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Evaluation of Robustness and Adaptability of a Biologically-inspired MANET Routing Protocol

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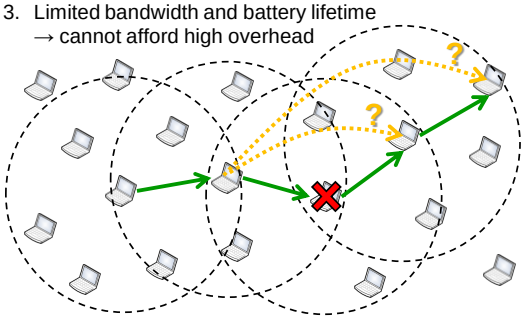
Outline

- Research background
  - Routing problems in MANETs
  - Weaknesses of existing protocols
- Our protocol (MARAS)
  - Attractor selection mechanism
  - Routing with attractor selection
- Evaluation
- Conclusion

Routing Problems in MANETs

1. Limited transmission range → multi-hop transmission
2. Continuous topology changes (failure, mobility, etc.)
3. Limited bandwidth and battery lifetime
   → cannot afford high overhead



Weaknesses of existing protocols

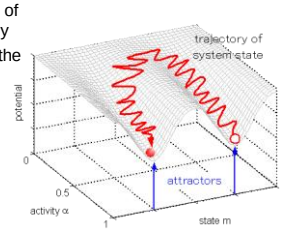
- Proactive routing protocols:
  - Wasting the energy and resources in maintaining all possible routes in the network → high overhead
- Reactive (on-demand) routing protocols:
  - Setting up the route *on-demand* → lower overhead
  - High interference from broadcast control packets
  - High delay in route discovery/recovery
- Hybrid routing protocols:
  - Complex and optimizing effort is required

On-demand robust and adaptive routing protocol with Attractor Selection

Attractor Selection Mechanism

- Biologically-inspired mechanism
  - Adopted from the mechanism of gene expression in cell biology
  - Robust and adaptive against the external influences and noise
- Model

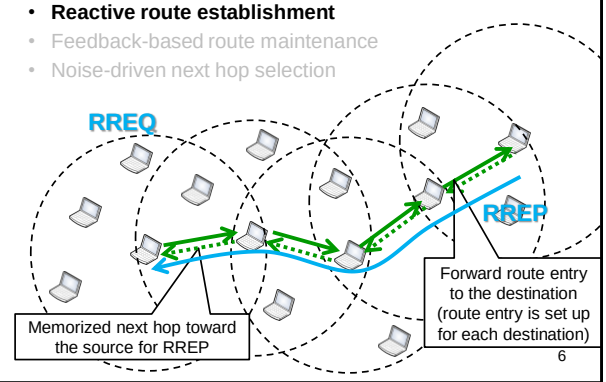
$$\frac{d\vec{m}}{dt} = f(\vec{m}) \times \alpha + \vec{\eta}$$



- Key controlling factors
  - Activity α: goodness of the current selected state
  - Noise η: randomness for discovering a better state

Routing With Attractor Selection

- **Reactive route establishment**
- Feedback-based route maintenance
- Noise-driven next hop selection



Routing With Attractor Selection

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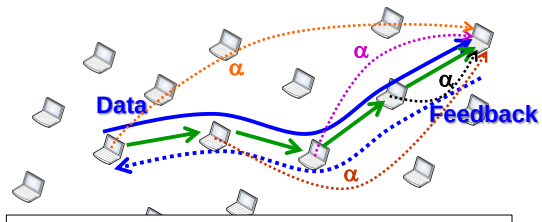


Each intermediate node calculates activity α for the route to the destination via the current selected next hop

Routing With Attractor Selection (2)

- Reactive route establishment
- **Feedback-based route maintenance**
- Noise-driven next hop selection

➢ Activity α is calculated based on *travelled hop count of the feedback packet up to the current node*

$$\alpha = \frac{\min_{\forall w_i \in W} w_i}{w_n}$$

where W = sliding window containing travelled hop count information, and w_n is the latest packet's travelled hop count

➢ Activity α is decayed over time if it is not refreshed by a new feedback packet

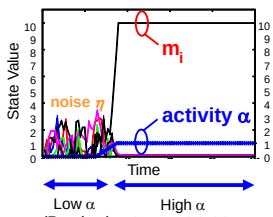
Routing With Attractor Selection (3)

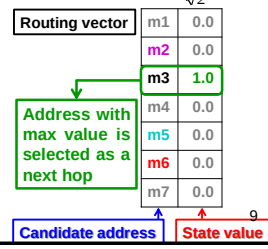
- Reactive route establishment
- Feedback-based route maintenance
- **Noise-driven next hop selection**

$$\frac{dm_i}{dt} = \frac{s(\alpha)}{1+m_{\max}^2 - m_i^2} - d(\alpha)m_i + \eta_i$$

where $m_{\max} = \max_{j=1,\ldots,M}(m_j)$, $d(\alpha) = \alpha$,

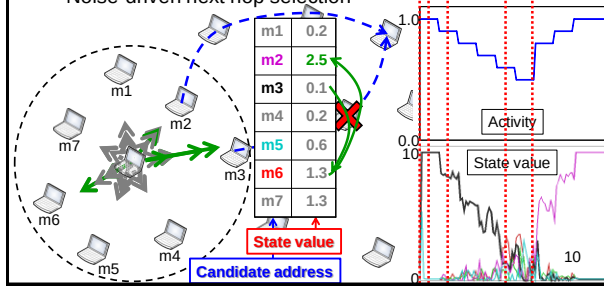
$s(\alpha) = \alpha[\beta\alpha^{\gamma} + \varphi^*]$, and $\varphi^* = \frac{1}{\sqrt{2}}$





