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Extension and Evaluation of Biologically-inspired Routing Protocol for MANETs

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Outline

Background

- Shifting trend from wired network to mobile networks
  - Mobile ad hoc network's advantage:

Mobility + Work without infrastructure = Flexibility

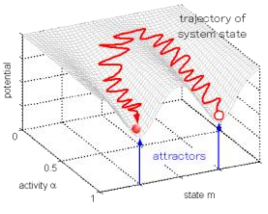
- Routing in MANETs faces many difficulties:

  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



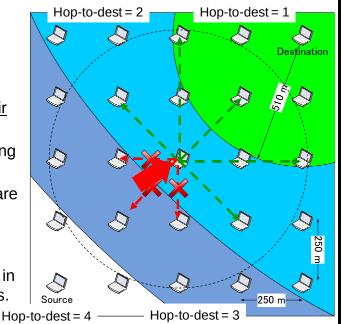
$$\frac{d\vec{m}}{dt} = f(\vec{m}) \times \alpha + \vec{\eta}$$

where

$\vec{m}$ = the vector of possible states
$f(\vec{m})$ = the function defining the energy potential
$\vec{\eta}$ = the vector of noise
α = the activity which controls the effects of $f(\vec{m})$ and $\vec{\eta}$

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 α
- Using the stored activity at each node, the routing vector is updated periodically.

Initial

Candidates	Prob.	Prob.
candidate_1	0.0	1/n
candidate_2	1.0	1/n
…	…	…
candidate_n	0.0	1/n

Randomly set up
Set up by route reply

Lowα

Candidates	Probability
candidate_1	0.0 ± noise
candidate_2	1.0 ± noise
…	…
candidate_n	0.0 ± noise

More effect from noise

Highα

Candidates	Probability
candidate_1	Low ± noise
candidate_2	High ± noise
…	…
candidate_n	Low ± noise

More deterministic

Feedback Mechanism

- The activity α is calculated at destination on each data packet arrival by the following equation

$$\alpha(t+\Delta t) = \begin{cases} \alpha_{new} & \text{if } \alpha(t) \leqq \alpha_{new} \\ \alpha(t) + c\,(\alpha_{new} - \alpha(t)) & \text{otherwise,} \end{cases}$$

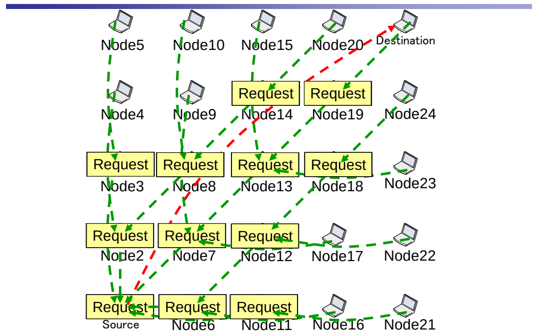
  where $\alpha_{new} = \frac{\min_{\forall w_i \in W} w_i}{w_n}$

  and W = sliding window containing travelled hop count information.

- The activity α embedded feedback packet is sent to 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 i

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

Routing Example



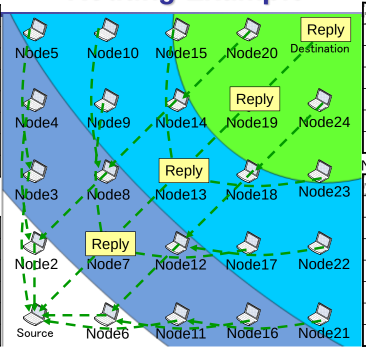
Routing Example

Node7 α=1.0

Cand.	Prob.
Node3	0.0
Node8	0.0
Node9	0.0
Node11	0.0
Node12	0.0
Node13	1.0
Node17	0.0

Source α=1.0

Cand.	Prob.
Node2	0.0
Node3	0.0
Node6	0.0
Node7	1.0
Node11	0.0



Node19 α=1.0

Cand.	Prob.
Node15	0.0
Node19	0.0
Node20	0.0
Node23	0.0
Node24	0.0
Dest	1.0

Node13 α=1.0

Cand.	Prob.
Node9	0.0
Node14	0.0
Node15	0.0
Node17	0.0
Node18	0.0
Node19	1.0
Node23	0.0

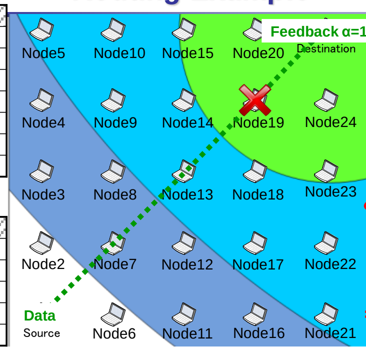
Routing Example

Node7 α=1.0

Cand.	Prob.
Node3	0.015
Node8	0.010
Node9	0.012
Node11	0.024
Node12	0.008
Node13	0.925
Node17	0.006

