j, k) is used. S delivers the i^{th} copy of the j^{th} packet when the destination node D has previously received any k of the g packets. S has dispatched all the copies of the packets in the tagged group but the destination has received only k among g packets and to denote this (*, *, k) transient state is used. If a node pair (S, D) is in (i, j, k) transient state one among the following 4 states will occur. Packet delivery process is described in **Figure 2**.

Routine Response Control

The packet delivery process involves the Routine Response Control where the parameter k is automatically updated to adjust to the service rates at the S and D.

2.4. Routing Methodology

Routing scheme works on finding the exact economical route to send the packets to the destination node. A generalization of the classic two-hop routing scheme with f-cast (2HR-(f, g)) where each packet waiting at the source is delivered to at most f distinct relay nodes (*i.e.*, each packet has a limited redundancy f) and can be received in order at its destination if it is a fresh packet and is among g packets of the group, the destination is requesting. As a common complication for the designing of relay algorithm with packet redundancy, there may exist some residual packets (copies) lingering for a long time in the network, even after they have already been received by the destination. Obviously, such remnant packets may create excess congestion, waste network buffer, and must somehow be removed. Sequence number based mechanism is used to overcome this problem.

1) If Dreplies Swithin the time, it initiates a handshake with D and then transmits the packet unswervingly to D

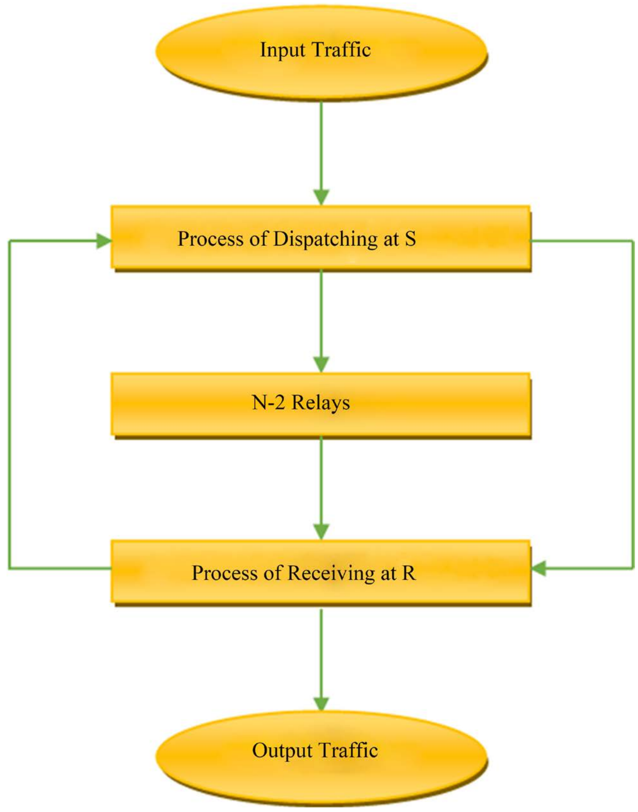

Figure 2. Packet delivery process.

("Source-to-Destination" transmission);

2) When S doesn't receive a broadcast reply from D then the source node transmits the packet to the intermediate node (within one hop transmission range) which in turn transfers the packet to the sink node. Transmission can be in either of the two forms with the probability:

a) ***Source-to-Relay***: Source delivers out the copies of packet P to the relay nodes that are locally generated at S. If Relay node R does not have the copy of P then S dispatches P to R or else S ruins inoperative during that time slot.

b) ***Relay-to-Destination***: When the sequence number matches the request number then the relay node transmits the packet P to the destination or else R ruins inoperative during that time slot.

3. Related Works

SR State: (Source-to relay state) When the Source delivers the i^{th} copy to the relay node I the destination does not receive the fresh packet from any other relay node.

RD State: (Relay-to-Destination) Some relay node delivers the fresh copy to the destination when S fails to deliver the i^{th} copy to a new relay node.

