Weak State Routing for Large Scale Dynamic Networks

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Outline

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- Weak State Routing
- Simulation
- Conclusions
Introduction

- In a large scale dynamic networks (large scale MANET), traditional routing protocols require high overhead to keep some information.
- This paper proposes Weak State Routing to solve this problem.
- The state information is weak, i.e. interpreted not as absolute truth, but as probabilistic hints.
- Nodes only have partial information about the region a destination node is likely to be.
Assumptions

- All nodes know their positions on a 2-D plane (GPS).
- By using single hop beacon messages, the nodes also know their neighbors and their positions.
- All nodes have uniform omnidirectional antennas.
- There is no ACK after transmitting.
Weak State Routing

- Weak State Routing (WSR) is based on link-state geographic routing protocol.
- WSR doesn’t maintain the state of each node, since there are many and large size beacon messages.
- It only maintains the state of each region.
Weak State Routing

- Every node has a table which maintains the states of the entire network.
- A weak state is composed of four parts:

<table>
<thead>
<tr>
<th>Component Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Weak Bloom Filter containing the SetofIDs portion</td>
</tr>
<tr>
<td>X</td>
<td>X coordinate of the center of the GeoRegion</td>
</tr>
<tr>
<td>Y</td>
<td>Y coordinate of the center of the GeoRegion</td>
</tr>
<tr>
<td>R</td>
<td>Magnitude of the radius of the GeoRegion</td>
</tr>
</tbody>
</table>
Weak State Routing

- In order to decrease the beacon message overhead, it decreases the size of the message by using bloom filter and tries to combine some states to one state.
**Weak State Routing**

- Use bloom filter to calculate the virtual ID (SetofID):
  - There are $k$ hash functions $BF_1$~$BF_k$ in each node.
  - Every hash function produces a position in virtual ID ($n$ bits, $n>k$).
  - Setting the bits at these positions to 1.
Weak State Routing

- If any two states can combine, then:
  - The new SetofID = SetofID₁ | SetofID₂
  - The new GeoRegion is the smallest circle that contains both GeoRegions.
To combine two states to one state, the two states must satisfy some properties as follows:

- Checking the GeoRegion radius after combining is smaller than or equal to threshold, $R$.
- $\theta_1 + \theta_2$ is smaller than or equal to threshold, $\theta$.
- Checking the total number of bits set to 1 in SetofID is smaller than or equal to threshold, $B$. 

**Weak State Routing**
The source transmits data to the next node which is closest to highest confidence area (it’s similar to geographic routing).

I want to send data to D which SetofID is 11000001

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>a₁</td>
<td>b₁</td>
<td>r₁</td>
</tr>
<tr>
<td>10001100</td>
<td>a₂</td>
<td>b₂</td>
<td>r₂</td>
</tr>
<tr>
<td>11001001</td>
<td>a₃</td>
<td>b₃</td>
<td>r₃</td>
</tr>
<tr>
<td>10101001</td>
<td>a₄</td>
<td>b₄</td>
<td>r₄</td>
</tr>
</tbody>
</table>
Weak State Routing

- At each time interval, the bits in each SetofID set to 1 are reset to 0 by a fixed probability $p$ in order to adapt to the dynamic networks.
- Once the number of 1 is below a threshold value, WSR removes the state since the state is too old.
- The data packet is sent to a random direction if there are multiple states which have the same confidence.
Simulation

- NS2
- 2500m x 2500m
- 500~1000 nodes
- Dynamic networks
- $v_{\text{min}} = 5\text{m/s}$, $v_{\text{max}} = 10\text{m/s}$
Simulation

- Packet delivery success rate
Simulation

- Total overhead per second
Simulation

- Number of transmissions per successfully received packet
Simulation

- End to end delay
Simulation

source

destination

Confidence: 0.71

Confidence: 0.84

Confidence: 1
Conclusions

- WSR decreases the size of beacon messages and adapts to large scale dynamic networks.
- Using bloom filter, this mechanism reduces the size of the table which every node maintains.
- In simulation, WSR offers a high packet delivery ratio, more than 98%.
- It also retains high reachability, low overhead and delay.