# Impact Of Message Size On Epidemic Routing In Mobile Opportunistic Networks

**Jasvir Singh, Raman Maini**

**Abstract:** The opportunistic mobile networks (OMNs) evolved from mobile adhoc networks (MANETs) with add on delay-tolerant network (DTN) features. In these networks, sender to receiver connectivity never arises mostly, due to dynamic nature of the hosts and the network partition due to mobility. The main use of OMNs is to provide connectivity in challenged environments. The paper details the analysis of epidemic routing protocol, against variable size of buffer at each host while considering the random way point and Random walk mobility models with fixed value of Time-to-live (TTL) in the network. The key contribution of the paper is to explore epidemic routing protocol with mobility models for the dissemination of message to the destination. Routing in opportunistic network uses the store-carry-forward technique for message transfer and network has to keep tradeoff between message delivery ratio and delivery delay. Opportunistic Network Environment (ONE) simulator is being used for experiments and results. The impact of buffer size at each host has great impact on the performance of routing protocol. The evaluated three metrics, the delivery ratio, overhead ratio and the average latency are measured against buffer size. The results show that for buffer size ranging from 2MB to 10MB, the epidemic protocol offers the best delivery performance in the network with random way point mobility model, there is a 13.8% improvement for a smaller message than a larger message. There is 82% reduction in the overhead ratio for the epidemic protocol and the average latency is almost comparable in epidemic protocol in the considered scenario.

**Keywords:** Opportunistic Mobile Networks, Epidemic Routing, Buffer Management, Efficient Delivery, Replication Management.

## 1. INTRODUCTION

The opportunistic networks have acquired increasing research interest in recent years. It has become essential to design networking protocols to overcome the problems arises due dynamic network topology. This implies that routing must be critically addressed in a highly challenged environment. The real objective of communication network is to send reliably a packet / data / message to the destination. The interesting point about opportunistic networks is the devices can communicate directly when they are within radio range [1]. All hosts has feature to move, as defined by mobility pattern and can connect dynamically with any other host. Designing an efficient routing protocol remains an open problem in opportunistic networks. The mobility of the host-can be an advantage and can facilitate for the routing mechanism [2]. Opportunistic networks assume disconnections, high mobility, partitions etc. as a standard practice, instead of exceptions in MANETs. Opportunistic mobile networks are used to provide network connectivity using local connection statistics in challenged environments. The opportunistic networks use the store carry forward strategy [3], where mobility of host facilitate in data dissemination. The results are based on a review of routing protocols, research publications between 2001 and 2017. The routing generally classified into multiple copies and single copies. In multiple copies, it is assumed that at least, single copy of the message out of multiple copies to arrive at the destination with a high delivery probability and a minimum delay [4]. While in the single copy, a message can be dropped in case of congestion, which gives rise to network delivery ratio decrease [4]. The mobile host in opportunistic networks connects and communicates with nearest host, which is in the radio communication range. Epidemic routing was introduced by [5] for mobile adhoc networks with high network partitions. A host with message m, when it meets another host and it does not have message m, the former host transfers the message to the latter host and, which further infects others. The message after infecting several other hosts in opportunistic network, it arrives at the destination. The epidemic routing maximizing the possibility of message delivery and minimizing the latency while at the same time maximizing resources being consumed. To overcome the problem of network partitions and intermittent connectivity, various routing techniques
have been proposed that have been classified on mobile opportunistic networks to date and there are several parameters of interest for performance evaluation, such as the delivery probability of the message, overhead ratio and delivery latency.
The main objective of the paper is to explore routing in opportunistic networks, i.e. context oblivious routing, mobility based routing and social context aware routing, as shown in Figure 1.


- *Correspondence Author*
- *Jasvir Singh*, Research Scholar Department of Computer Science and Engineering, Punjabi University, Patiala, India,*
- *Email: jassiccet@gmail.com*
- *Raman Maini, Professor Department of Computer Science and Engineering, Punjabi University, Patiala, India*
- *Email: research_raman@yahoo.com*

