Performance Comparison and Improvement of Broadcasting Protocols in Mobile Ad-hoc Network

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ABSTRACT

Mobile Ad-hoc Network (MANET) is expected to be deployed in various scenarios having complex node mobility and connectivity dynamics in the future. Optimal broadcasting in mobile Ad-hoc networking is crucial for providing control and routing information for multicast and point to point communication algorithms. In this paper presents an overview on the state of the art of broadcasting techniques in mobile Ad-hoc networks, compare their performance and make recommendations to improve the efficiency performance of broadcasting techniques. In this research work we have introduced the four different types of broadcasting protocols, describe a clear concept of these protocols because we are going to work with these protocols. For this research work, we have used ns-2 simulator in Red Hat Linux environment successfully. We specially make comparison between simple flooding broadcast and probabilistic broadcast with 7 different probabilities by using two parameters which are average number of redundant broadcast and average number of single broadcast. For optimal power efficient broadcast we have analyzed the collected data and finally we have found that in probabilistic broadcast, the probability of approximately 0.275 is the best one.

Keywords: MANET, simple flooding, probability based, area based and neighborhood based broadcasting.

1. INTRODUCTION

Wireless cellular systems have been in use since 1980s. We have seen their evolutions to first, second, third and now forth generation wireless systems. These systems work with the support of a centralized supporting structure such as an access point. The wireless users can be connected with the wireless system by the help of these access points when they roam from one place to the other place.

The adaptability of wireless systems is limited by the presence of a fixed supporting coordinate. It means that the technology can not work efficiently in that places where there is no permanent infrastructure. Easy and fast deployment of wireless networks will be expected by the future generation wireless systems. This fast network deployment is not possible with the existing structure of present wireless systems.

Recent advancements such as Bluetooth introduced a fresh type of wireless systems which is frequently known as mobile Ad-hoc networks. Mobile ad-hoc networks or "short live" networks control the nonexistence of permanent infrastructure. Mobile Ad-hoc network offers quick and horizontal network deployment in conditions where it is not possible. Otherwise Ad-hoc is a Latin word which means, "for this or for this only".

2. RELATED WORKS

Ad-hoc network is very popular network. Broadcasting is a common operation in a network to resolve many issues. Particularly in a mobile ad hoc network (MANET), the host mobility operations are expected to be executed more frequently. Many research works have been done on Ad-hoc network, many also have been done on broadcasting protocols. But about all of those were bounded in comparisons among different broadcasting protocols depending on the analysis of the different performance parameters. The different researchers used different ones but not all at a time. These performance parameters are shown below.

- Data Packet Delivery Ratio
- Latency
- Packet loss
- Normalized routing load
- Throughput
- Protocol efficiency/ successful packets delivery (in percentage)
- Routing overhead

But here we have worked with two new parameters.

- Average number of redundant broadcast
- Average number of single broadcast

We have used these two parameters to make comparison between probabilistic broadcasting with 7 different probabilities and simple flooding broadcasting. We have also shown the comparison in Probabilistic broadcasting using 7 different probabilities to suggest the best one. The work has been done in this field only by the center for reliable and high-performance computing (CRHC) [1]. But they published it as lab assignment named, “lab108” only. There is no published paper on
result analysis or comparison of results or suggestion on results.

3. AD-HOC NETWORKS

A mobile Ad-hoc network is a temporary network formed dynamically in an arbitrary manner by a collection of nodes as need arises.

![Figure1. Mobile Ad-hoc Network](image)

Typically, the membership of node group is dynamic that is node may join and leave group at any time. There is no restriction on the location or number of members in a node group. A node may be a member of more than one group at a time. A node does not have to be a member of a group to send packets to it. A node group may be permanent or transient. A permanent group has a well known administratively assigned address. It is the address but not the membership of the group that is permanent. At any time a permanent group may have any number of members even zero [2].

4. ROUTING

Routing means throughout or carry out of information from node to node. In an Ad-hoc network, routing is instead carried out by the participating nodes themselves. Each node has the ability to forward traffic for others and this ability is what makes it possible for traffic to flow throw the Ad-hoc network over multiple hops. Unlike a stationary router in a conventional network, an Ad-hoc node does not need to be equipped with several network interfaces, since all communications are usually done through a single wireless channel [3].

4.1 Categories of routing protocols

Ad-hoc network uses different types of routing protocols to deliver data packets from source to destination. Some important types are shown below.