SR + RD State: (Source-to-relay and relay-to-destination) Both the transmission turns out simultaneously.

SD State: (Source-to-Destination) S directly transmits a fresh packet to the destination.

Algorithm 1 2HR-(r, g) Algorithm

```
if the node S gets a transmission opportunity then
if the node D is among the one-hop neighbours of node S then
        S executes Procedure 1 with D;
        {
                source-to-destination transmission
        }
else
```

S randomly selects one node (say K) from its one-hop neighbors;
S flips an unbiased coin;
if it is the head then
    S executes Procedure 2 with K;
    {
        source-to-relay transmission
    }
else
    S executes Procedure 3 with K;
    {
        relay-to-destination transmission
    }
end if
end if
end if

Process 1 SD

S initiates a handshake to obtain the *R*G(*D*) and IN(D) from node *D*;
if *S*G ≥ *R*G(*D*) then
if *SN*(*P*t) > I*N*(*D*) then {*Ph* is the head-of-line packet at the local-queue of *S*}
    S retrieves from its already-sent-queue the packet *P* with (*P*) = I*N*(*D*);
    S sends the *P* to node *D*;
else if *SN*(*P*t) == I*N*(*D*) then
    S sends *P*t directly to node *D*;
else
    {
    I(*D*) = *SN*(*P*t) + 1
    }
S sends to node *D* the packet waiting right behind *P*t in the local-queue;
end if
S deletes all packets with *S*G < *R*G(*D*) inside the already-sent-queue and local-queue;
S moves ahead remaining packets waiting at its local-queue.

Process 2 SR

S initiates a handshake with node K;
if K has one copy of *P*t then
S remains idle;
else
S sends a copy of packet *P*t to K;
if f copies have been distributed for packet *P*t then
S puts *P*t to the end of its already-sent-queue;
S moves ahead the remaining packets in its local-queue;
end if
K puts *P*t at the end of its relay-queue dedicated to node *D*;
end if

Process 3 RD

S initiates a handshake to obtain the *R*G(K) and IN(K) from node K;
if *S* has a packet *P* in the relay-queue dedicated to K with *S*N(*P*) = IN(K) then
S sends packet *P* to node K;
else
S remains idle;
end if
S deletes all packets with *S*G ≤ *R*G(K) from its relay-queuededicated to K;
Every time node S wins a transmission opportunity, it operates as follows.

Step 1: ("Source-to-destination") If S transmits directly to D a new packet of group RG(D). A packet is called a *new packet* if it has not been received yet by its destination.

Step 2: Otherwise, S randomly chooses to perform one of the following operations with equal probability:

- **Source-to-relay:** It randomly selects one node, say R, from the one-hop neighbors, and checks whether R is a new node. If not, it delivers to R a copy of the head-of-line packet Ph at its local-queue;
- **Relay-to-destination:** The node S acts as a relay and randomly selects a node (say K) from the one-hop neighbors. After obtaining the RG(K) and IN(K) from K, S checks whether there exists a fresh packet of group RG(K) in its relay-queue specified for K. If so, it transmits this packet to K and removes all packets with SG ≤ RG(K) from its relay-queue for K; otherwise, it remains idle for this time slot.

The whole process of the proposed algorithm is illustrated in **Figure 3**.

4. Experimental Classification Results and Analysis

In **Figure 4** the blue dotted line indicates the existing system which shows the exact throughput for every node capacity $\omega(m, r)$ with minimum transmission power.

$$\omega(m,r) = \min\left\{\frac{1}{E\left[XS(1)\right]}, \frac{1}{E\left\{\left[XD(r+1)\right]\right\}}\right\} \quad (1)$$

where

$XS(k)$: The time at the local queue.

$XD(k)$: The time at the virtual queue.

m**:** Transmission power, r**:** Redundancy limit.