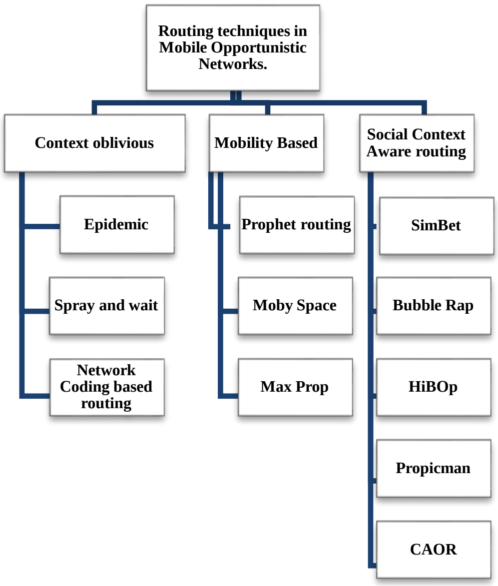


***Figure 1** Classification of routing protocols of mobile opportunistic networks.*

One of the common feature in all protocols is that, they are replication based, meaning there exists multiple copies of the message in the network. The scope of replication is limited in several means to achieve efficiency. To evaluate delivery performance of Epidemic routing [5] [6], the Opportunistic Network Environment Simulator is being used with different mobility model.

## 2. RELATED WORK

Network technology, developed over the last few years, has provided a wide range of applications, such as online services and user-generated information with WhatsApp, Facebook, utube etc.; they face new challenges, as the current Internet architecture is heavily overloaded. The new alternative paradigm [11] [12] in the form of an opportunistic network is useful, as with the availability of latest computing devices such as smartphone, gadgets etc. In the case of wireless networks, if the distance increases and the hosts cross the communication radio range, then the communication can be made possible with opportunistic networks. Network hosts can communicate independently of distance and type of host. Opportunistic networks eliminate the hypothesis of end to end connection while providing opportunities for connectivity to mobile hosts when there is no access available to the Internet [14]. The mobile host can take advantage of mobility and contacts for efficient data delivery. The host can exploit the mobility and contacts for data transfer in the network. It gives rise to the need to focus on routing in Opportunistic Networks, since routing is most important component of a network. The dynamic topology in opportunistic networks forces the hosts to a dynamic routing approach and buffering of messages to ensure a high delivery probability. It is essential, that a routing protocol is highly adaptive to the given scenario. Since transmission speed, delivery probability and needed resources are depending on the environment and energy consumption should always stay low. Furthermore, in areas with a lack of infrastructure, an Opportunistic Networks can provide an alternative network, as long as there are suitable mobile devices. Local P2P networks can easily be established with mobile hosts and the righty chosen routing algorithm.

## 3. OPPORTUNISTIC NETWORKS

In an opportunistic network, architecture provides interoperability in disputed networks in which one or more hypotheses of the Internet model may not be true. The opportunistic network capture the idea that like in traditional networks, communication links does not exist always in opportunistic networks. OMNs routing follows the transfer hop by hop paradigm [15]. While a host gets a message from another host, the primary host keeps the message in the buffer. A host keeps a message copy when it is in motion. Lastly, when the host encounters another host, the primary host advances the message with the hope that the latter host can send the message to the target host. The adaptability of protocol with network parameters that change dynamically, the use of context information to exploit the routing mechanism, the management of host movement patterns, the number of message copies, etc. constitutes the basis for the classification of routing protocols [16]. The focus was on the suitability of protocols to adapt to the dynamically changing network features, resulting from the user movement patterns that are driven by their social behaviour. Opportunistic network routing summarizes the following basic features:

• Hop by Hop message transfer without having an end to end communication link.
• It stores the message, keep it for as long time and transmits during its contact with another host.
• It uses replication of message instead of using forwarding mechanism.
• The network has very high latency of message delivery.

The existing routing techniques in opportunistic network are classified based on data forwarding behavior of host. The biggest challenge in routing to guarantee the delivery of messages using the statistics of the available information and in various scenarios. In mobile opportunistic networks, routing techniques can be classified into context oblivious, mobility-based and context-sensitive routing techniques, as shown in Figure 1

## 4. CONTEXT OBLIVIOUS

Routing in virtual circuits into non-direct networks is a widely studied problem. Given a graph G, the problem is a sequence of requests, in which each request consists of a destination-source pair (i, j) and a bandwidth requirement d (i, j). A key knowledge required is, on the context information in the hosts to be communicated, to design efficient routing protocols in opportunistic networks. However, this type of information is not always available. An algorithm foreign to the context is that which determines a collection of flows, one for each source-destination pair (i, j), without any knowledge of the requests. The Flooding based routing algorithms belong to the routing group outside the context, from unlimited flooding techniques to limited flooding solutions. There is no constraint on the amount of replication. In flooding techniques, a source host sends a request packet on all its outgoing connections. Each host receives an application packet and forwards the packet on all its outgoing connections, except for the one corresponding to the incoming connection where the packet arrives.

