Empirical Study of the Epidemic and Optimized Link State Routing Protocols (OLSR) for the Scalable Wireless Ad-Hoc Network Simulations (SWANS)

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Abstract

A Mobile Ad-Hoc Networks (MANETs) is a network architecture that can be rapidly, deployed without relying on pre-existing fixed network infrastructure. The nodes in a MANET scan dynamically join and leave the network, frequently, often without warning, and possibly without disruption to other nodes' communication. MANETs are becoming increasingly popular as more and more, mobile devices find their way to the public. A crucial problem in MANETs is finding an efficient route between a source and a destination [1]. The Epidemic routing protocol is a one of the Reactive protocol and the OLSR protocol is a one of the proactive routing protocol for MANETs. In this work, the Epidemic routing and OLSR protocols are implemented, and its performance is measured under different nodes population and mobility scenarios.

Keywords: epidemic, OLSR, MANETs, protocol

Introduction

MANETs is a network architecture that can be rapidly, deployed without relying on pre-existing fixed network infrastructure. The nodes in a MANETs can dynamically join and leave the network, 0 frequently, often without warning, and possibly without disruption to other nodes' communication. Finally, the nodes in the network can be highly mobile, thus rapidly changing the node constellation and the presence or absence of links (Clausen *et. a*l., 2008).

Nodes in the MANETs exhibit nomadic behavior by freely migrating within some area, dynamically creating and tearing down associations with other nodes. Groups of nodes that have a common goal can create formations (clusters) and migrate together, similarly to military units on missions or to guided tours on excursions. Nodes can communicate with each other at any time and without restrictions, except for connectivity limitations and subject to security provisions. Examples of network nodes are pedestrians, soldiers, or unmanned robots. Examples of mobile platforms on which the network nodes might reside are cars, trucks, buses, tanks, trains, planes, helicopters or ships (Bhorkar *et. al.,* 2009, Perkins, *et. al.,* 2003, & Barr *et. al.,* 2005).

Epidemic Routing is to distribute application messages to hosts, called carriers, within connected portions of Ad-Hoc networks. In this way, messages are, quickly distributed through connected portions of the network. Epidemic Routing then relies upon carriers coming, into contact with another connected portion of the network through node mobility. At this point, the message spreads to an additional island of nodes. Through such transitive transmission of data, messages have a high probability of eventually reaching their destination.

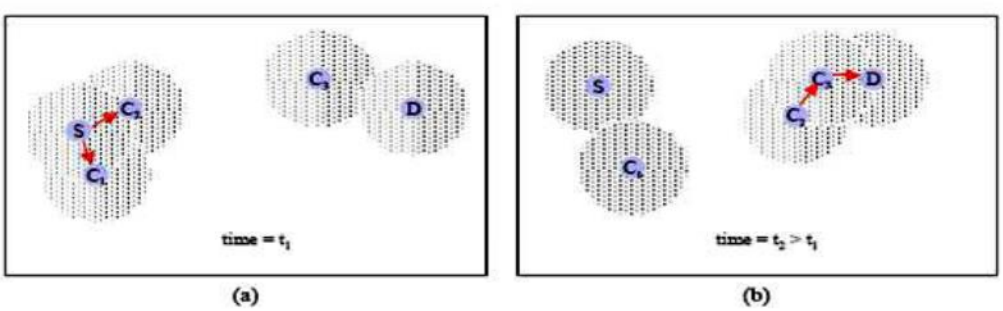

Figure1: A source, S, wishes to transmit a message to a destination but no connected path is available in part (a). Carriers, C1-C3 are leveraged to transitively deliver the message to its destination at some later point in time as shown in (b)

