Switching of Routing Algorithms in Wireless Networks for Fire Fighting

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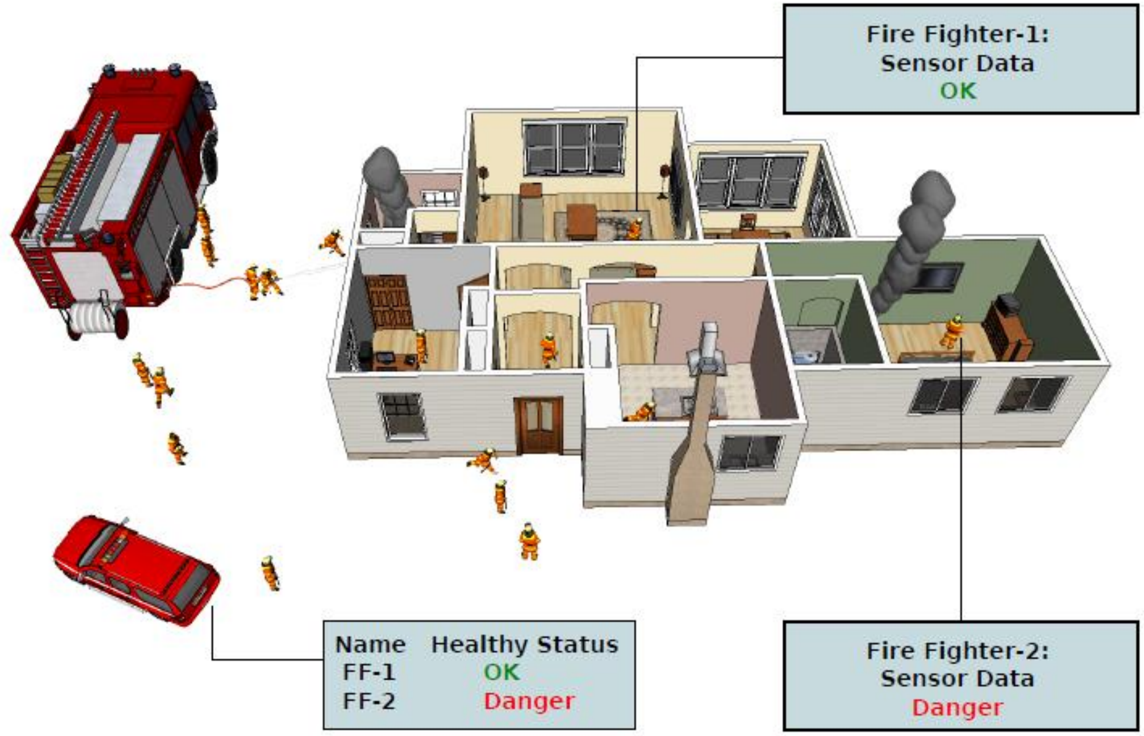
Outline

- Problem Statement
- Proposed Adaptive Routing Framework
- Analytical Model for Switching of Routing Algorithms
- Conclusions and Future Work