Source α=1.0

Cand.	Prob.
Node2	0.011
Node3	0.023
Node6	0.009
Node7	0.951
Node11	0.006



Nod[illegible]19 α=[illegible]0

[illegible]	[illegible]b.
[illegible]	[illegible]002
Node[illegible]	[illegible].005
Node[illegible]	[illegible].031
Nod[illegible]	[illegible]014
N[illegible]4	[illegible]07
De[illegible]	0[illegible]49

Node13 α=1.0

Cand.	Prob.
Node9	0.022
Node14	0.006
Node15	0.012
Node17	0.014
Node18	0.009
~~Node19~~	~~0.933~~
Node23	0.004

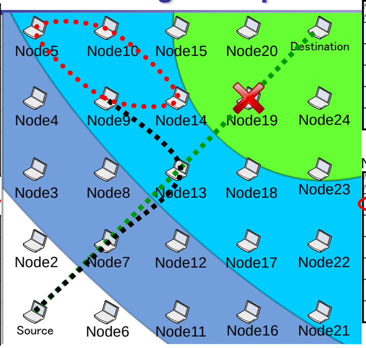
Routing Example

Node7 α=0.3

Cand.	Prob.
Node3	0.015
Node8	0.010
Node9	0.012
Node11	0.024
Node12	0.008
Node13	0.925
Node17	0.006

Source α=0.3

Cand.	Prob.
Node2	0.011
Node3	0.023
Node6	0.009
Node7	0.951
Node11	0.006



Node9 α=0.0

Cand.	Prob.
Node5	0.192
Node10	0.201
Node13	0.186
Node14	0.225
Node15	0.196

Node13 α=0.3

Cand.	Prob.
Node9	0.932
Node14	0.013
Node15	0.013
Node17	0.008
Node18	0.021
Node23	0.013

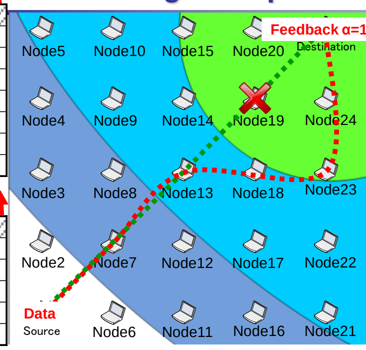
Routing Example

Node7 α=1.0

Cand.	Prob.
Node3	0.031
Node8	0.032
Node9	0.011
Node11	0.012
Node12	0.021
Node13	0.883
Node17	0.010

Source α=1.0

Cand.	Prob.
Node2	0.022
Node3	0.018
Node6	0.014
Node7	0.921
Node11	0.016



Node9 α=0.0

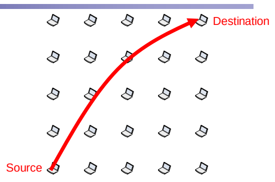
Cand.	Prob.
[illegible]de5	0.192
Node10	0.201
Node13	0.186
Node14	0.225
Node15	0.196

Node13 α=1.0

Cand.	Prob.
Node9	0.016
Node14	0.018
Node15	0.022
Node17	0.018
Node18	0.012
Node23	0.914

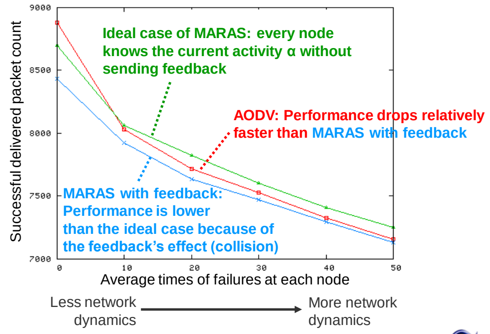
Simulation Setting

- 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

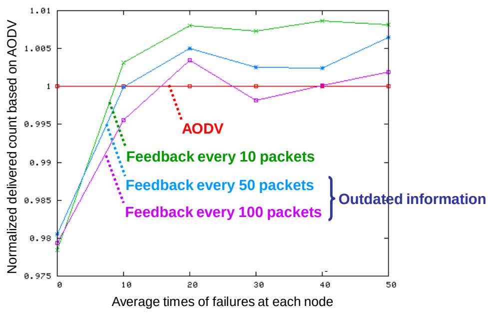


- Simulation time: 1000 s
  - Traffic time 0 – 900 s
- Failure Model
  - Down time 500 s
    - 10 times => 50 s per time
    - 50 times => 10 s per time

Simulation Result – MARAS vs. AODV



Simulation Result – Delayed Feedback



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