## EPIDEMIC ROUTING

The epidemic is a flood-based routing protocol in which an exchange in pairs of summary vectors containing messages between two mobile hosts guarantees the sending of messages. [6] Proposed a routing protocol for intermittent networks called epidemic routing protocol. Mobile hosts store messages until they can find the destination. Replication is the process in which the source host sends a message in the network and, in turn, keeps the original copy of message. An index of these messages, called summary vector [17] maintained in each host, is exchanged when two hosts are found. The interaction between a set of hosts, when they are within the interval between them, involves following steps

(a) Summary vectors exchange between hosts: Every host in the network maintains a unique ID for the message that is in the host buffer. Both SVs and SVd are the summary vectors of S (source) and D (destination). The two hosts exchange SVs and SVd as shown in Figure 2.

(b) Exchange of message: The source host determine the SVs = SVd /SVs, that is the set of messages, maintained by host D, but not available in the buffer of host S. At the same time, host D calculates SVd = SVs /SVd. If the set calculated by the host is unoccupied, it asks other host to send the message with the similar message ID.

There are some metadata, such as the ID of the source host, the ID of the destination host, the TTL, the length of the message that is maintained in the protocol. Other additional information is also kept when required by the specific protocol. Simply replicate messages on all hosts in the radio range. When the host sends a message to the correspondent receiver, the previous host deletes the message, but retains the message ID at host so that it does not accept the message again from any other host. It means that the host can no longer be influenced. The retained identification is often referred to as an anti-pack.

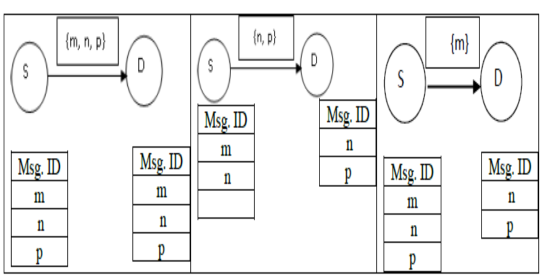


***Figure 2** The Epidemic Routing message exchange between the source and destination host.*

This means that as long as space is available in the buffer, the messages will spread like an epidemic of a disease through the network when hosts meet and "infect" each other. [18] Proposed that direct routing uses position knowledge with DTN, which reduces duplicate messages and network resources, which improves the probability of delivery and reduces the delay in delivery. The direct flooding is obviously superior to the epidemic routing protocol.

## 5. PERFORMANCE METRICS AND EVALUATION METHODOLOGY

### A. Simulation setup

The protocol described in section 4 was analyzed using ONE simulator. The ONE [20] is Java-based simulation tool designed especially for research in opportunistic networks. The simulator was developed in 2009 at the University of Aalto, and is now managed cooperatively by the University of Aalto. The simulator is being used by many researchers as part of their work. The ONE simulator can be run on Linux, Windows, or any other platform supporting Java. The version used in this work is One_1.5.1-RC2. A multiple independent simulations were generated with different seeds for epidemic protocol with a buffer size varying from 2MB to 20MB with Random Waypoint and Random walk mobility model and the results are plotted. Simulations usually runs much faster than in real time. In the simulation configuration, a simple type of Bluetooth interface with a transmission rate of 2 Mbps used on all hosts.

### B. Simulation Parameters

Table 1 describes the simulation configuration used for considered protocol analysis.

***TABLE 1**. SIMULATION PARAMETERS*

| Simulation Parameters (setup information) | |
|---|---|
| Total Simulation Time | 43200 sec (12h) |
| World size | 4500*3400m |
| Interface Type | Simple Broadcast |
| Interface | Bluetooth interface |
| Mobility Model | Random Way Point<br>Random Walk |
| Routing Protocols | Epidemic |
| Host Buffer Size | 2MB, 4MB,6MB,8MB, 10MB,15MB,20MB |
| Hosts | 50 |
| Interface Transmit Speed | 2Mbs |
| Interface Transmit Range | 10m |
| Host Movement Speed | Minimum=0.5m/s<br>Maximum=1.5m/s |
| Message Generation Rate | One message per 25 to 35 seconds |
| Message size | 256KB, 1MB |
| Message TTL (minutes) | 300 |