The red line indicates the proposed system which indicates the increased throughput (packets/slot). Using the above throughput result, the optimal throughput capacity $\omega^* = \max_r \{\omega(m,r)\}$ is obtained for any r and a

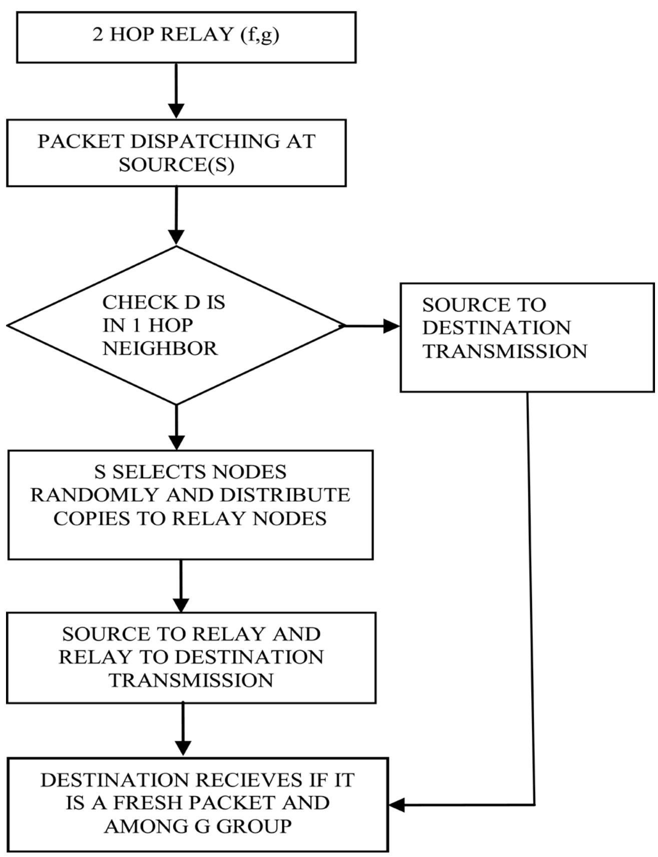

Figure 3. Flow diagram for algorithm.

