An Adaptive Routing Protocol with Attractor Selection for Mobile Ad Hoc Network

(モバイルアドホックネットワークにおけるアトラクタ選択モデルに基づく適応的なルーティングプロトコル)

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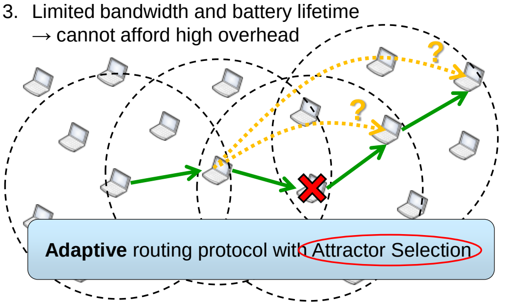
Outline

- Research background
  - Routing problems in MANETs
  - Attractor selection mechanism
- Mobile Ad hoc Routing with Attractor Selection (MARAS)
- Evaluation
- Conclusion and Future Work

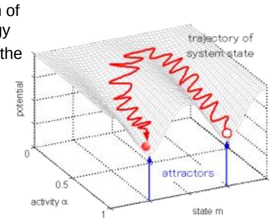
Routing Problems in MANETs

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



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



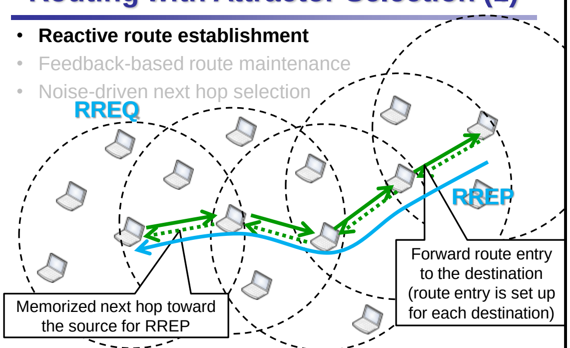
- Model

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

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

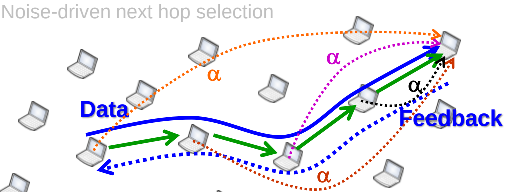
Routing with Attractor Selection (1)

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



Routing with Attractor Selection (2)

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



- Activity α is calculated for the route to the destination via the current selected next hop
- Upon receiving feedback packet at time t_0,

$$\alpha(t_0) = \frac{\min_{t_0 - T < t \le t_0} w(t)}{w(t_0)}$$

The minimum travelled hop count in the last *T* s

travelled hop count of feedback packet at t_0

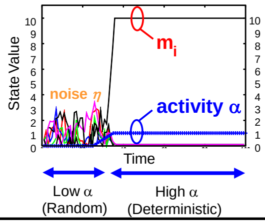
Routing with Attractor Selection (3)

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

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

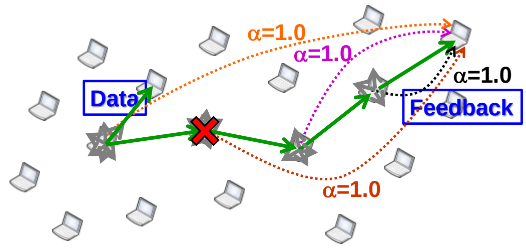


Routing vector	
m1	0.9
m2	0.6
m3	8.2
m4	0.5
m5	0.8
m6	0.8
m7	0.3

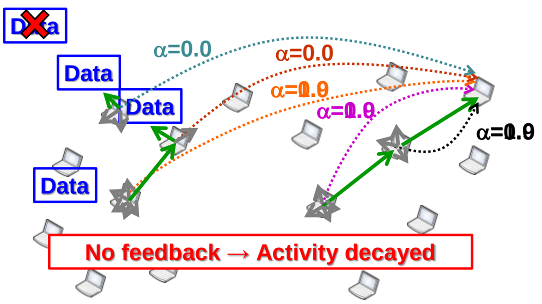
Address with max value is selected as a next hop

