
Comparison of Modified Token Based Congestion Control (mTBCC) Algorithm With Standard Token- Based congestion Control (TBCC) Algorithm for Adaptive Forwarding for Opportunistic Networks

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ABSTRACT

In this research, the comparison of modified token-based congestion control algorithm with standard token based congestion algorithm for adaptive forwarding for Opportunistic Network (ON) is presented in terms of its ability to redirect the traffic from more congested node of ON to congestion-free node of ON without necessarily compromise computational time. The node density was controlled by varying the greatest connected component expressed in percentage and the corresponding results were used to evaluate the performance of the two algorithms using dropped messages and Network Transit Time (NTT) as performance metrics. The mTBCC algorithm produced an average improvement of 6.6% at QS-10, 8.1% at QS-20, 4.1% at QS-40 respectively in dropped messages over TBCC. In addition, average improvement of 7.6 % at 50% GCC, 2.3% at 60% GCC, 4.5% at 70% GCC, and 7.1% at 80% respectively in NTT was recorded over TBCC.

Keyword: Opportunistic Network, congestion control, network transit time, dropped messages

INTRODUCTION

Communication in challenge network environment where destination node sometimes encounters the sender because of being far away from the sender or no internet access, makes TCP/IP not suitable to be applied. In this situation, opportunistic network (ON) concept provides alternative measure necessary for data transfer. The major significant difference between internet communication paradigm and opportunistic networks communication is that end-to-end communication path does not always exist leading to disconnection, high latency, and high error rate in communication. Traditional Opportunistic Network congestion control mechanisms are mostly directed towards

particular node on certain criteria, which eventually overload the node and consequently become congested with time under different applications (Vidya & Hemanth, 2014). They are not adaptable to different opportunistic network scenarios, mainly because they were designed to a specific scenario with special features. On other hand, adaptive forwarding techniques often provide results with fair and efficient resource use. Thus, this approach is especially relevant to opportunistic, where connected paths usually exist between the source node and the destination node. To sustain the network operating at an acceptable efficiency, nodes in opportunistic networks would need to evaluate the likelihood of congestion, by

dissecting the local data. To address this challenge, opportunistic network uses store-carry-and-forward approach to forward packet from source to destination.

Opportunistic Networks

Opportunistic networks are one type of Delay Tolerant Networks (DTN) applications where network contact is characterized by intermittent connectivity and the connected path rarely exist between

the source and destination node. This makes the TCP/IP protocol ineffective in this kind of networking environment because link re-establishment can exist briefly and unpredictable period. Furthermore, links are subject to frequent disruption and to make the data communication feasible in an opportunistic network, relay nodes take custody of the message during the link breakage and forward it when connectivity resumes (Vidya & Hemanth, 2014).