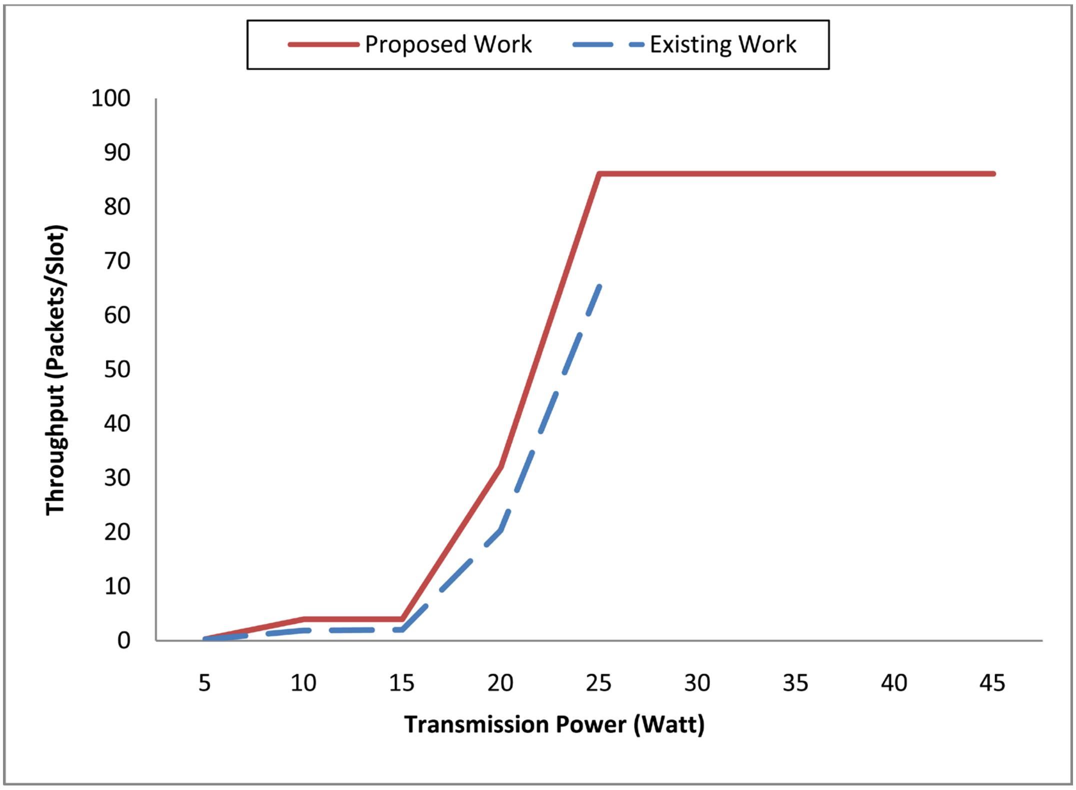

Figure 4. Transmission power vs throughput.

fixed m. From this result the maximum throughput capacity $\omega^* = \max_{m,r}\{\omega(m,r)\}$ for any r and m of a network is calculated using Formula (2).

$$\omega^* = \max\left\{\left.\frac{1}{E\{[XD(r+1)]\}}\right|_{r=r_0}, \left.\frac{1}{E[XS(1)]}\right|_{r=r_1}\right\} \tag{2}$$

where

$$r_0 = \max\{r \mid E[XS(1)] \le E\{[XD(r+1)]\}\} \tag{3}$$

$$r_1 = \min\{r \mid E\{[XD(r+1)]\} \le E[XS(1)]\} \tag{4}$$

ω^* does not increase any more when υ increases beyond some threshold because the node is able to cover the whole network region and destination receives each packet. The Transmission power of each node is increased which increases the throughput capacity.

Average packet delivery delay of one packet T_p is calculated using the formula

$$T_p = \frac{T(f,g)}{g} \tag{5}$$

Expected packet delivery delay $E\{T_p\}$ is determined using the below formula

$$E\{T_p\} = \sum_{k=1}^{g}\sum_{j=1}^{L_{k-1}} N_{1k}(1,j) \tag{6}$$

where, g: group size; k: D has received k of g packets; N: Markov chain matrix.

The packet delay can be reduced using Markov Chain Framework. This can be achieved through the 4 states with the increasing Throughput in **Figure 5**. **Table 1** describes the Energy vs Delay in detail (**Figure 6**).

Figure 7 describes the Number of Packets Sensed vs Residual Energy for the Existing System and the Pro-

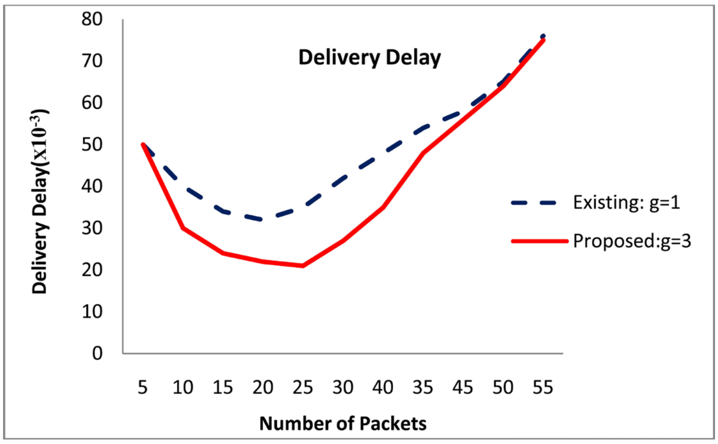

Figure 5. Delivery delay.

Table 1. Delay vs energy.