Fig 1 depicts Epidemic Routing at a high level, with mobile nodes represented as dark circles and their wireless communication range shown as a dotted circle extending from the source. In Fig1 (a), a source, S, wishes to send a message to a destination, D, but no connected path is available from to transmit its messages to its two neighbors, C1 and C2, within direct

communication range. Later, as shown in Fig1 (b), C2 comes into direct communication range with another host, C3,and transmits the message to it. C3 is in direct range of D and finally sends the message to its destination.
Epidemic Routing supports the eventual delivery of messages to arbitrary destinations with minimal assumptions regarding the underlying topology and connectivity of the underlying network. In fact, only periodic pair wise connectivity is required to ensure eventual message delivery. The Epidemic Routing protocol works as follows. The protocol relies upon the transitive distribution of messages through Ad-Hoc networks, with messages eventually reaching their destination. Each host maintains a buffer consisting of messages that it has originated as well as messages that it is buffering on behalf of other hosts. For efficiency, a hash table indexes this list of messages, keyed by a unique identifier associated with each message. Each host stores a bit vector called the summary vector that indicates which entries in their local hash tables are set. While not explored here, a "Bloom filter" would substantially reduce the space overhead associated with the summary vector. When two hosts come into communication range of one another, the host with the smaller identifier initiates an anti-entropy session with the host with the larger identifier. To avoid redundant connections, each host maintains a cache of hosts that it has spoken with recently. Anti-entropy is not re-initiated with remote hosts that have been contacted within a configurable time period (Vahdad & Becker 2000).

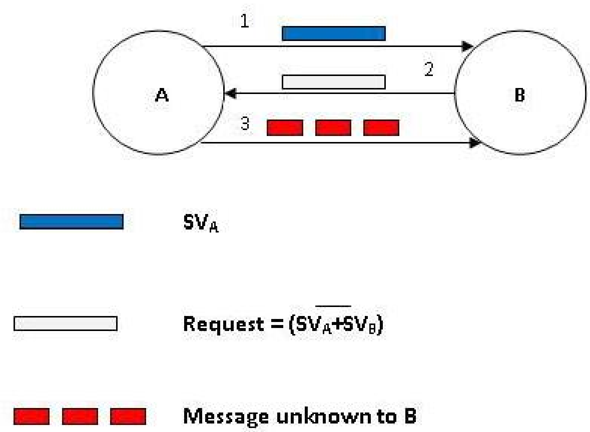

Figure 2: The Epidemic Routing protocol when two hosts, A and B, come into transmission range of one another.

Fig 2 depicts the message exchange in the Epidemic Routing protocol. Host A comes into meets with Host B and initiates an anti-entropy session. In step one, A transmits it summary vector, SVA to B. SVA is a compact representation of all the messages being buffered at A. Next, B performs a logical AND operation between the negation of its summary vector, (the negation of B's summary vector, representing the messages that it needs) and SVA. That is, B determines the set deference between the messages buffered at A and the messages buffered locally at B. It then transmits a vector requesting these messages from A. In step three, A transmits the requested messages to B. This process is repeated transitively when B comes into contact with a new neighbor. Given sufficient buffer space and time, these anti-entropy sessions guarantee eventual message delivery through such pair wise message exchange.

OLSR is a proactive routing protocol, inherits the stability of a link state algorithm and has the advantage of having the routes immediately available when needed due to its proactive nature. In a pure link state protocol, all the links with neighbor nodes are declared and are flooded in the whole network. The OLSR protocol is an optimization of the pure link state protocol for the mobile ad-hoc networks. First, it reduces the size of the control packets: instead of all links, it declares only a subset of links with its neighbors that are its multipoint relay selectors. Secondly, it minimizes the flooding of its control traffic by using only the selected nodes, called multipoint relays, to broadcast its messages. Therefore, only the multipoint relays of a node retransmit the packets. This technique significantly reduces the number of retransmission in a flooding or broadcast procedure. OLSR protocol performs hop by hop routing, i.e. each node uses its most recent information to route a packet. Therefore, when a node is moving, its packets can be successfully delivered to it, if its speed is such that its movement could be followed in its neighborhood, at least (Clausen & Jacquet 2003, Ying *et. al.*).