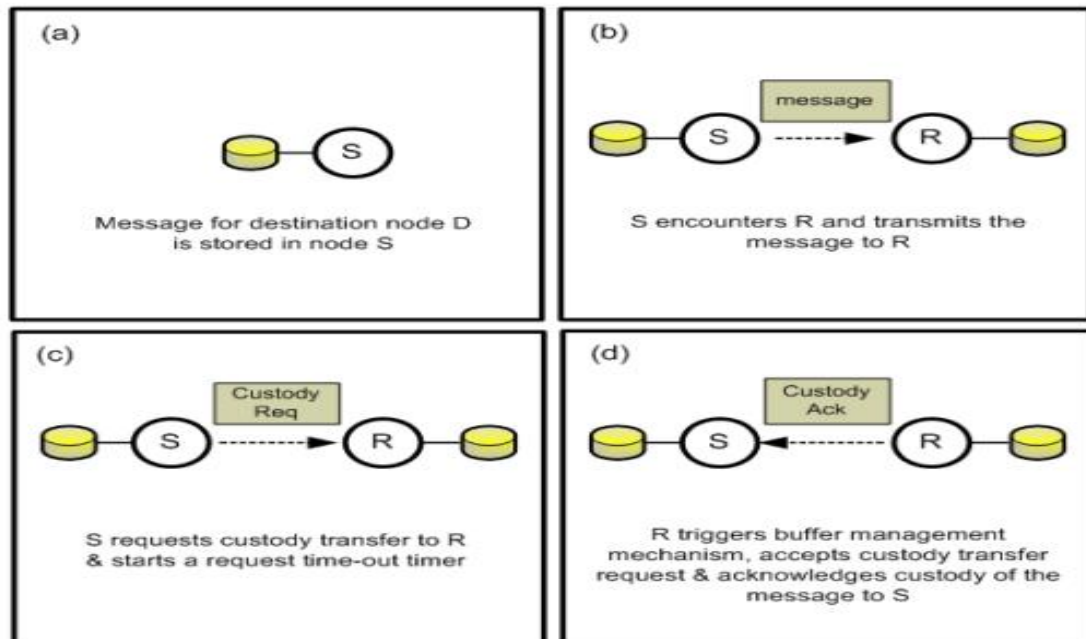


Figure 1: Opportunistic Network Scenario (Vidya & Hemanth, 2014)

The basic opportunistic network scenario is presented in Figure 1, which describes how transfer reliability and congestion control functions interact. A custody transfer scenario is depicted where a message meant for node D, currently occupies the persistent buffer of node S (Figure 1(a)). During its mobility, node S encounters node R as the next best hop of the message to node D based on its routing protocol requirements and forward the message to node R (Figure 1(b)). S requests for custody transfer service of the message to R

and set the request time-out timer to begin (Figure 1(c)). On getting the custody request, R triggers its storage management mechanism to determine the impact of receiving such message in future, and decide whether to accept or reject the custody request. In this scenario, R accepts the request (Figure 1(d)). An opportunistic network has different routing protocol based on historical knowledge or replication scheme for message successful delivery.

The aim of this research is to compare the performances of mTBCC with TBCC using

dropped message and Network Transit Time (NTT) as key performance metrics in order to reduce the effects of congestion in Delay Tolerant Networks (DTN). This research is divided into different sections: Apart from section one, section two deals with literatures survey. Section three cover TBCC and mTBCC, section four consist of simulation results and discussions. Section five finally conclude and summarized the paper.

LITERATURE SURVEY

There are numerous researches conducted by researchers in this area but the reviews of the key once relevant to this research are considered. Silva *et al.* (2015) proposed directed site-bond percolation theory based DTN congestion model to study the network behavior under congestion. In their work, the network was represented in graphical form (V, E) where V represented sites and E denoted edges of the graph otherwise called bond. ONE simulator was used to simulate the model and the results showed that the DTN behavior under congestion was identical using both epidemic and first contact routing protocol and considered average buffer block time and average buffer occupancy. However, the model decision-making parameters respond to congestion untimely.

Similarly, Stewart *et al.* (2016) developed one-copy DTN protocol to address the issue of congestion, shortest path routing and operate effectively at high load network. The mechanism was simulated using ONE simulator. The results presented showed maximization of packet delivery probability. However, the decision-making parameters, which include proximity measure, net destination queue waiting time, and the modeled estimated delivery cost as

exponential function demand much computational time thereby making the algorithm to respond to congestion untimely.

Coe and Raghavendra (2010) presented token-based method for congestion control aimed at monitoring the total amount of data entering the network to the total network capacity. The state of the previous congestion control strategies by different researchers were presented followed by the TBCC algorithm. The Greatest Connected Components (GCC) metric was introduced to provide additional control over network connectivity characteristics. Token was uniformly distributed across all the network nodes initially and then randomized. The TBCC was simulated using Discrete Event Simulator (DES). This mechanism did well in terms of maximizing total Network Transit Time (NTT) and minimizing average dropped messages. However, deleting a message that has traversed several hops in the network results to waste of bandwidth, buffer resources and also induced the retransmission node for retransmission of such message when the need arise.

Adedokun, et al 2017 carried out research on modification of Token based congestion control with adaptive forwarding for opportunistic network by considering dropped messages and Network Transit Time (NTT) as performance metrics. The research yields promising result though other performance metric such as link congestion were not considered.