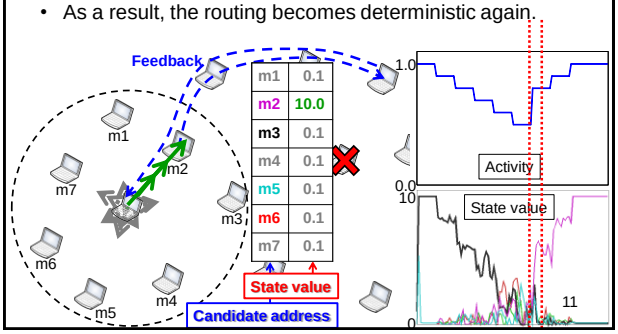
Next Hop Selection Example

- First, let the routing vector is set up by RREP.
- Then, the link failure occurs and the activity is decayed. → high value decreases and effect of noise increases
- Noise-driven next hop selection



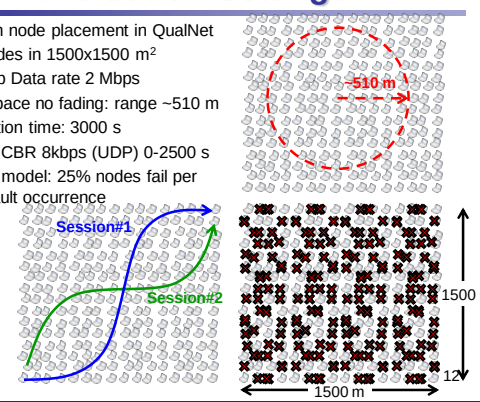
Next Hop Selection Example (2)

- When the next hop which improves the system condition is selected, the activity is increased.
- As a result, the routing becomes deterministic again.

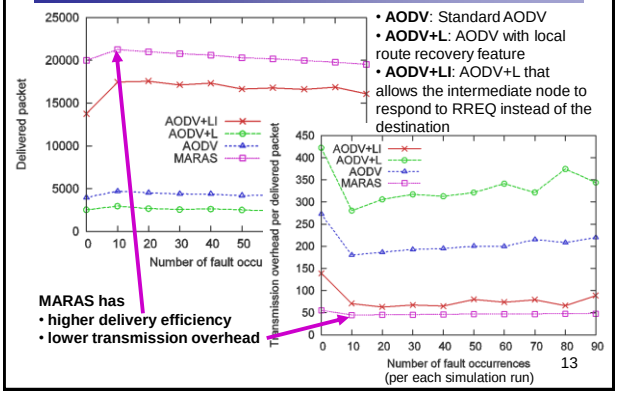


Evaluation Settings

- Uniform node placement in QualNet
- 256 nodes in 1500x1500 m²
- 802.11b Data rate 2 Mbps
- Free-space no fading: range ~510 m
- Simulation time: 3000 s
- Traffic: CBR 8kbps (UDP) 0-2500 s
- Failure model: 25% nodes fail per each fault occurrence



Single Session Results



- **AODV**: Standard AODV
- **AODV+L**: AODV with local route recovery feature
- **AODV+LI**: AODV+L that allows the intermediate node to respond to RREQ instead of the destination

MARAS has
- **higher delivery efficiency**
- **lower transmission overhead**

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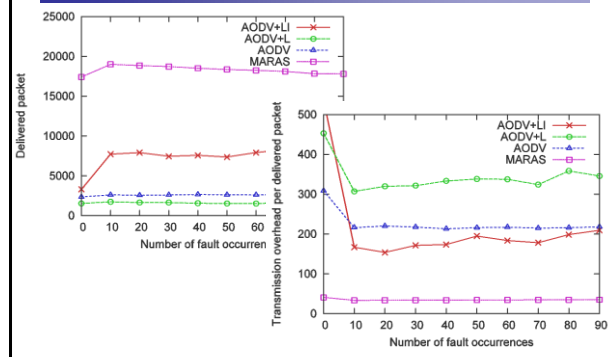
Two Sessions Results



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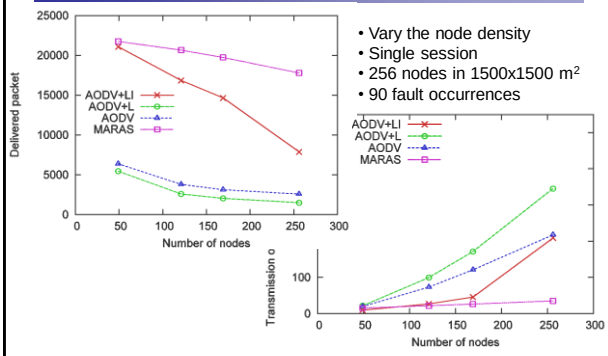
Scalability Test



- Vary the node density
- Single session
- 256 nodes in 1500x1500 m^2
- 90 fault occurrences

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Conclusion and Future Work

- Biologically-inspired routing protocol
- Data packet forwarding: the next hop is selected by attractor selection state value (highest value)
- Noise-driven route maintenance by attractor selection and feedback packet
- Result: comparing to AODV in evaluated scenarios with failures
  - Robust: able to maintain high delivery packet count
  - Adaptive: able to recover from failures with low transmission overhead
- Future work:
  - Mobility scenario
  - Performance comparison with AntHocNet

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Thank you for your attention
Q&A