Number of rounds	Global Energy (Joules/round)							
	In 10 % delay				In 50% Delay			
	Deployed Node = 1000	Deployed Node = 1500	Deployed Node = 2000	Deployed Node = 2500	Deployed Node = 1000	Deployed Node = 1500	Deployed Node = 2000	Deployed Node = 2500
0	504(J)	750(J)	1000(J)	1250(J)	500(J)	750(J)	1000(J)	1250(J)
100	448.35	696.43	937.50	1180.6	441.90	681.25	926.55	1170.60
200	418.7	642.86	875.00	1111.20	383.80	612.50	853.10	1091.20
300	377.08	589.29	812.50	1041.80	325.70	543.75	779.65	1011.80
400	343.40	535.72	750.00	972.40	267.60	475.00	706.20	932.40
500	288.75	482.15	687.50	903.00	209.50	406.25	632.00	853.00
600	254.10	428.58	625.00	833.60	151.40	337.50	554.30	774.60
700	204.45	374.01	562.50	764.20	93.00	268.75	485.85	694.20

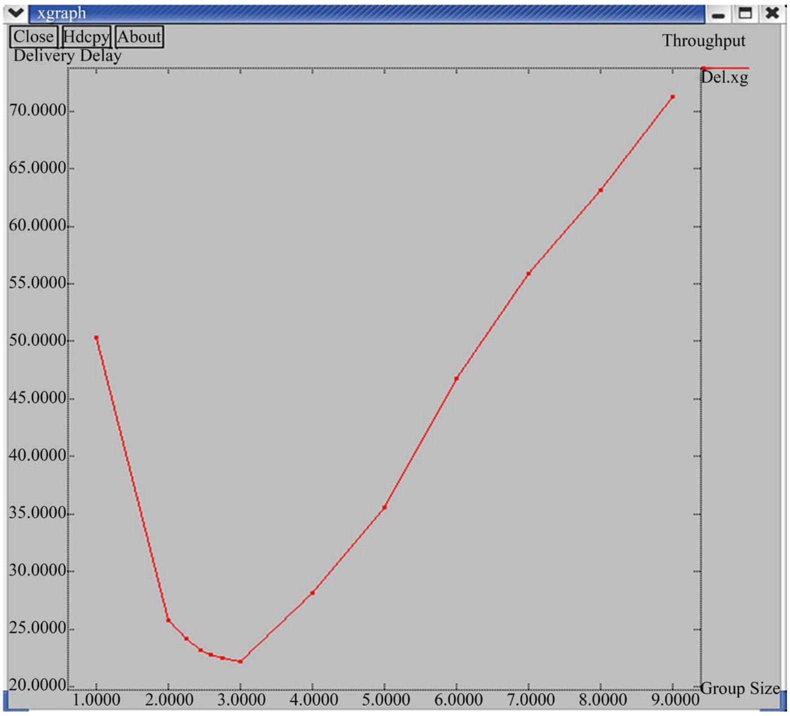

Figure 6. Packet delay vs throughput.