From the literatures reviewed and their limitations, it is evident that TBCC drops a good number of messages when buffer overflows without any consideration, which is the major limitation of the algorithm and in turn affect the overall performance of the network. Adedokun et, al 2017 extended

the work of Coe and Raghavendra 2010 by addressing the aforementioned problem. The researchers addressed the problem by rerouting the incoming message to the most nearby congestion free node using adaptive forwarding mechanism, which takes in to consideration the available largest free buffer space and the least migration cost from the congested node.

1. Token Based Congestion Control

1.1 Token-based congestion control

(TBCC): The aim of TBCC is to monitor the amount of traffic entering the network with the network capacity such that a node accommodates as much data as it can forward (Coe & Raghavendra, 2010). Interested reader can refer to the works of (Coe & Raghavendra, 2010) for further research.

1.2 Modified Token Based Congestion Control:

The modified Token-based congestion control algorithm was developed by Adedokun et al 2017. In modifying the algorithm, the researcher replicate the works of Coe and Raghavendra 2010 by;

- i. Initialization of token using queue size
- ii. confirming source node encounters new neighbor(s)
- iii. Establishing that source node generates new message
- iv. Steps i-iii of 3.1 is repeated in order to modified TBCC
- v. The modification takes place in step iv of 3.1 by redirect the message to any intermediate node whose queue state is not full. If buffer is full for all nodes, drop the message.

- vi. Step v of 3.1 is repeated and the opportunistic network environment simulation scenario was setup using ONE with eclipse. The Java Virtual Machine was configured and the environment variables were set up. Finally, deployment of 60 mobile nodes in a Helsinki area test-bed (4500x 3400m) and configuration of the nodes to be inner and outside GCC nodes.

RESULTS AND DISCUSSION

This section compares the performance of the token-based congestion control algorithm with modified token-based congestion control algorithm mechanism for Opportunistic Network. The token-based congestion control strategy was implemented on the sixty mobile nodes test bed. The network is segmented into inner Greatest Connected Component (GCC) and the outside Greatest Connected Component (GCC).

Comparison of (mTBCC) and (TBCC) Performance for Network Transit Time

The essence of minimizing the network transit time is to ensure that messages arrive at the intended destination nodes on time, which improves the performance level of the network.

The percentage improvement of the modified token based when compared to the conventional token-based congestion control is calculated using equation (1).

$$\text{performace Im provement} = \frac{TBCC - mTBCC}{TBCC} * 100 \quad (1)$$

Table 1: comparison of NTT between modified token-based congestion control and the conventional token based congestion control mechanism.

Initial number of token/node	50% GCC Connected		60% GCC Connected		70% GCC Connected		80% GCC Connected	
	TBCC (Secs)	mTBCC (Secs)	TBCC (Secs)	mTBCC (Secs)	TBCC (Secs)	mTBCC (Secs)	TBCC (Secs)	mTBCC (Secs)
10	2859.69	2566.49	2501.51	2431.29	1739.38	1669.66	1549.76	1339.91
20	3466.32	3031.41	2590.92	2510.18	1860.30	1760.25	1735.95	1543.74
40	4930.32	4406.23	2750.34	2680.19	2200.32	2010.28	2060.15	1950.54
60	6048.83	5715.84	2825.75	2781.61	2459.41	2380.20	2329.08	2206.32
80	6048.24	5715.57	2825.62	2781.58	2459.38	2380.34	2329.43	2206.61
100	6048.30	5715.87	2825.15	2781.57	2459.42	2380.28	2329.18	2206.11

Source (Adedokun et al 2017; Coe & Raghavendra, 2010)

Figure 2 to figure 5 show the network transit time for 70% and 80% greatest connected component for different number of token per node using Helsinki simulation environment.