Candidate address | State value

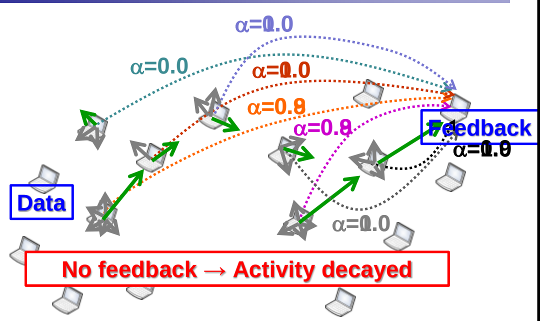
Routing Example



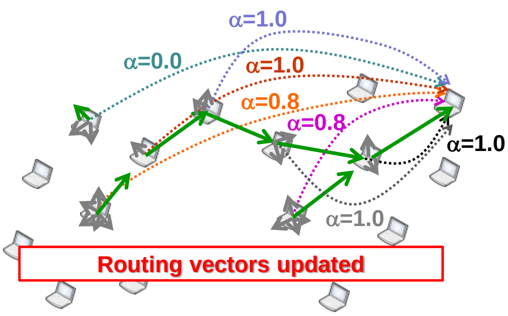
Routing Example



Routing Example

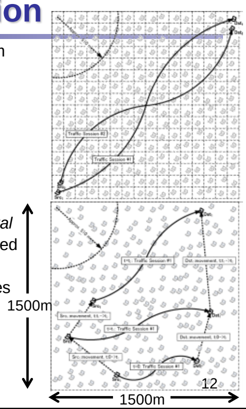


Routing Example



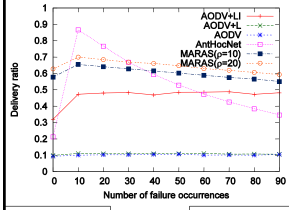
Evaluation

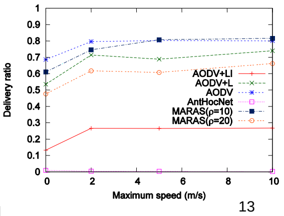
- 256 nodes in 1500x1500 m^2, range ~510m
- 802.11b Data rate 2 Mbps
- Simulation time: 1000 s (for all scenarios)
- Traffic: CBR 8kbps (UDP) 0-1000 s
- Failure scenario:
  - Uniform node placement
  - 1 or 2 traffic sessions
  - 25% nodes selected randomly
  - This group of node fails for *fixed interval*
  - After recovery, another group is selected
  - Process is repeated for #occurrences
  - Shorter interval for higher #occurrences
- Mobility scenario:
  - Random node placement
  - 1, 2, or 10 traffic sessions
  - Random waypoint mobility model
  - Max speed: 2, 5, or 10 m/s



Evaluation 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
- **AntHocNet**: Swarm Intelligence (ant colony)-based ad hoc routing
- **MARAS**: Our proposal of attractor selection-based routing protocol





Longer Failure ↔ Shorter Failure

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Conclusion and Future Work

- Biologically-inspired routing protocol
  - Next hop selection is based on attractor selection mechanism
  - Noise-driven route maintenance controlled by attractor selection and feedback information-based activity
- Adaptive in both failure and mobility scenarios, as MARAS:
  - maintain sufficiently high delivery efficiency and low overhead regardless node failures, node movements, and traffic levels.
  - adapt to various scenarios without parameter modification
- Future work:
  - Study the effects of each parameter in details to fine-tune MARAS to achieve even better performance
  - Investigate the traffic management capability of MARAS as it can achieve high performance despite longer path length.

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Thank you for your attention

Q&A