Methodology

SWANS provides implementations of Java standard network interfaces at the application layer, sockets at the network layer, UDP and TCP at the transport layer, AODV and DSR at the routing layer, 802.11 at the MAC layer and several path loss and fading models at the physical link layer (Barr 2004).

In our experiments, nodes were placed uniformly at random locations in a square area of (1000m x 1000m). Random Waypoint and Static mobility models were used in this area. In these models, each node picks a location and moves there at a chosen speed according to mobility models. In my case, the speed of movement ranged from [Minimumspeed, Maximumspeed] meters per second. Also First in First out (FIFO) and MOFO (Evict most forwarded first) queuing policies used in these two mobility models. The simplest policy is FIFO. This policy is simple to implement and bounds the amount of time that a particular message is likely to remain live. Once enough new messages have been introduced into the system older messages are likely to be flushed from most buffers.

Our design for Epidemic Routing associates a unique message identifier, a hop count and an optional acknowledgement request message. In our implementation, the hosts in the Ad-Hoc network are statically assigned ID's. The hop count field determines the maximum number of epidemic exchanges that a particular message is subject to. While the hop count is similar to the TTL (Time-To-Live) field in packets, messages with a hop count of one will only be delivered to their end destination. As discussed below, such packets are dropped subject to the requirements of locally available buffer space. Larger values for hop count will distribute a message through the network more quickly. This will typically reduce average delivery time, but will also increase total resource consumption in message delivery.

Our design for OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbors. With the Hello message, the Multipoint Relay (MPR) selector set is constructed which describes which neighbors has chosen this host to act as MPR and from this information; the host can calculate its own set of the MPRs. The Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about their own advertised neighbors, which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages.

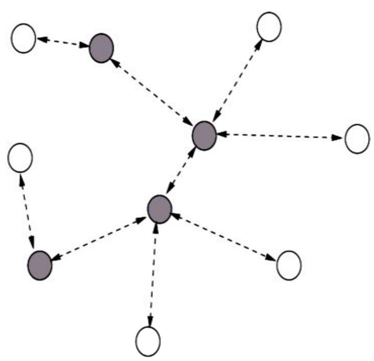

Figure 3: An OLSR routed network. The gray nodes are chosen as MPRs by one or more neighbor

Table1: Various parameters used in the experiment set up

Protocols	Epidemic & OLSR
Area Dimension	1000*1000 meters
Number Of Nodes	12
Mobility model	RandomWayPoint & Static
Simulation Time	1 to 6 hours
Pause Time	60 seconds
Precision	1
Minimum Speed	1 meter/second
Maximum Speed	10 meter/second

Results and Discussion

During the simulation runs, the number of messages sent and received by each node is counted and thedelay in receiving packets by each node is recorded and is written to data files. The simulation experiments are repeated for 1, 2, 3, 4, 5 and 6 hours durations without altering other simulation parameters.

Message Delivery Ratio

The first performance metric that is to be measured is the message delivery ratio. It is calculated using the formula,

$$MessageDeliveryRatio = \frac{TotalNumberOfReceivedMessage}{TotalNumberOfSentMessages} * 100$$

In Figs 4 and 5 we plot the Message Delivery Ratio per hour during simulation run for Static mobility model and Random Waypoint mobility model respectively.