Fire Fighting Scenario

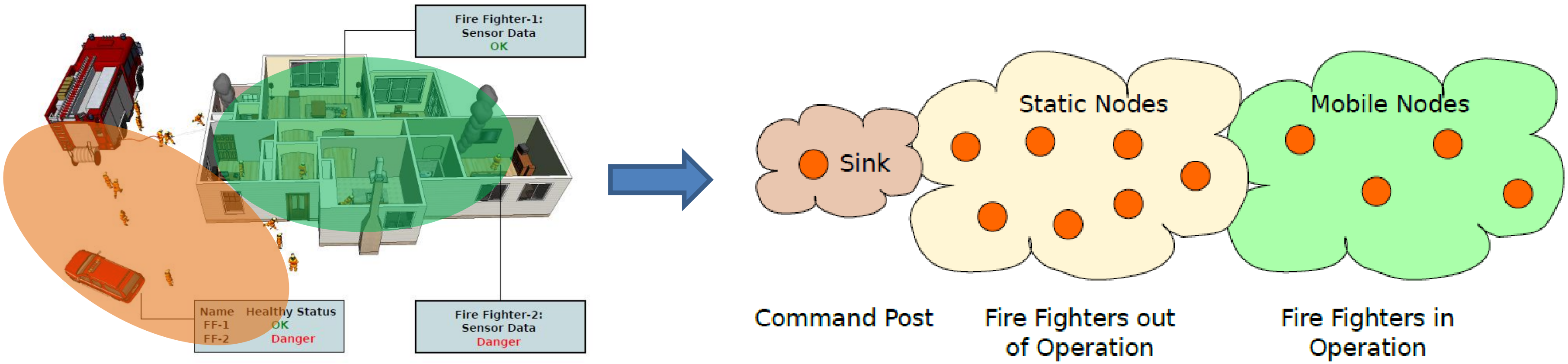


- A building is on fire
- Some fire fighters are in operation
- Rest of the fire fighters stay outside as backup
- All sensor data should be sent to the command post

Classification of Routing Algorithms

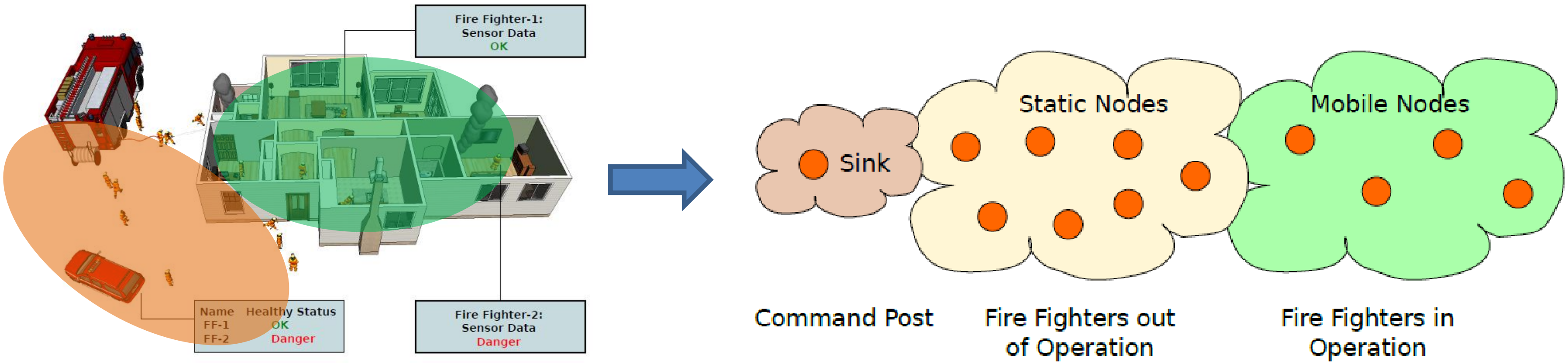
- Mobile Ad-hoc Network (MANET)
- Proactive
  - Maintain routes all the time
  - Difficult to cope with mobility
- Reactive
  - On demand
  - Inefficient if the traffic is low and route response time is important
- Hybrid
  - Try to integrate the advantages of both proactive and reactive routing

Problem Statement



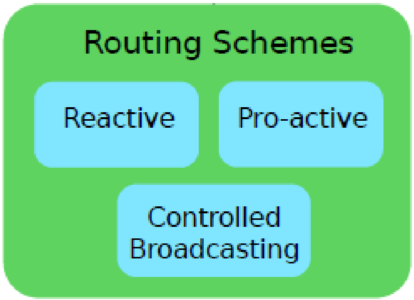
- Heterogeneous network
- Objective:
  - Best routing performance
- Static nodes: low dynamic → stable connectivity → proactive routing, like Optimized Link State Routing (OLSR)
- Mobile nodes: high dynamic → instable connectivity → reactive routing, like Ad-hoc On-demand Distance Vector (AODV)
- Solution:
  - A self adaptive routing protocol, which allows coexistence of different routing algorithms in a network.

Focus of This Presentation

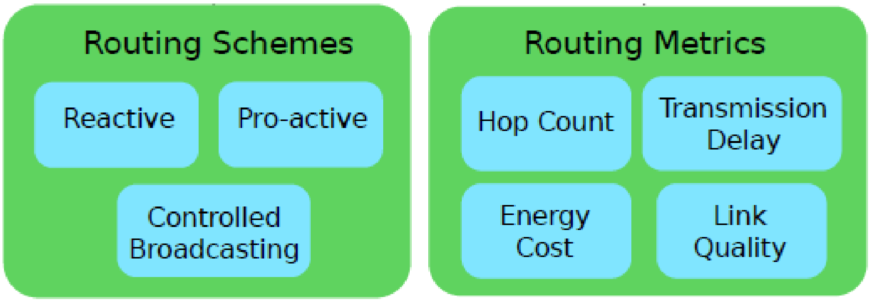


- Propose a self adaptive routing framework
- Develop decision algorithms based on analytic performance evaluation models of ad hoc routing protocols from literature