- Unicast (one to one/peer to peer)
- Multicast (one to many/many to many)
- Broadcast (one to all)
- Geocast (send packet from source to all nodes inside a region)
- Anycast (access nearest of any of receivers sharing the same service)

In this research work, we have worked with broadcasting routing protocols. Actually we are going to compare overall performance of different broadcasting algorithms used in Ad-hoc network.

5. BROADCASTING

“Broadcasting” is the transmission of datagram (packets) to all other nodes in the network. Broadcasting is necessary in MANET routing protocols. For example, many unicast routing protocols such as – Dynamic Source Routing (DSR), Ad-hoc on Demand Distance Vector (AODV), Zone Routing Protocol (ZRP) and Location Aided Routing (LAR) use broadcasting.

5.1 Broadcasting Methods

Broadcasting methods have been categorized into four families utilizing the IEEE 802.11 MAC specifications [3] and [4].

- Simple flooding [5] and [6]: Requires each node in a MANET to rebroadcast all packets.
- Probability based [7]: Assigns probabilities to each node to rebroadcast depending on the topology of the network.
- Area based [7]: Common transmission distance is assumed and a node will rebroadcast if there is sufficient coverage area.
- Neighborhood based [8] and [9]: State on the neighborhood is maintained by neighborhood method, and the information obtained from the neighboring nodes is used for rebroadcast.

5.1.1 Simple Flooding Method

![Figure2. O (n^2) number of messages in a simple flooding method](image)

In this method [5] and [6], a source node of a MANET transmits a message to all its neighbors. Each of these neighbors will check if they have seen this message before, if yes the message will be dropped, if no the message will be re-transmitted at once to all their neighbors. The process goes on until all nodes have the message. A polynomial number of messages is of the magnitude \( n^2 \) in a MANET of size \( n \) and is depicted in Fig. 2.

Although this method is very reliable for a MANET with low density nodes and high mobility but it is very harmful and unproductive as it causes severe network congestion and quickly exhaust the battery power. Blind flooding ensures the coverage, the broadcast packet is guaranteed to be received by every node in the network providing there is no packet loss caused by collision in the MAC layer and there is no high-speed movement of nodes during the broadcast process. However, due to the broadcast nature of wireless communication media,
redundant transmissions in blind flooding may cause the broadcast storm problem [10], in which redundant packets cause contention and collision.

5.1.2 Probability Based Method

The probability based approach tries to solve the problems of the simple flooding method. Each node \( i \in N \) is given a predetermined probability, “\( p_i \)” for re-broadcasting. In this context, having some nodes not to rebroadcast and minimize the network congestion and collisions. In this approach there is a danger that some nodes will not receive the broadcast message [7].

In dense networks, multiple nodes share similar transmission coverage. Thus, randomly having some nodes not rebroadcast, they save node and network resources without harming delivery effectiveness. In sparse networks, there is much less shared coverage. Thus, nodes won’t receive all the broadcast packets with the probabilistic scheme unless the probability parameter is high.

\[ \forall i \text{ Such that } p_i = 1, \text{ in another word probability is } 100\%. \] The probability based approach is reduced to a simple flooding approach. More efficient broadcasting reduces “\( p_i \)”, as the number of neighbor density increase and vice versa.

6. SIMULATION RESULTS WITH ANALYSES

To attain goals of our research work we focus on a two part study. Each study is outlined in a subsection below. While our two studies vary some parameters, the ones outlined in Table 1, network parameters remain constant for all simulations.

Table 1: Simulation parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>NS-2(Version-2.34)</td>
</tr>
<tr>
<td>Routing Protocol used</td>
<td>AODV</td>
</tr>
<tr>
<td>Protocol studied</td>
<td>Simple flooding, Probabilistic flooding (with 8 different probabilities)</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>10 sec</td>
</tr>
<tr>
<td>Simulation Area</td>
<td>2500*2500</td>
</tr>
<tr>
<td>Transmission Range</td>
<td>20m</td>
</tr>
<tr>
<td>Interface queue type</td>
<td>DropTail/ Pri Queue</td>
</tr>
<tr>
<td>Antenna model</td>
<td>Omni Antenna</td>
</tr>
<tr>
<td>Channel type</td>
<td>Wireless Channel</td>
</tr>
</tbody>
</table>

Radio-propagation model | Two Ray Ground
Network interface type  | Wireless Phy
Max packet in interface queue | 50
Number of nodes | 400
Node Movement Model | Random Way Point model
Traffic Type | CBR
Packet size | 256
Bandwidth | 22.0e6(22.0 *1000000)
Starting node | 210

6.1 Parameter used for calculation

Some common parameters are used for all study and analysis discussed below.