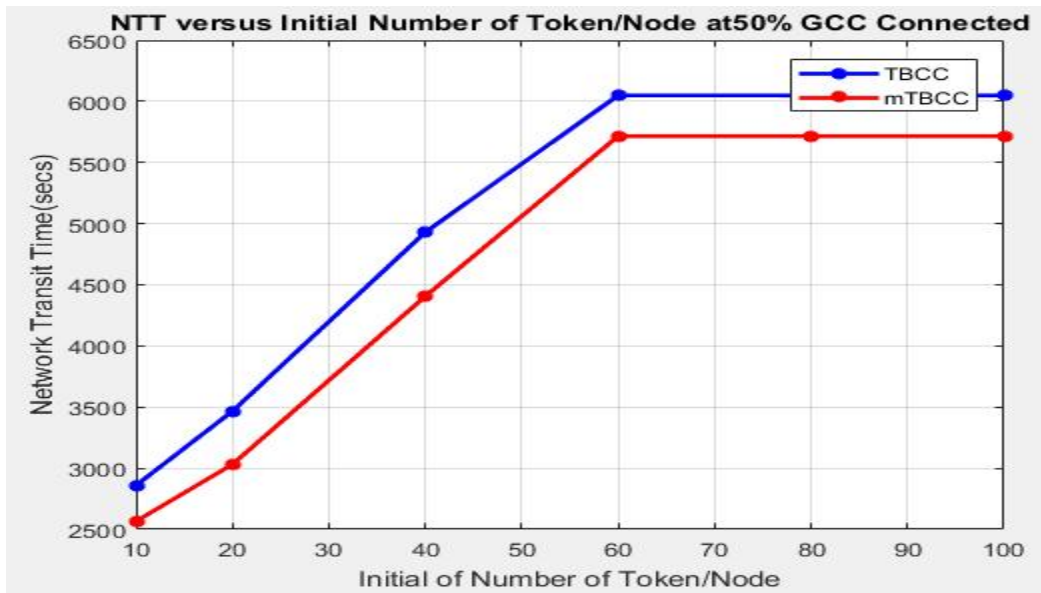


Figure 2: NTT versus Initial Number of Token/Node at 50% GCC Connected

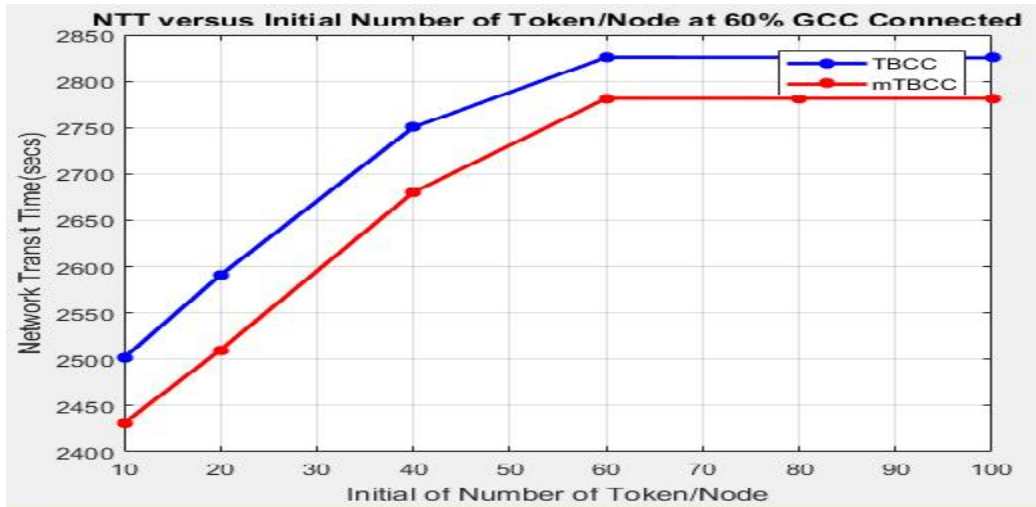


Figure 3: NTT versus Initial Number of Token/Node at 60% GCC Connected

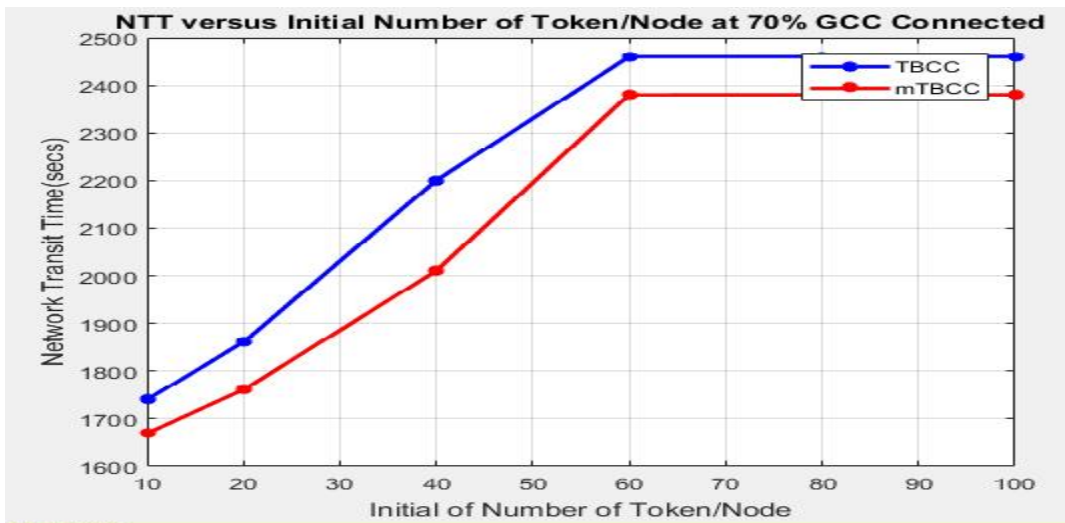


Figure 4: NTT versus Initial Number of Token/Node at 70% GCC Connected

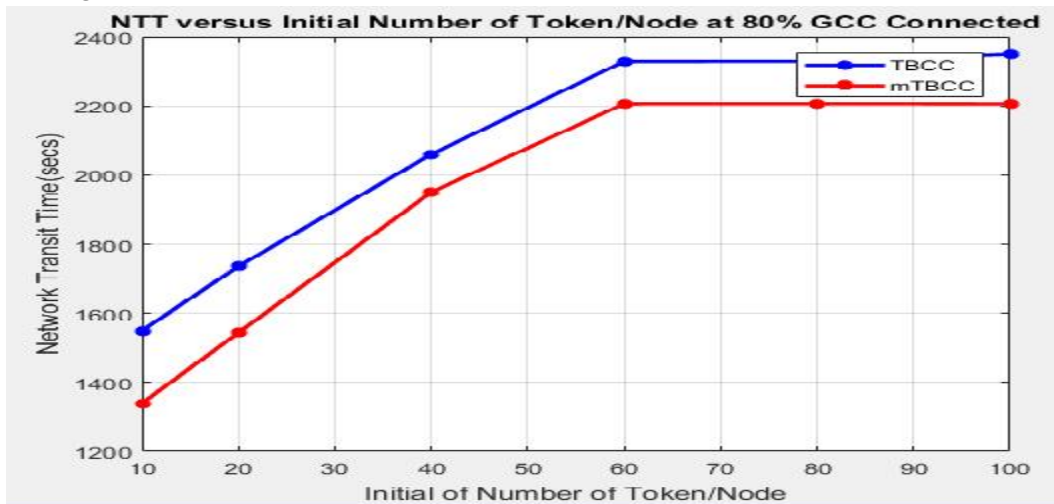


Figure 5: NTT versus Initial Number of Token/Node at 80% GCC Connected

It is observed from those indicated figures that the modified token-based congestion control algorithm significantly reduced the network transit time across the different values of token per node and at various values of the greatest connected component expressed in percentage when compared to conventional token-based congestion control algorithm. This is attributed to fact that it has the potential to redirect the packets from the congested to congestion free node and this brings the packets closer to the intended destination on time. The modified token based congestion control algorithm outperform the convention token based congestion control algorithm by

6.6% at 50%, 2.3% at 60%, 4.5% at 70% and 7.1% at 80%.