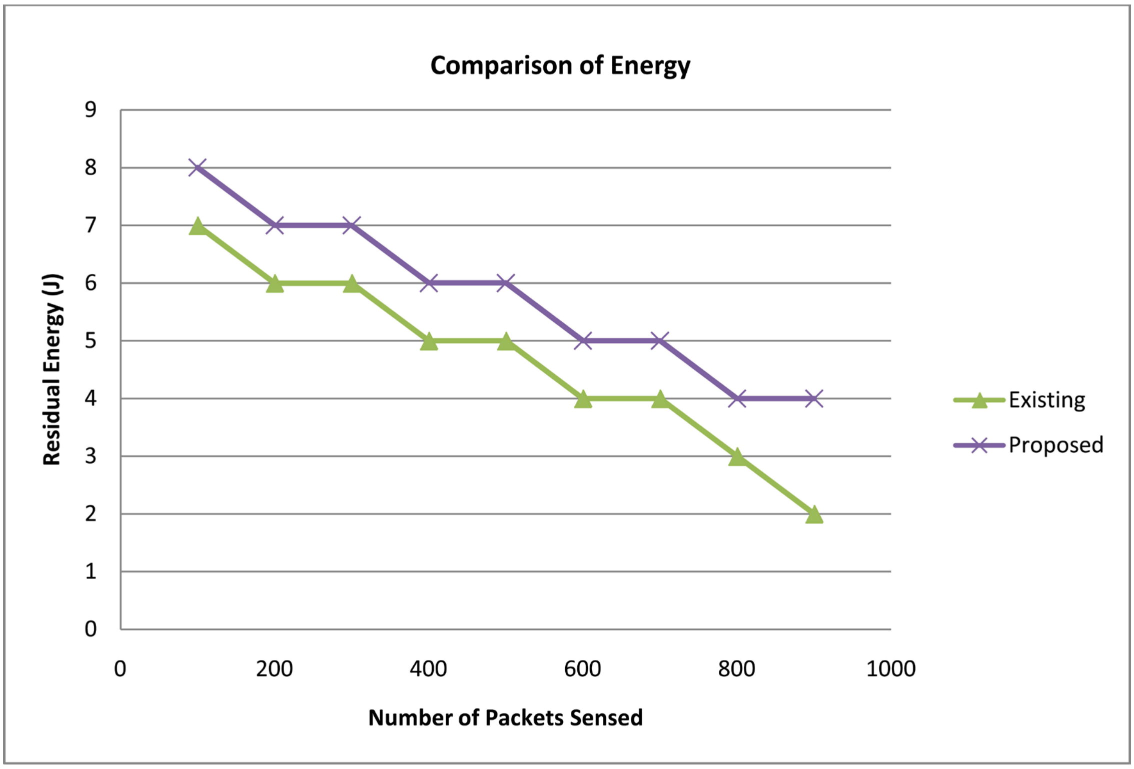

Figure 7. Number of packets sensed vs residual energy.