- Probability: Inputted by us as an argument in black shell of Red-Hat Linux when running pbcast_sim.tcl (command: ns pbcast_sim.tcl - prob 0.1/0.2/0.3/…/1.0 )
- Number of source node: Getting from trace file pbsim.tr, created after running pbcast_sim.tcl. This type of node is always starting with the following.
  s -t 0.000000000 -Hs 210 -Hd -2 -Ni 210 -Nx 1250.00 -Ny 1250.00 -Nz 0.0…….
- Number of destination node: Getting from trace file pbsim.tr, created after running pbcast_sim.tcl. This type of node is always starting with the following.
  r -t 0.003232417 -Hs 209 -Hd -2 -Ni 209 -Nx 1250.00 -Ny 1125.00 -Nz 0.00……
- Total nodes from Trace file: This indicates total nodes including all broadcasting.

6.1.1 Study 1 on probability vs. average number of broadcasting:

Two additional parameters are used for this calculative study. These are shown below.

- Number of redundant broadcasting: These can be calculated using following relation.
  Number of redundant broadcasting = Total nodes - Source nodes
- Average of redundant broadcasting: These can be calculated using following relation.
  Average of redundant broadcasting = Broadcasting / Destination nodes
Table 2: Probability vs. average number of broadcasting calculation

<table>
<thead>
<tr>
<th>Broadcasting name</th>
<th>Probability</th>
<th>Number of source nodes</th>
<th>Number of destination nodes</th>
<th>Total nodes (from Trace file)</th>
<th>Number of redundant broadcasting (Total nodes - Source nodes)</th>
<th>Average number of redundant broadcasting (Broadcasting / Destination nodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probabilistic broadcast</td>
<td>0.1</td>
<td>1</td>
<td>12</td>
<td>13</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>2</td>
<td>18</td>
<td>26</td>
<td>24</td>
<td>1.333333333</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>110</td>
<td>365</td>
<td>1180</td>
<td>1070</td>
<td>2.931506849</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>158</td>
<td>384</td>
<td>1618</td>
<td>1460</td>
<td>3.802083333</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>206</td>
<td>398</td>
<td>2031</td>
<td>1825</td>
<td>4.585427136</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>279</td>
<td>400</td>
<td>2476</td>
<td>2197</td>
<td>5.4925</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>364</td>
<td>400</td>
<td>3100</td>
<td>2736</td>
<td>6.84</td>
</tr>
<tr>
<td>Simple flooding broadcast</td>
<td>1.0</td>
<td>400</td>
<td>400</td>
<td>3443</td>
<td>3043</td>
<td>7.605</td>
</tr>
</tbody>
</table>

6.1.2 Analysis 1 on probability vs. average number of broadcasting:

From the calculation table 2, we have seen that increasing probability increases the redundancy in broadcasting message. Besides, it also increases number of source nodes, number of destination nodes, total nodes (including redundant broadcasts) and number of broadcasting along with it. By analyzing the calculation table 2, we plot the graph given below in fig. 3, where only the values of probabilities and average number of broadcasting are considered.

![Probability vs. average number of broadcasting](image)

In this graph, X-axis mention eight different points because here we are working with eight measurement values and Y-axis shown increases in probability and average number of broadcasting individually in two different plotting lines.

6.1.3 Study 2 on probability vs. average number of single broadcasting:

Two additional parameters are used for this calculative study. These are shown below.

- Number of single broadcasting: These can be calculated using analyzing trace file very carefully.
- Average of single broadcasting: These can be calculated using following relation.

\[
\text{Average number of single Broadcasting} = \frac{\text{Single broadcasting}}{\text{Destination nodes}}
\]

6.1.4 Analysis 2 on probability vs. average number of single broadcasting:

From the calculation table 3, we have seen that increasing probability decreases the number of single broadcasting message. Besides, it also increases number of source nodes, number of destination nodes, total nodes (including redundant broadcasts) along with it. But from probabilities 0.7 to 1.0 there is no node with single broadcast. By analyzing the calculation table 3, we plot the graph given below in fig. 4, where only the values of probabilities and the average number of single broadcasting are considered. In this graph X-axis mention eight different points and Y-axis shown increases in probability and decrease in average number of single broadcasting individually in two different plotting lines. At points 6, 7 and 8 through the X-axis the average
number of single broadcasting are zero which means there is no single broadcasting node, all node must have redundant messages due to broadcast from their neighbors. From this graph we can analyze that when the probability is approximately 0.275, the average number of single broadcasting is also approximately 0.275. So, in this point both parameters obtain same value.