Comparison of (mTBCC) and (TBCC) Performance for Dropped Messages

The significance of minimizing the dropped messages is that it enhances the network performance in delivery messages to their respective destination nodes and relieves the retransmission node for any message retransmission. Table 2 shows the comparison of dropped messages between modified token-based congestion control and the standard token-based congestion control mechanism.

Table 2: Comparison of Dropped Messages for mTBCC and TBCC (Adedokun et al 2017; Coe & Raghavendra, 2010)

Connected	TBCC (QS-10)	TBCC (QS-20)	TBCC (QS-40)	mTBCC (QS-10)	mTBCC (QS-20)	mTBCC (QS-40)
50%	22893	17012	14769	21504	15467	14599
60%	11136	9402	6190	10737	8828	5460
70%	3389	2962	1484	3037	2830	1436
80%	1174	954	707	759	720	702

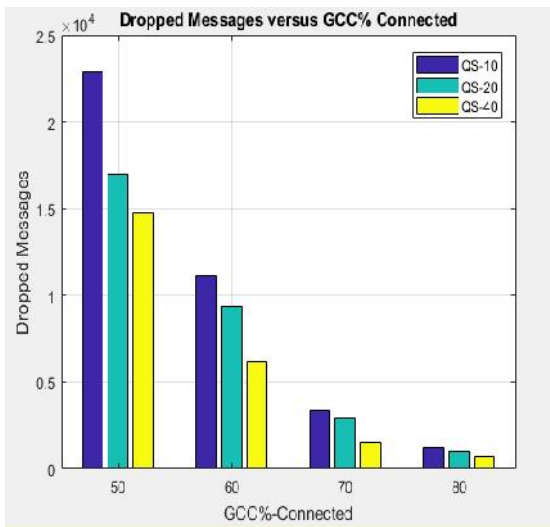


Figure 6a

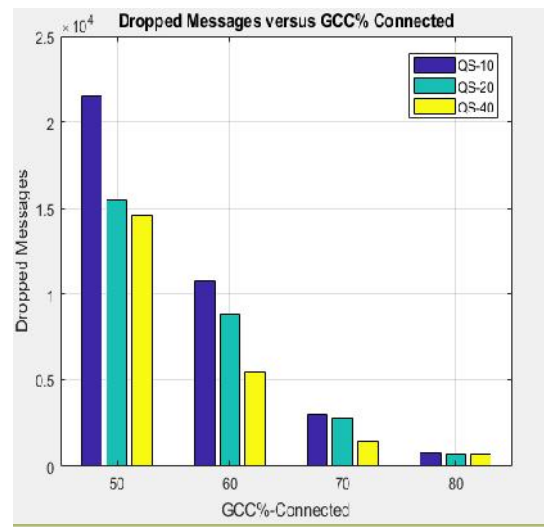
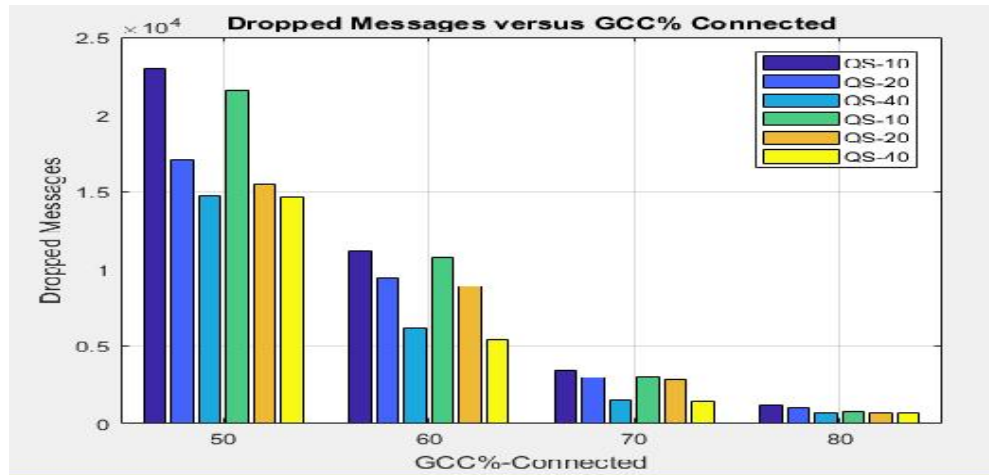


