A Simulative Study on the Factors Affecting Single-copy and Multi-copy Protocols in DTN

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Abstract. Due to its characteristics such as long communication delay, high dynamic topology, sparse distribution of nodes and frequent link break, routing are the key research issues of delay tolerant networks. Performance analysis of different routing protocols is the major step before selecting and designing the routing protocol. Routing protocols perform different under different network environments (e.g., memory space, traffic, message size etc.). In this paper, the factors that affect the performance of single-copy and multi-copy algorithm in DTN are studied. The performance analysis is compared in terms of delay, packet delivery ratio and overhead.

Keywords: single-copy; multi-copy; routing; DTN

1 Introduction

The source to destination path may not be connected at any given time instant in delay tolerant networks (DTN). Thus, data is delivered using a store-carry-forward model. Node in the network stores data locally, and upon contact with other nodes, forwards the data. In other words, a link is established between the pair of nodes, whenever they encounter. This link is time-sensitive in that it is only valid for the duration when the nodes are in range of one another [1].

Due to its characteristics such as long communication delay, high dynamic topology, sparse distribution of nodes and frequent link break, routing are the key research issues of delay tolerant networks.

The typical DTN protocols can be classified into two categories: 1) single-copy protocol, such as Direct Delivery [2] and First Contact [3], only single-copy of each message exists in the network. 2) multi-copy protocol, such as Epidemic [4, 5], Spray and Wait [6] and MaxProp [7], multiple copy of each message exists in the network.

In Direct Delivery, the node carries messages until it meets their final destination. In First Contact routing the nodes forward messages to the first node they encounter,
which results in a "random walk" search for the destination node and only a single copy of every message in the network. To prevent two nodes who stay in contact for a long time exchanging the same messages back and forth, the receiving node accepts a message only if the message has not passed through it before [10].

Epidemic routing, also known as Flooding, in contrast, forwards all non-duplicated messages, including its own, to every node it encounters – eventually delivering its messages to the appropriate destinations [8].

In Spray and Wait, the source node copies its message to the first r intermediaries it encounters. These intermediaries then use direct delivery to deliver the message to the intended destination. Using this approach the r redundant copies reduce the expected latency of the network while using only rN bytes of bandwidth. We see that if r = 0 this method is equivalent to direct delivery, and as r gets larger, it behaves more like epidemic routing.

In MaxProp, each node maintains a buffer of messages sorted by a Delivery Likelihood (DL) metric that corresponds to the nodes ability to deliver messages, possibly through intermediaries, to a specified destination d. During transfer opportunities, the packets with the highest DL are transferred first while packets with the lowest DL are the first to be deleted to make room for newer packets. MaxProp floods the messages but explicitly clears them once a copy gets delivered to the destination. Above protocols cover the most important classes of DTN routing protocols [1].

A protocol, in order to be widely accepted and deployed should reveal little private information, and require resource as low as possible. Performance analysis of different routing protocols is the major step before selecting and designing the routing protocol. In this paper, performance analysis is carried out in single-copy and multi-copy protocols under different network conditions. The performance analysis is compared in terms of delay, packet delivery ratio and overhead.

The remainder of this paper is organized as follows. Section 2 presents the simulation methodology. Simulation results are presented in Section 3. Conclusion is in Section 4.

2 Simulation Methodology

The performance of proposed protocol is compared with several related works. The simulations were performed in ONE 1.41 simulator [1].

2.1 Performance Metrics

Protocol performance was evaluated in the simulation with following metrics [1]:

1. Delivery Probability is the ratio of data packets being successfully received by the destination nodes versus data packets being sent by the source nodes.
2. Latency represents the average message delay from creation to delivery.
3. Overhead Ratio is defined as:

\[
\text{overhead ratio} = \frac{\text{number of relayed messages} - \text{number of delivered messages}}{\text{number of delivered messages}}
\]
2.2 Simulation Configuration

Table 1 summarizes the simulation configuration.

Table 1. Simulation configuration

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation time</td>
<td>21600s</td>
</tr>
<tr>
<td>Buffer size</td>
<td>5M-35M</td>
</tr>
<tr>
<td>Wait time</td>
<td>0-120</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>20m/s</td>
</tr>
<tr>
<td>Transmit speed</td>
<td>2 Mbps, 10Mbps</td>
</tr>
<tr>
<td>Event generators</td>
<td>30s,35s,40s,45s,50s,55s,60s</td>
</tr>
<tr>
<td>Message sizes</td>
<td>500KB – 1.5MB</td>
</tr>
<tr>
<td>Number of Nodes</td>
<td>480</td>
</tr>
</tbody>
</table>

3 Simulation Results

3.1 Varying Memory Size

The message packets are sent between randomly chosen sources and destinations. The results show that memory constraints can severely affect the performance of DTN routing schemes. Performance increases in all the cases with increasing memory size, as shown in Figure 1. With very small memory size, the stress of memory requirement is relatively heavy. When the queue size of a station is above the threshold, the performance change of all the protocols is not obvious because there is not much requirement on the computational cost and memory space in choosing of relay node.

Single-copy schemes have lower overhead but are not so good in packet delivery. Direct delivery transfers messages directly between the source and the destination, relying entirely on the mobility of each node. Because the Direct delivery routing protocol will only transport the message when the node meet the destination node, so the buffer size just effect the number of messages that could be stored at the node. The more messages the node could store, the higher delivery ratio. First contact routing protocol will send the message to the node that first meet, this protocol also has a liminal buffer.

Multi-copy protocol adopts a so-called ‘’store-carry-forward’’ paradigm – a node receiving a packet buffers and carries that packet as it moves, passing the packet on to new nodes that it encounters. MaxProp protocol and Spary and Wait protocol have a good performance in delivery rate than single-copy protocol, especially at the high buffer. The buffer size beyond the threshold will not obviously affect the delivery rate, delay and overhead. Cause of these due to the copies of the message is limited, the usage of buffer is also limited [10].
3.2 Varying Message Size

The source to destination path may not be connected at any given time instant in delay tolerant networks (DTN). A link is established between the pair of nodes, whenever they encounter. This link is time-sensitive in that it is only valid for the duration when the nodes are in range of one another [1].

The efficiency of the message transfer on a link is also a factor of the size of the message being transmitted as shown in Figure 2. Larger packets require a longer transmission time and suffer a correspondingly larger chance of errors. The measurement of the link quality with smaller control messages may be inaccurate for larger data messages. As the message size increased, the delivery rate decreased in all the protocols. As the message size increased, the overhead increased in Spray-and-Wait. Single-copy protocols are not sensitive to varying message sizes in terms of delay and overhead.
Conclusion

Routing protocols perform different under different network environments (e.g., memory space, traffic, time-to-live, mobile speed etc.). In this paper, the factors that affect the performance of single-copy and multi-copy algorithm in DTN are studied. The performance analysis of single-copy and multi-copy routing protocol is carried out under different network conditions. The results have been generated for various load conditions, mobility parameters, memory size, nodes mobile speed and TTL of message.

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References