### C. PERFORMANCE METRICS

This section discuss the various parameters that are commonly used for performance measurement. Both M and Md are the set of messages generated and delivered in network. Since OMN routing is based on replications, consider that each message has a replica, 0≤ ri ≤ N, where N indicates the total number of hosts in the network. Furthermore, the time ti is the time instance in which the message mi is created and delivered to its destination.

a) Probability of delivery of the message: it is the fraction of generated messages, which have been successfully delivered to the corresponding destination within the specified time. The probability of delivery of the message is evaluated as | Md | / | M.

b) Overhead Ratio of Message: The number of message transmissions for each message created. As such, there are multiple copies of a message on the network. The overhead ratio is evaluated as $\sum_{i=1}^{|M|}(ri - |Md|)/|Md|$.

c) Average Latency of the message: The metric that provides the average time necessary to deliver a message from its origin to its destination and is evaluated as $\sum_{i=1}^{|Md|}$( ti'- ti )/|Md|.The random waypoint mobility model is used in the simulation to make the scenario comparable to the application in real time. Mobility varies from 0.5 to 1.5 m / sec. A buffer size of 2 MB to 25 MB is assigned to each host and its transmission range is limited to only 10 m. Therefore, during the store carry forwarding methodology, each host can carry messages only up to 20 MB and the host can forward messages to every other host that is within a 10 m radius. This situation will increase the probability of messages falling during the transmission of messages. Since a simulator is compatible with the external event generator, the message event generator is configured to generate messages every 25-35 seconds and whenever the message size can be 256 KB or 1 MB.

## 6. RESULTS AND PERFORMANCE EVALUATION

The performance evaluation in terms of various results from the simulation environment based on general settings defined in the table 1 are described using graphs and tables. To evaluate the delivery performance, three metrics have been used as described in simulation setup. The configuration file(s) defines various settings for the simulation.

### A. Delivery Probability

It is evident from Figure 4 (a) (b), that the probability of delivery of epidemic protocol is high with respect to the random way point mobility model for the considered scenario with fixed TTL and message size of 256 KB and 1 MB. It has been observed that random way point model offers the best performance in delivery probability on the network. As with a 256 KB message, the delivery ratio is 41.30%, while with a message size of 1 MB, the delivery ratio comes out to be 27.50%. Therefore, there are improvements in the case where the message size of 256 KB is 13.8% greater than the message size of 1 MB. In short, the minimum message size (256 KB) offers excellent performance on the network than the larger message size (1 MB).

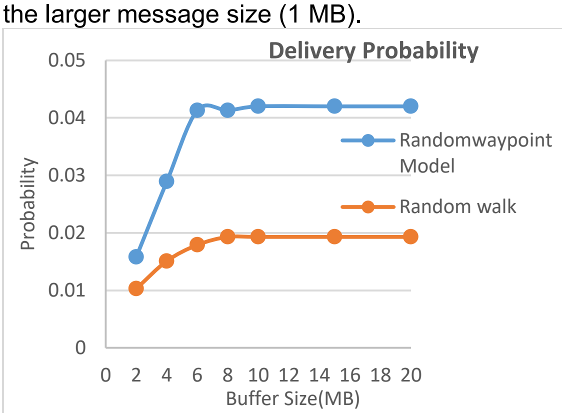


***Figure 4*** *(a) Delivery probability of epidemic routing protocol for varying Buffer size with the message size 256KB*