Figure 6b

Figures 6(a & b): Dropped Messages versus percentage GCC Connected for TBCC and Mtbcc



It can be seen that the modified token based congestion control algorithm shown in Figure 7b significantly minimize the number of dropped messages based on the fact that it has the potential to redirect the traffic from the congested node to suitable neighboring node which eventually brings the message closer to the final destination. Unlike the conventional TBCC, that instantly drops messages once the buffer size becomes full. The results showed that dropped message was reduced by 6.6% at QS-10, 8.1% at QS-20, and 4.1% at QS-40 respectively

Minimizing dropped messages helps in enhancing the network's performance in terms of delivering messages to their respective destination nodes and relieves the retransmission node for any message retransmission.

CONCLUSION

The modified token-based scheme was developed by hybridizing adaptive forwarding into the conventional token-based congestion control mechanism. The modified scheme was simulated and its results obtained compared with the

conventional token-based scheme in the Helsinki simulation region. The results showed that dropped message was reduced by 6.6% at QS-10, 8.1% at QS-20, and 4.1% at QS-40 respectively. In addition, network transit time was reduced by 4.5% at 70% and 7.1% at 80% GCC, which indicates significant improvement. However, the research did not consider link congestion during the course of the research, ideal assumption was made that all participating nodes are cooperating in forwarding packets.

REFERENCES

- Vidya, K., & Hemanth S. (2014). Routing and congestion control strategies in opportunistic networks: A survey. *International Journal For Technical Research In Engineering*. 2 (11), 2347, 4718.
- Coe, E., & Raghavendra C. (2010). *Token based congestion control for DTNs*. Paper presented at the IEEE Aerospace Conference, 2010.
- Akestoridis, D.-G., Papanikos N., & Papapetrou E. (2014). *Exploiting social preferences for congestion control in*

- opportunistic networks*. Paper presented at the IEEE 10th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), 2014
- Kun, W., Huang G., Lei S., & Bo L. (2014). *An improved congestion control algorithm based on social awareness in Delay Tolerant Networks*. Paper presented at the IEEE International Conference on Communications (ICC), 2014.
- Wei, K., Guo S., Zeng D., & Xu K. (2014). *A multi-attribute decision making approach to congestion control in delay tolerant networks*. Paper presented at the 2014 IEEE International Conference on Communications (ICC).
- Patil, P., & Penurkar M. (2015). *Congestion avoidance and control in Delay Tolerant Networks*. Paper presented at the International Conference on Pervasive Computing (ICPC), 2015
- Silva, A. P., Hil M. R., Hirata C. M., & Obraczka K. (2015). *A Percolation-Based Approach to Model DTN Congestion Control*. Paper presented at the IEEE 12th International Conference on Mobile Ad Hoc and Sensor Systems (MASS), 2015
- Stewart, M. F., Kannan R., Dvir A., & Krishnamachari B. (2016). *CASPaR: Congestion avoidance shortest path routing for delay tolerant networks*. Paper presented at the 2016 International Conference on Computing, Networking and Communications (ICNC).
- Silva, A. P., Obraczka K., Burleigh S., & Hirata C. M. (2016). *Smart Congestion Control for Delay-and Disruption Tolerant Networks*. Paper presented at the 13th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON), 2016.
- Adedokun, E. A., Shaibu , I. S., and Basira Yahaya (2017). *Towards the development of a modified Token based congestion control with Adaptive Forwarding for opportunistic Networks*. International Journal of computer application. Volume 174, no.7, pg. 5-10