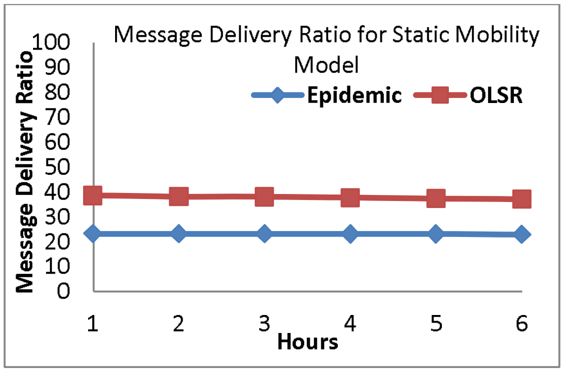

Figure 4: Message Delivery ratio per hour using the Static mobility Model

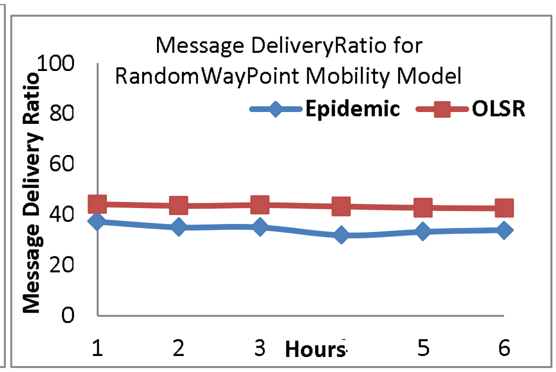

Figure 5: Message Delivery ratio per hour using the Random Waypoint mobility Model

Message Transmission Delay Time

The second performance metric that is to be measured is the message transmission delay time. It is calculated using the formula,

$$MessageTransmissionDelayTime = MessageReceivedTime - MessageSentTime$$

In Figures 6 and 7 we plot the Message transmission delay per hour during the simulation run for Static and Random Waypoint mobility models respectively.

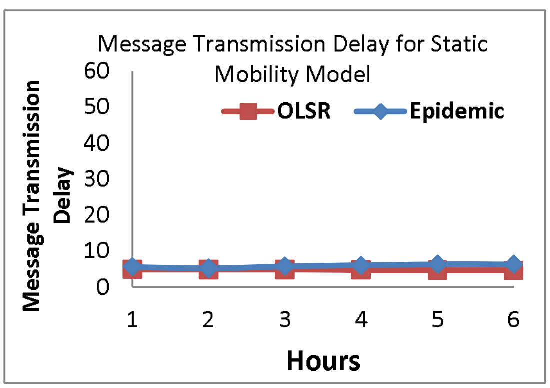

Figure 6: Message transmission delay per hour using the Static mobility model

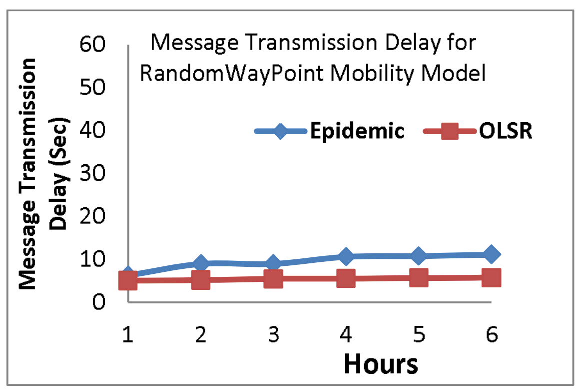

Figure 7: Message transmission delay per hour using the Random Way Point mobility model

In the experiment mentioned above, an attempt is made to determine the message delivery ratio and message transmission delay of increasing the simulation time within a fixed number of nodes and a fixed area. The simulation time varied from 1 hour to 6 hours, within a fixed area (1000 x 1000 meters) and 12 nodes. All messages sending rates were constant. The nodes were arranged in a random fashion.

Figs 4 and 5 indicate the Message Delivery Ratio of 12 nodes, at different simulation time intervals. Both the Figs 4 and 5 were obtained using Static Mobility model and Random Way point Mobility model respectively. According to the results obtained the Random Waypoint Mobility model shows of high performance than the Static Mobility model in Average message transmission, and also according to the results obtained OLSR protocol shows of high performance than the Epidemic routing protocol.

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Conclusion

In this work, the performance of OLSR protocol and Epidemic Routing protocol in Jist/SWANS simulator have been implemented and evaluated under different test scenarios. The results indicate OLSR protocol showing higher performance than the Epidemic routing protocol.

In future, this research work also includes validating the performance of many other recently developed protocols in the presence of the implemented mobility models. Also there are new mobility models proposed by researchers and these findings would also be added to the simulator and the performance would be tested.

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