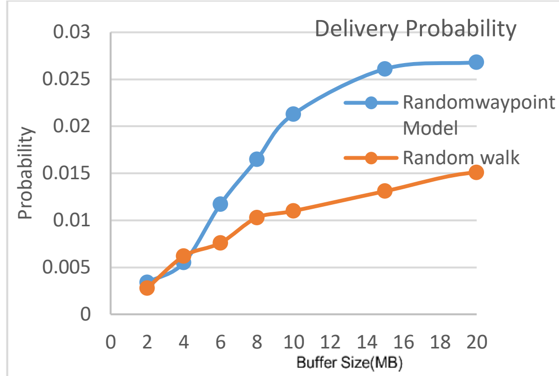


***Figure 4*** *(b) Delivery probability of epidemic routing protocol for varying Buffer size with the message size 1MB*

### B. Overhead Ratio

Figure 5 (a) (b) shows the relation of overheads for the epidemic protocol with TTL (300) and with buffer ranging from 2MB to 20MB for messages of 256 KB and 1 MB. Here, we see that for a message size of 1MB, the overhead ratio has been reduced to 40 packets to 7 with random way point, while the ratio has been reduced from 22 to 7 packets with random walk mobility model. In the case of 1MB message size, there is 82% reduction in the overhead ratio for the epidemic protocol random way point, while overhead ratio has been reduced by 68% with random walk model. It has been observed that with the epidemic protocol, multiple replicas of messages are generated, which in turn increases the cost of delivery, so with an increase in buffer size, the protocol can reduce the percentage of overheads with a high percentage. The random way point mobility model, significantly reduces the overhead ratio with message size of 1MB.

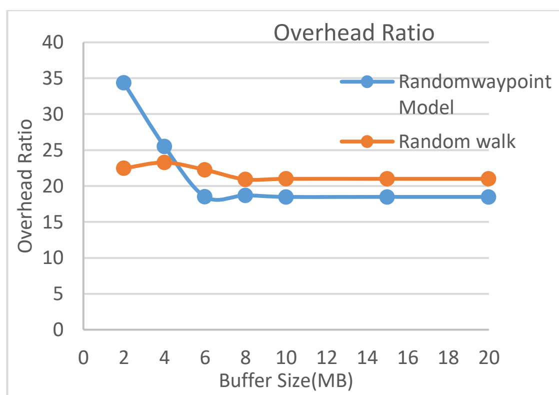


***Figure 5****(a) Overhead Ratio of epidemic routing protocol for varying Buffer size with the message size 256KB*

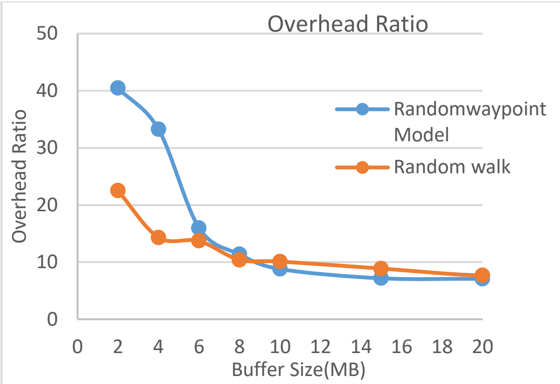


***Figure 5****(b) Overhead Ratio of epidemic routing protocol for varying Buffer size with the message size 1MB.*

### C. Average Latency

We evaluate the performance with two series of messages of 256 KB and 1 MB. It is evident from Figure 6 that the average latency experienced by the epidemic protocol is similar and increases with the increase of buffer size ranging from 2MB to 20MB with both the mobility models. This is because, as the more buffer space is available, the message can wait for the longest time i.e. TTL of message before the message is delivered to its destination or discarded due to a lapse of time. Thus, we observe that the average latency increases with the increase of the buffer size.

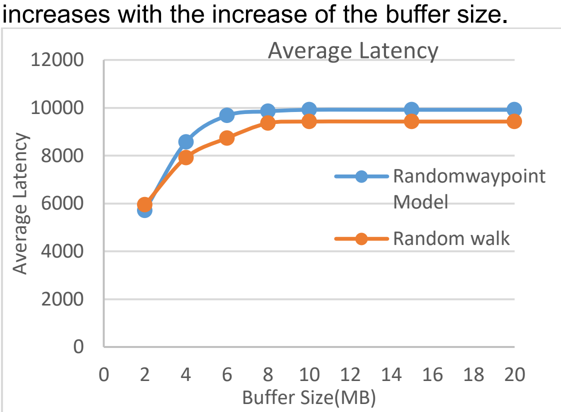


***Figure 6*** *(a) Average Latency of epidemic routing protocol for varying Buffer size with the message size 256KB*

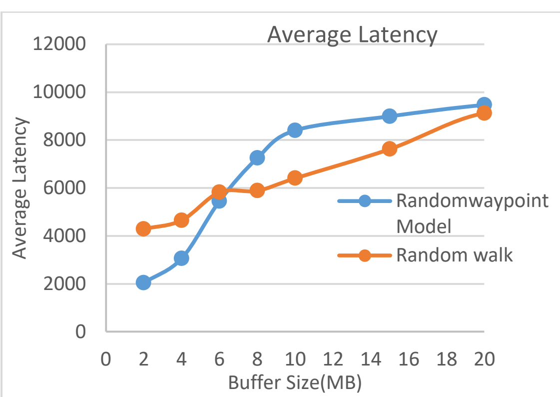


***Figure 6*** *(b) Average Latency of epidemic routing protocol for varying Buffer size with the message size 1MB*

***Table 2****. The results of the simulation for experiment 5(A).*
The message delivery probability for the variable buffer size

