Outline

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Background

- Shifting trend from wired network to mobile networks
  - Mobile ad hoc network’s advantage: Mobility + Work without infrastructure = Flexibility
- Routing in MANETs faces many difficulties:
  - Continuous topology changes
  - Limited channel capacity
  - Communication is easily interfered by other signals
- A robust, adaptive, and self-organizing routing protocol is required.

Biological Mechanism

- Biological systems are well-known for self-organizing capability.
- We adopted the method from adaptive response by attractor selection in cell biology.
- Attractor selection model is defined by:
  \[
  \frac{di}{dt} = f(i) + az + \eta
  \]
  where
  - \(i\) = the vector of possible states
  - \(f(i)\) = the function defining the energy potential
  - \(z\) = the activity which controls the effects of \(f(i)\) and \(\eta\)

MANETs Routing with Attractor Selection

- AODV-like flooding route establishment
- Each node maintains a routing vector for each source and destination pair
- Probabilistic data forwarding
- The next hop candidates are selected based on the Hop-To-Destination value
- Attractor selection is used in next hop selection process.

Routing Vector Maintenance

- Each node maintains its own neighbor list and candidate list.
  - The probability value is controlled by feedback activity \(\alpha\)
  - Using the stored activity at each node, the routing vector is updated periodically.

Randomly set up

<table>
<thead>
<tr>
<th>Candidates</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>candidate_1</td>
<td>0.0</td>
</tr>
<tr>
<td>candidate_2</td>
<td>1.0</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>candidate_n</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Set up by route reply

<table>
<thead>
<tr>
<th>Candidates</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>candidate_1</td>
<td>Low</td>
</tr>
<tr>
<td>candidate_2</td>
<td>High</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>candidate_n</td>
<td>Low</td>
</tr>
</tbody>
</table>

More effect from noise | More deterministic
The activity $\alpha$ is calculated by the following equation:

$$\alpha(t + \Delta t) = \begin{cases} 0 & \text{if } \alpha(t) \leq \alpha_{\text{min}} \\ \alpha(t) + (\alpha_{\text{max}} - \alpha(t)) & \text{otherwise} \end{cases}$$

where $\alpha_{\text{min}}$ and $\alpha_{\text{max}}$ are thresholds.

- The activity is embedded into a feedback packet sent by the source every time the data packet arrives at the destination.
- Periodically, the routing vector is updated using the stored activity by the following attractor selection model's equation for each candidate node $i$:

$$d_n(i) = \frac{d_n(i)}{1 + \beta a_n(i) - \beta a_n(i) + \gamma}$$

$\beta$ and $\gamma$ are parameters, and $W$ is a sliding window containing travelled hop count information.

The routing example illustrates the process where a data packet is routed through multiple nodes before reaching the destination.
Simulation Setting

- Simulator: QualNet 4.0
- Topology:
  - Static grid
  - Grid unit = 250 m
- No. of nodes: 25 nodes
- Wireless specification:
  - IEEE 802.11b module with 2 Mbps data rate
  - Free-space model without fading
- Traffic:
  - Application: CBR
  - Transport protocol: UDP
  - Data rate: 8 Kbps
  - No. of session: 1 session
  - Simulation time: 1000 s
    - Traffic time: 0 – 900 s
    - Down time: 500 s
    - 10 times = 50 s per time
    - 50 times = 10 s per time

Simulation Result – MARAS vs. AODV

- MARAS with feedback: Performance is lower than the ideal case because of the feedback’s effect (collision)
- AODV: Performance drops relatively faster than MARAS with feedback

Simulation Result – Delayed Feedback

- Normalized delivered count based on AODV
  - Feedback every 10 packets
  - Feedback every 50 packets
  - Feedback every 100 packets

Conclusion and Future Work

- Biologically-inspired routing protocol for MANETs
  - Probabilistic data packet forwarding
  - Noise-driven routing protocol
  - Feedback-based protocol
- Result
  - MARAS has higher delivery efficiency than AODV in the considered dynamic scenario.
- Future work
  - Adding hop-to-destination value estimating method
  - Evaluating the other parameters’ effects on the performance, such as, update interval, window interval, etc.
  - Increasing traffic sessions, mobility, and scenarios

Thank you for your attention

Q&A