Proposed Adaptive Routing Framework



Proposed Adaptive Routing Framework



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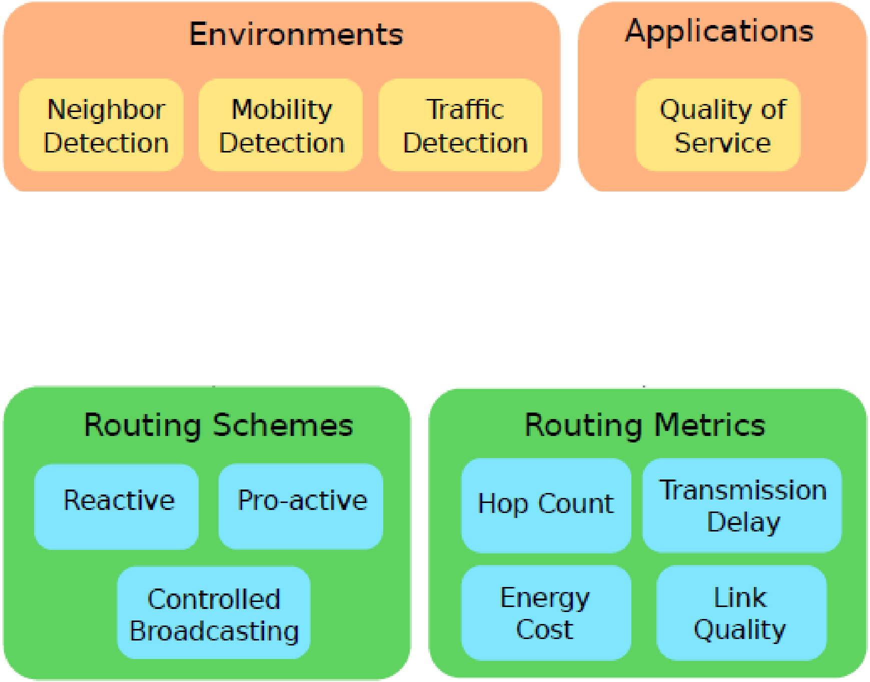
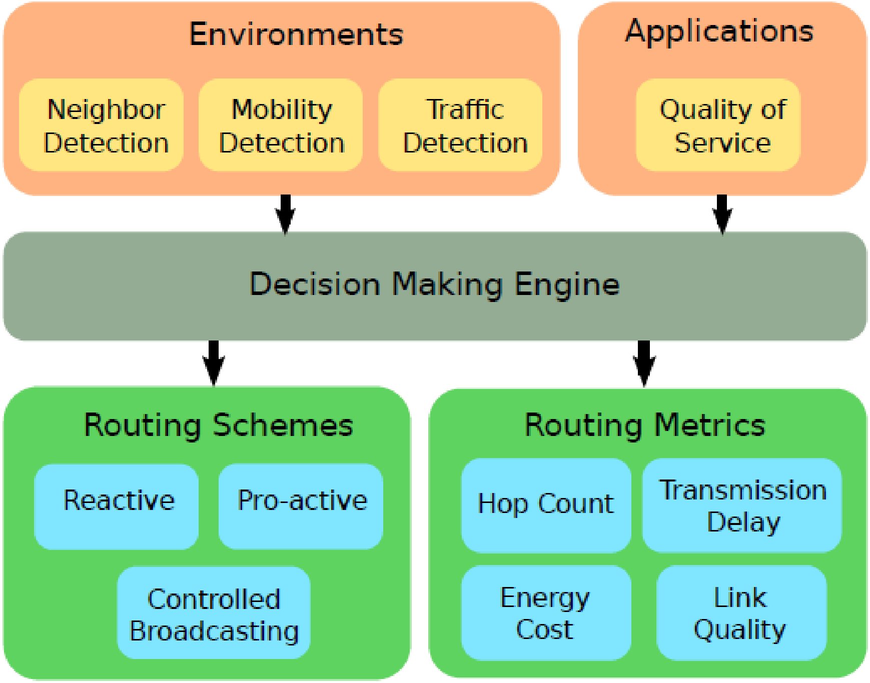


Proposed Adaptive Routing Framework



- Reactive routing as the default algorithm
- Each node may apply different routing algorithms to different neighbors
  - Through monitoring the change of its neighbor list
  - Frequent change means high dynamic → reactive routing
  - Infrequent change implies low dynamic → proactive routing

Challenge: When to switch?