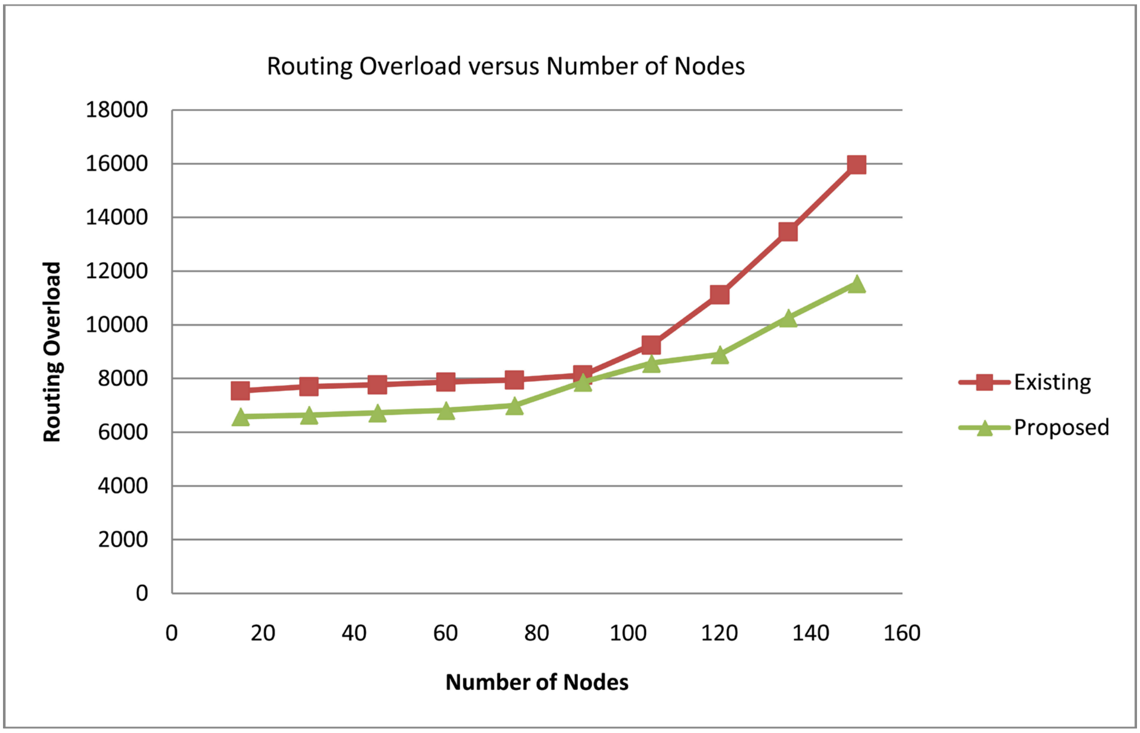

Figure 8. Routing overhead vs number of nodes.

posed system and **Figure 8** describes the Routing Overhead vs Number of nodes for the Network with the specific Lifetime.

5. Conclusions

The throughput for every node capacity of MANET is determined along with delay control by adjusting the transmission range, limiting the packet redundancy and grouping the packets. A generalized group based two-hop routing scheme with f-cast (2HR-(f, g)) algorithm is used where each packet waiting at the source is delivered to at most f distinct relay nodes (*i.e.*, each packet has a limited redundancy f) and can be received in order at its destination if it is a fresh packet and is among g packets of the group, and the destination is requesting. Transmission power of each node is manipulated to amend to specified transmission range and limited packet redundancy limit. Increasing the transmission power increases the throughput capacity and minimizes the delay. This in turn increases the performance of the network. Tuning parameters like f, v and g carefully, the optimized throughput capacity of each node along with minimized delay is achieved which helps in delivering the packets efficiently in the dynamic network topology.

Future research work is to derive the throughput for every node capacity with minimum delay in which each node has constrained buffer space, and further explore the possible thresholds of buffer size.

References

[1] Liu, J., Jiang, X., Nishiyama, H. and Kato, N. (2013) Throughput Capacity of MANETs with Power Control and Packet Redundancy. *IEEE Transactions on Wireless Communications*, **12**, 3035-3047.

[2] Andrews, J., Shakkottai, S., Heath, R., Jindal, N., Haenggi, M., Berry, R., Guo, D., Neely, M., Weber, S., Jafar, S. and Yener, A. (2008) Rethinking Information Theory for Mobile Ad Hoc Networks. *IEEE Communications Magazine*, **46**, 94-101. http://dx.doi.org/10.1109/MCOM.2008.4689214

[3] Harold Robinson, Y., Rajaram, M., Golden Julie, E. and Balaji, S. (2016) Dominating Set Algorithm and Trust Evaluation Scheme for Secured Cluster Formation and Data Transferring. *International Journal of Computer*, *Electrical*, *Automation*, *Control and Information Engineering*, **10**, 388-393.

[4] Harold Robinson, Y. and Rajaram, M. (2015) Energy-Aware Multipath Routing Scheme Based on Particle Swarm Optimization in Mobile Ad Hoc Networks. *The Scientific World Journal*, **2015**, Article ID: 284276. http://dx.doi.org/10.1155/2015/284276

[5] Zhuang, Y., Pan, J. and Cai, L. (2010) Minimizing Energy Consumption with Probabilistic Distance Distributions in Wireless Sensor Networks. *Proceedings of IEEE INFOCOM*, 1-9.

