Epidemic Routing for Partially-Connected Ad Hoc Networks

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Outline

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  - Goals and Components
  - Anti-Entropy sessions
- Messages
- Simulations
- Conclusions
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Introduction

- Existing Ad Hoc Routing Protocols
  - Assume existence of connected path between source and destination
  - Network partition between source and destination
  - Message not delivered to destination

- Intermittently Connected Networks
  - Need for eventual and Timely Delivery
  - Weak and Episodic Connectivity
  - Mobile Sensor Networks, Smart Dust, Military/Disaster Recovery Applications
Epidemic Routing

- *Epidemic Routing*, random pair-wise exchange of messages among mobile nodes
- Eventual Message Delivery Model
- Distribute messages to hosts within connected portions of the network
- Relies on the mobility of the *carriers* to connect to other networks
Epidemic Routing Example

Time = $t_1$

Time = $t_2 > t_1$
Goals and Components

- **Goals**
  - Probabilistic distribution of messages through partially connected ad hoc networks
  - Minimize amount of resources consumed
  - Maximize the percentage of delivery

- **Components**
  - Buffer, messages to be transmitted indexed by a hash table
  - Summary vector, a compact representation of all the messages being buffered at that node.
  - Cache, list of hosts that the node has spoken to recently
Anti-Entropy Session

- Host A transmits its summary vector $S_{VA}$ to B
- Host B determines the set difference $S_{VA} + S_{VB}'$ between the messages buffered at A and the messages buffered locally at B.
- Transmits a vector requesting these messages from Host A
- A transmits the requested messages
Messages

- Each Message is associated with
  - Message Identifier, a 32 bit unique number
    - A Combination of Host Id and Message Id
  - Hop-Count, limits the no of anti-entropy sessions
    - Similar to TTL field in IP packets
    - High priority messages can be set with high Hop count to ensure delivery
  - Ack request, signals the destination of a message to provide an acknowledgement of the message delivery.
    - Acknowledgements can be modeled as simple return messages
    - PiggyBacking (with any other message back to sender)
Simulation

- Each simulated node has a *Epidemic Routing* agent layered on top of Internet MANET Encapsulation Protocol (IMEP) Layer.
- Epidemic Routing agent, consists of the Buffer, Summary vector for the buffer and the code for the anti-entropy sessions
- IMEP layer notifies the routing agent when a new node comes within/moves out of the radio range.
- Based on the neighbor notifications the routing agent initiates the anti-entropy sessions
Simulation Environment

- 1500m X 300m rectangular area
- 50 mobile nodes
- Each node picks a random spot and moves towards it
- Speed uniformly distributed between 0-20 m/s
- Each message is 1KB in length
- 45 nodes send messages to other 44 nodes at 1 msg/sec
- 45 x 44 = 1980 messages after 1980 secs.
Simulation Results

Radio Ranges

CDF for Message Delivery as a function of transmission range
### Simulation Results

#### Radio Ranges 2

<table>
<thead>
<tr>
<th>Range</th>
<th>Delivery Rate (%)</th>
<th>Baseline Rate</th>
<th>Latency Avg (s)</th>
<th>Latency Max (s)</th>
<th>Hops Avg</th>
<th>Hops Max</th>
<th>Coverage Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 m</td>
<td>100.0</td>
<td>98.2</td>
<td>0.2</td>
<td>1</td>
<td>2.4</td>
<td>8</td>
<td>10.91%</td>
</tr>
<tr>
<td>100 m</td>
<td>100.0</td>
<td>34.3</td>
<td>12.8</td>
<td>177</td>
<td>6.3</td>
<td>21</td>
<td>1.75%</td>
</tr>
<tr>
<td>50 m</td>
<td>100.0</td>
<td>0.9</td>
<td>153.0</td>
<td>760</td>
<td>3.7</td>
<td>14</td>
<td>0.44%</td>
</tr>
<tr>
<td>25 m</td>
<td>100.0</td>
<td>0.0</td>
<td>618.9</td>
<td>3758</td>
<td>3.3</td>
<td>9</td>
<td>0.11%</td>
</tr>
<tr>
<td>10 m</td>
<td>89.9</td>
<td>0.0</td>
<td>44829.7</td>
<td>198107</td>
<td>3.4</td>
<td>9</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

Characteristics of Epidemic Routing as a function of Radio Range
Simulation Results

Radio Ranges 3

- Delivery Rate, % of messages delivered to destination
- Baseline Delivery, % of messages delivered using DSR
- Latency, Average and Maximum time to deliver the message
- Hops, Average and Maximum number of hops to deliver the message
- Coverage Floor, lower bound on the % of the area covered by the individual node’s transmitter.
Simulation Results

Hop Count Limit

Delivery rates at various hop count limits

Percent of messages delivered

Message delivery latency

Message hop limit
- 8 hops
- 4 hops
- 3 hops
- 2 hops
- 1 hop
Simulation Results

Buffer Capacity

Delivery rates at various buffer capacities with 4 hop limit
Conclusions

- Routing protocol designed to operate without end-to-end connected path
- Eventual Delivery Model
- Anti-Entropy sessions
- Summary Vectors to exchange messages
- High Delivery rate
Limitations

- Sensitive to node density and transmission coverage as a function of the total target area
- Large resource consumption (memory)
- Reduction in Hop Count increases the latency
- Increasing speed with high hop count causes congestion
- ???
References


- home.himolde.no/~kd/in904/h04/