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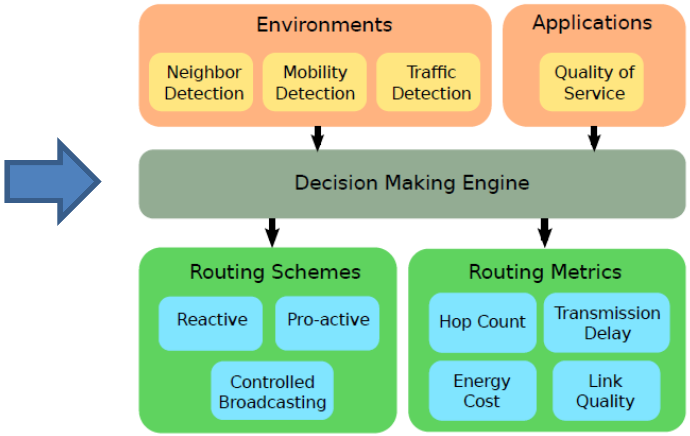
Cost Functions for Switching of Algorithms



$$Objective: \min(Cost)$$

(1) Reduce the overall cost

$$Cost = \alpha Cost_{Switch} + \beta Cost_{Algorithm}$$

(2) Cost for algorithm and cost for switching

$$Cost_{Switch} = \mathrm{f}_s^{Switch}(Overhead_{Switch}^{CtrlMsg})$$

(3) Switching cost in terms of number of control messages

$$Cost_{Algorithm} = \mathrm{f}_s^{Algorithm}(Overhead_{Algorithm}^{CtrlMsg}(t))$$

(4) Routing algorithm cost in terms of number of control messages

Future: other metrics are to be considered, such as packet loss rate, end to end delay, etc.

$Cost_{Algorithm}$: Control Traffic Overhead (1/2)

	Reactive	Proactive
Fixed	$\lambda o_r N^2$	$h_p N + o_p t_p N^2$
Mobility	$o_r \mu a L N^2$	$o_p \mu A N_p N^2$

Network Parameters	
N	Number of nodes
μ	Link break rate (mobility)
L	Average length of a route

Data Traffic Parameters	
λ	Route creation rate per node
a	Average number of active routes per node (activity)

Reactive Protocol Parameters	
h_r	Hello rate (0 when possible)
o_r	Route request optimization factor

Proactive Protocol Parameters	
h_p	Hello rate
t_p	Topology broadcasting rate
o_p	Broadcast optimization factor
AN_p	Average number of active next hops

[1] Viennot, L., Jacquet, P., Clausen, T.H.: "Analyzing Control Traffic Overhead versus Mobility and Data Traffic Activity in Mobile Ad-hoc Network Protocols", Wirel. Netw. 10(4), 447455 (Jul 2004)

CostAlgorithm: Control Traffic Overhead (1/2)

	Reactive	Proactive
Fixed	➡ $\lambda o_r N^2$	$h_p N + o_p t_p N^2$
Mobility	$o_r \mu a L N^2$	$o_p \mu A N_p N^2$

$o_r \lambda N N$

Number of route requests

Every node broadcasts it once

Reduce number of broadcasting

Data Traffic Parameters	
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$o_r \mu a N L N$

Number of routes
Number of active links
Number of link breaks
Each node broadcasts each link break once

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λ	Route creation rate per node
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Mobility	$o_r \mu a L N^2$	$o_p \mu A N_p N^2$

$$h_p N + o_p\, t_p N\, N$$

Each node sends hello messages
Each node broadcasts its topology
Topology is broadcasted through the network

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λ	Route creation rate per node
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$$o_p \mu A N_p N N$$

Number of active links
Number of link breaks
Each node broadcasts the link break once

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Cost$_{Algorithm}$: Control Traffic Overhead (1/2)