[6] Harold Robinson, Y. and Rajaram, M. (2016) A Memory Aided Broadcast Mechanism with Fuzzy Classification on a Device-to-Device Mobile Ad Hoc Network. In: Harold Robinson, Y. and Rajaram, M., Eds., *Wireless Personal Communications*, Springer, US, 1-23. http://dx.doi.org/10.1007/s11277-016-3213-0

[7] Spyropoulos, T., Psounis, K. and Raghavendra, C.S. (2008) Efficient Routing in Intermittently Connected Mobile Networks: The Multiple-Copy Case. *IEEE/ACM Transactions on Networking*, **16**, 77-90. http://dx.doi.org/10.1109/TNET.2007.897964

[8] Harold Robinson, Y. and Rajaram, M. (2015) Trustworthy Link Failure Recovery Algorithm for Highly Dynamic Mobile Ad Hoc Networks. *International Journal of Computer*, *Electrical*, *Automation*, *Control and Information Engineering*, **9**, 233-236.

[9] Robinson, Y.H. and Rajeswari, S.R. (2011) Energy-Based Dynamic Encryption for Wireless Sensor Networks. *Wireless Communication*, **3**, 661-663.

[10] Golden Julie, E., Tamil Selvi, S. and Harold Robinson, Y. (2014) Opportunistic Routing with Secure Coded Wireless Multicast Using MAS Approach. *International Journal of Computer*, *Electrical*, *Automation*, *Control and Information Engineering*, **8**, 1247-1250.

[11] Harold Robinson, Y. and Rajaram, M. (2014) A Novel Approach to Allocate Channels Dynamically in Wireless Mesh Networks. *International Journal of Computer*, *Electrical*, *Automation*, *Control and Information Engineering*, **8**, 1865-1868.

[12] Harold Robinson, Y. and Rajaram, M. (2015) Establishing Pairwise Keys Using Key Predistribution Schemes for Sensor Networks. *International Journal of Computer*, *Electrical*, *Automation*, *Control and Information Engineering*, **9**, 608-612.

[13] Ramalakshmi, S. and Robinson, Y.H. (2014) ATMPH: Attaining Optimal Throughput Capacity of MANET with Power Control in Heterogeneous Network. *Programmable Device Circuits and Systems*, **6**, 111-115.

[14] Grossglauser, M. and Tse, D. (2001) Mobility Increases the Capacity of Ad-Hoc Wireless Networks. *Proceedings of* 20*th Annual Joint Conference of the IEEE Computer and Communications Societies*, **3**, 1360-1369. http://dx.doi.org/10.1109/infcom.2001.916631

[15] Gamal, E., Mammen, J., Prabhakar, B. and Shah, D. (2006) Optimal Throughput Delay Scaling in Wireless Net-

works—Part I: The Fluid Model. *IEEE Transactions on Information Theory*, **52**, 2568-2592. http://dx.doi.org/10.1109/TIT.2006.874379

[16] Gao, J., Liu, J., Jiang, X., Takahashi, O. and Shiratori, N. (2012) Exact Capacity Study for a Class of MANETs. 2012 1*st IEEE International Conference on Communications in China* (*ICCC*), Beijing, 15-17 August 2012, 173-178. http://dx.doi.org/10.1109/iccchina.2012.6356873

[17] Liu, J., Jiang, X., Nishiyama, H. and Kato, N. (2011) Delay and Capacity in Ad-Hoc Mobile Networks with f-Cast Relay Algorithms. *IEEE Transactions on Wireless Communications*, **10**, 2738-2751. http://dx.doi.org/10.1109/TWC.2011.062111.101976

[18] Li, P., Fang, Y. and Li, J. (2010) Throughput, Delay, and Mobility in Wireless Ad-Hoc Networks. *Proceedings of IEEE INFOCOM*, San Diego, 14-19 March 2010, 1-9. http://dx.doi.org/10.1109/infcom.2010.5461902

[19] Liu, J., Jiang, X., Nishiyama, H. and Kato, N. (2012) Generalized Two-Hop Relay for Flexible Delay Control in MANETs. *IEEE/ACM Transactions on Networking*, **20**, 1950-1963. http://dx.doi.org/10.1109/TNET.2012.2187923