| | Randomwaypoint Model | | Random walk | |
|---|---|---|---|---|
| Buffer Size(MB) | 256KB | 1MB | 256KB | 1MB |
| 2 | 0.0158 | 0.0034 | 0.0103 | 0.0028 |
| 4 | 0.0289 | 0.0055 | 0.0151 | 0.0062 |
| 6 | 0.0413 | 0.0117 | 0.0179 | 0.0076 |
| 8 | 0.0413 | 0.0165 | 0.0193 | 0.0103 |
| 10 | 0.042 | 0.0213 | 0.0193 | 0.011 |
| 15 | 0.042 | 0.0261 | 0.0193 | 0.0131 |
| 20 | 0.042 | 0.0268 | 0.0193 | 0.0151 |

***Table 3****. The results of the simulation for experiment 5 (B).*
The overhead ratio for the variable buffer size

| | Randomwaypoint Model | | Random walk | |
|---|---|---|---|---|
| Buffer Size(MB) | 256KB | 1MB | 256KB | 1MB |
| 2 | 34.34 | 40.46 | 22.46 | 22.5 |
| 4 | 25.52 | 33.25 | 23.27 | 14.33 |
| 6 | 18.53 | 16 | 22.26 | 13.72 |
| 8 | 18.71 | 11.37 | 20.92 | 10.4 |
| 10 | 18.49 | 8.8 | 21 | 10.12 |
| 15 | 18.49 | 7.18 | 21 | 8.89 |
| 20 | 18.49 | 7.1 | 21 | 7.68 |

***Table 4.*** *The results of the simulation for experiment 5(C).*
The average Latency for the variable buffer size

| | Randomwaypoint Model | | Random walk | |
|---|---|---|---|---|
| Buffer Size(MB) | 256KB | 1MB | 256KB | 1MB |
| 2 | 5713.32 | 2040.9 | 5944.38 | 4291.92 |
| 4 | 8574.76 | 3056.1 | 7922.75 | 4647.54 |
| 6 | 9678.33 | 5447.9 | 8739 | 5823.13 |
| 8 | 9854.04 | 7247.5 | 9361.01 | 5881.06 |
| 10 | 9920.02 | 8403.8 | 9428.3 | 6403.11 |
| 15 | 9920.02 | 8990.2 | 9428.3 | 7619.27 |
| 20 | 9920.02 | 9461.4 | 9428.3 | 9117.44 |

## 7. RESULTS AND DISCUSSION

This paper summarizes the results, the performance of Epidemic routing protocol in the opportunistic mobile networks. The probability of delivery of the epidemic protocol is high with random way point mobility model for the scenario considered with buffer size ranging from 2MB to 20MB and for a message size of 256 KB and 1 MB with the message TTL(300). It has been found that the epidemic protocol offers the best delivery performance in the network with random way point mobility model. In the case of a 256 KB message, the delivery ratio comes out to be 41.20%, while in the case of a message of 1 MB; the delivery ratio is 27.50%. Therefore, there is a 13.8% improvement for a smaller message than a larger message. It also shows that the increase in epidemic routing distribution rate with a smaller message but with greater use of network resources and a longer delivery delay for a large message. Hence, it is possible to evaluate the occupation of the host by the messages in the network. In the case of 1MB message size, there is 82% reduction in the overhead ratio for the epidemic protocol with random way point, while overhead ratio has been reduced by 68% with random walk mobility model. An average latency is almost comparable in epidemic protocol with variable buffer and different mobility model fixed TTL of message.

## 8. CONCLUSION AND FUTURE WORK

In the future, we would like to explore experiments to evaluate performance with real time data sets and in scenarios that are more adverse. In short, the lowest message (256 KB) offers better performance on the network than the larger message size (1 MB) with the buffer size ranging from 2MB to 20MB with random way point and random walk mobility model.

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