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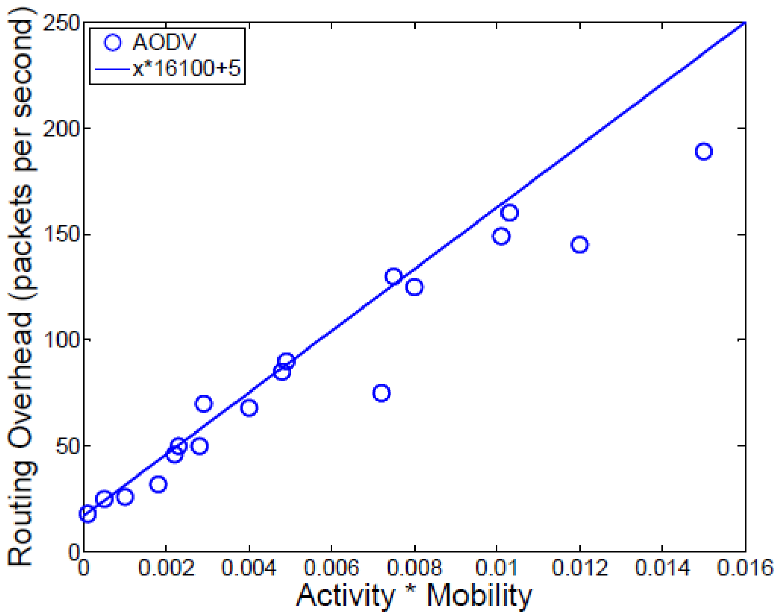
Cost$_{Algorithm}$: Control Traffic Overhead (2/2)

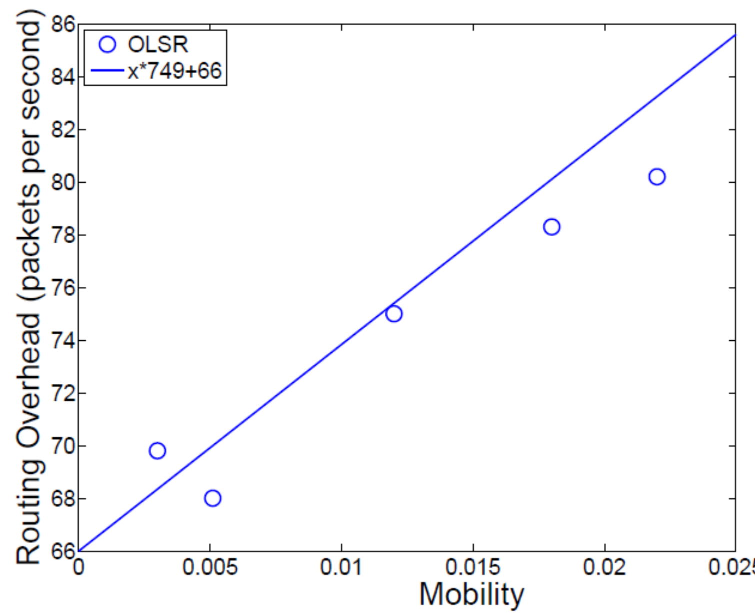
- Scenario
  - 50 Nodes in the area of 1500x300 meter
  - Random Waypoint mobility, different pause time → Mobility
  - Different number of source nodes (10, 20 or 30) → Activity
- Assumptions
  - No congestion occurs in the network
  - Average link break rate is constant
  - The network always remains connected

[2] J. Broch, D.A. Maltz, D.B. Johnson, Y.-C. Hu, and J. Jetcheva. A performance comparison of multi-hop wireless ad hoc network routing protocols. In MobiCom'98, October 1998. Dallas.

Parameter Determination



AODV: Control packets per second vs. μa



OLSR: Control packets per second vs. μ

AODV

- $o_r \mu a L N^2 + \lambda o_r N^2 = 16100x + 5$
- $x = \mu a$
- $o_r = 16100/(LN^2)$

OLSR

- $o_p \mu A N_p N^2 + h_p N + o_p t_p N^2 = 749 + 66$
- $x = \mu$
- $o_p A N_p = 749/N^2$
- $o_p = 66/(t_p N^2)$