Table 3: Probability vs. average number of single broadcasting calculation

<table>
<thead>
<tr>
<th>Broadcasting name</th>
<th>Probability</th>
<th>Number of source nodes</th>
<th>Number of destination nodes</th>
<th>Total nodes (from Trace file)</th>
<th>Number of single broadcasting</th>
<th>Average Number of single broadcasting (single broadcasting /destination node)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probabilistic broadcast</td>
<td>0.1</td>
<td>1</td>
<td>12</td>
<td>13</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>2</td>
<td>18</td>
<td>26</td>
<td>10</td>
<td>0.55555555556</td>
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<tr>
<td></td>
<td>0.3</td>
<td>110</td>
<td>365</td>
<td>1180</td>
<td>37</td>
<td>0.101369863</td>
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<td>2031</td>
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<td>279</td>
<td>400</td>
<td>2476</td>
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</tr>
<tr>
<td></td>
<td>0.9</td>
<td>364</td>
<td>400</td>
<td>3100</td>
<td>0</td>
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</tr>
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<td>1.0</td>
<td>400</td>
<td>400</td>
<td>3443</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Fig. 4. Probability vs. average number of single broadcasting.

7. DISCUSSIONS

7.1 Discussion 1 (from analysis 1)
This causes an increase in power absorption but we know power assumption is a major problem in Ad-hoc network. Besides, increase in probability will cause the increase of congestion in channel bandwidth, increase packet delivery time and also increase packet loss possibility etc.

7.2 Discussion 2 (from analysis 2)
Because less probability increases possibility to have node with no broadcasting message, we should not apply broadcasting with least probability although it makes highest performance in broadcasting. Again probability from 0.7 to 1.0 has no single node with single broadcasting message. So, we should use probability in between two. Analyses from Fig. 4, we can think that the Probability 0.275 will be optimal because it causes same value at both parameters. After this value probability increases but number of single broadcasting decreases (i.e. redundant broadcasting increases) and before this value, power absorption, channel bandwidth congestion and time to transmission is considered to be a major concern. So we think, this is the optimal power efficient broadcasting among all of these at probability 0.275.

7.3 Discussion 3
7.3.1 Comparative discussion between simple flooding and probabilistic flooding
- From Table 2, we have seen that the number of source nodes (400) and the number of destination nodes (400) are same at probability 1.0. It means, at this probability all nodes receive redundant broadcast. From this table we know that when
probability is 1.0, it becomes simple flooding. So, probabilistic flooding with any probability must be better than simple flooding.

- Simple flooding has highest average number of broadcasting (7.605), so it is worsen than probabilistic flooding.
- Simple flooding has the number of single broadcasting is zero, so it is worse than probabilistic flooding.
- Simple flooding wastes channel bandwidth by increasing channel congestion. On the other hand probabilistic broadcast make lower channel congestion.
- Probabilistic broadcasting reduces the broadcast storm problem when compare to simple flooding.

8. CONCLUSIONS
The MANET is faced with the problem of energy efficiency in order to maximize the network lifetime. The goal of this research work is to explore energy efficient protocols in broadcasting scenarios. From the analysis and discussion we can say that the probabilistic broadcast is better than simple flooding. Because

- It saves energy to increase network lifetime.
- It makes less channel congestion by nodes and thus uses channel bandwidth efficiently.
- It decreases the broadcast of redundant messages and thus increases system performance.
- When probability is approximately 0.275, then the probabilistic broadcasting will be the best in broadcasting action.

9. FUTURE WORK
In this research study we have worked with two broadcasting protocols. These are simple flooding broadcast and probabilistic broadcasting with 7 different probabilities. We have shown the comparison between these two. So, we may extend this research work by adding another two broadcasting protocols which we have mentioned earlier and compare all them with each other in future.

REFERENCES