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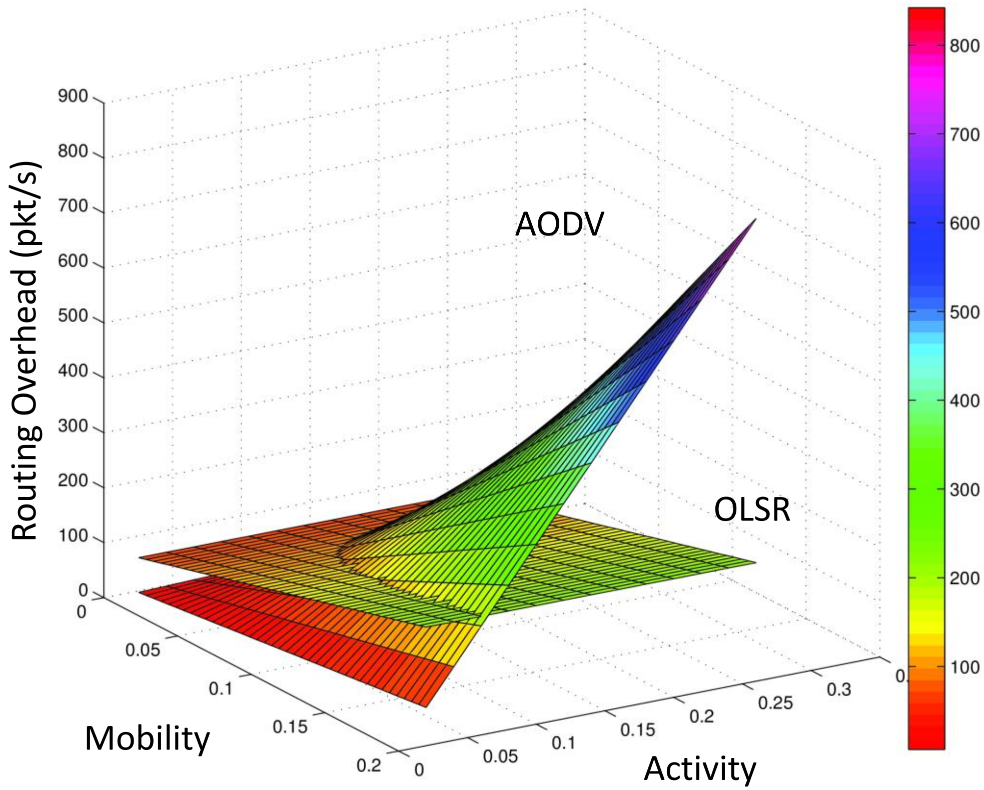
Routing Overhead Comparison - Analytic

- Routing overhead vs. mobility and activity
- AODV has lower overhead when activity is low
- OLSR outperforms AODV when activity increases



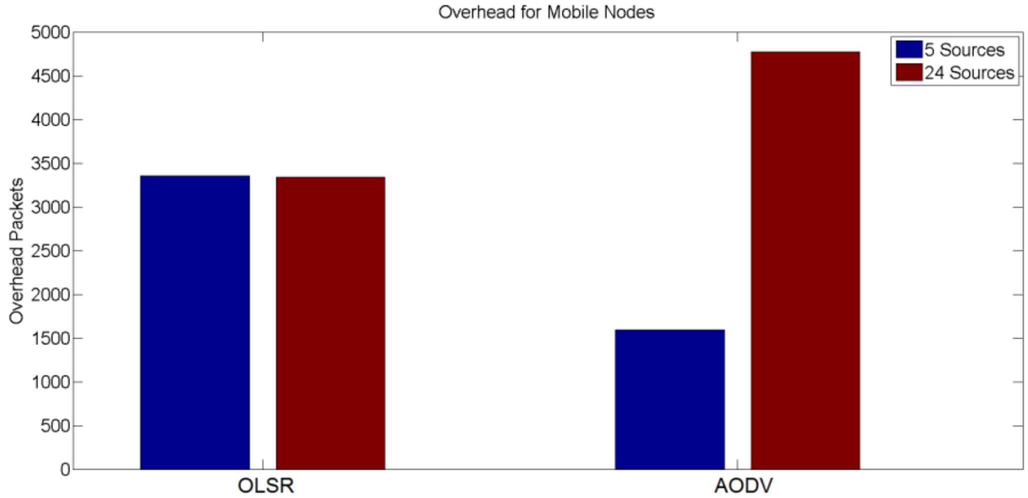
AODV

- $o_r \mu a L N^2 + \lambda o_r N^2$

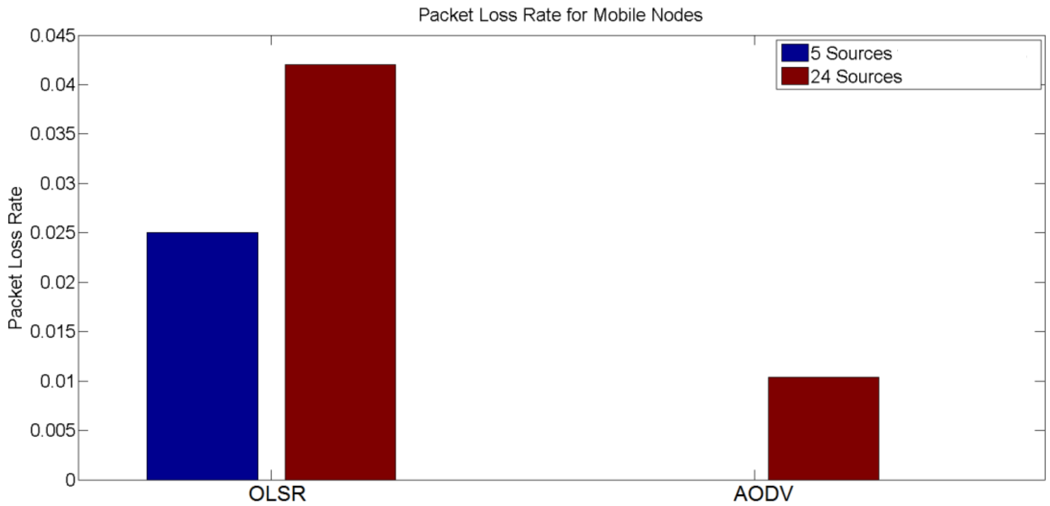
OLSR

- $o_p \mu A N_p N^2 + h_p N + o_p t_p N^2$

Routing Overhead Comparison - Simulative



Control Overhead with Mobility



Packet Loss Rate with Mobility

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$Cost_{Switch}$: Algorithm Switching Cost

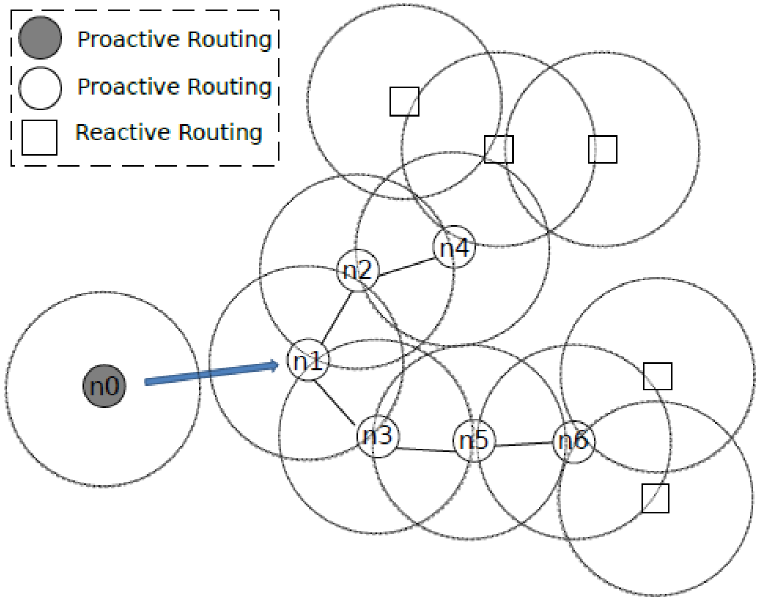
$$Objective: \min(Cost)$$

$$Cost = \alpha Cost_{Switch} + \beta Cost_{Algorithm}$$

$$Cost_{Switch} = \mathrm{f}_s^{Switch}(Overhead_{Switch}^{CtrlMsg})$$

$$Cost_{Algorithm} = \mathrm{f}_s^{Algorithm}(Overhead_{Algorithm}^{CtrlMsg}(t))$$

- Node joins or leaves a proactive sub-network
  - Broadcast through the sub-network
- Switching cost is determined by the proactive routing algorithm



Conclusions and Future Work

- Conclusions
  - Propose self adaptive routing framework
  - Adapt an analytical model based on cost functions
  - Provide detailed expressions for $Cost_{Algorithm}$
  - Estimate depending on protocol and scenario
- Future Work
  - Determine the scaling factors o_r and o_p analytically
  - Adapt the parameters to typical fire fighting scenarios

Question?