A Biologically Inspired QoS Routing Algorithm for Mobile Ad Hoc Networks

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Outline

- Introduction
- EARA-QoS
- Simulation
- Conclusion

Introduction(1/3)

- MANET is very flexible and suitable for applications such as temporary information sharing.

- However, multi-hop routing, random movement of mobile nodes and other features unique to MANETs lead to enormous overheads for route discovery and maintenance.

Introduction(2/3)

- Besides, given the nature of MANETs, it is difficult to support realtime applications with appropriate QoS.

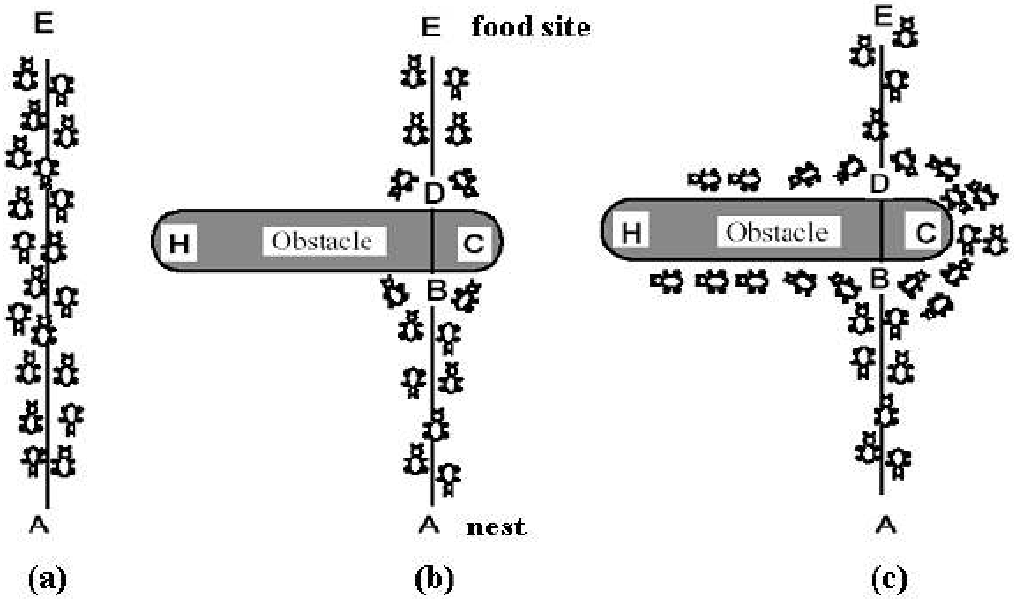
- But at the same time, QoS is of great importance in MANETs.

Introduction(3/3)

- In this paper, we propose a new version of the self organised Emergent Ad hoc Routing Algorithm with QoS provisioning (EARA-QoS)

EARA-QoS

- EARA-QoS(Emergent Ad hoc Routing Algorithm with QoS providing)



EARA-QoS(Cont.)

- Positive feed back:to reinforce existing pheromone on good paths
- Ant-like pakcet: to find new path
- Artificial pheromone
- Negative feed back:to decay the pheromone

EARA-QoS(Cont.)

Probabilistic routing table	**Neighbourhood1(j)**	**Neighbourhood2(k)**
DestinationA	*Routing probability (Pi,j,A)*	*Pi,k,A*
DestinationB	*Pi,j,B*	*Pi,k,B*
DestinationC	*Pi,j,C*	*Pi,k,C*
DestinationD	Pi,j,D	Pi,k,D

Pheromone table of node i	**Neighbourhood1(j)**	**Neighbourhood2(j)**
DestinationA	pheromone value	pheromone value
DestinationB	pheromone value	pheromone value
destinationC	pheromone value	pheromone value
destinationD	pheromone value	pheromone value

EARA-QoS(Cont.)

The following control packets are used in EARA-QoS to perform routing computation:

- Route Request Packet (RQ)
- Route Reply Packet (RP)
- Reinforcement Signal (RS)
- Local Foraging Ant (LFA)
- Hello Packet (HELLO)

EARA-QoS(Cont.)

- *1) The Average MAC Layer Utilisation*

$$\phi_i = \frac{\sum T_{busy}}{T_{mac}}, \qquad T_{busy} \subseteq T_{mac} \qquad (1)$$

- *2) The Transmission Queue :*

$$\eta_i = \frac{q_i}{q_{max}} \qquad (2)$$

$$\eta_{i,n} = 1 - \frac{q_{i,n}}{\sum_{l \in \mathcal{N}_i} q_{i,l}} \qquad (3)$$

EARA-QoS(Cont.)

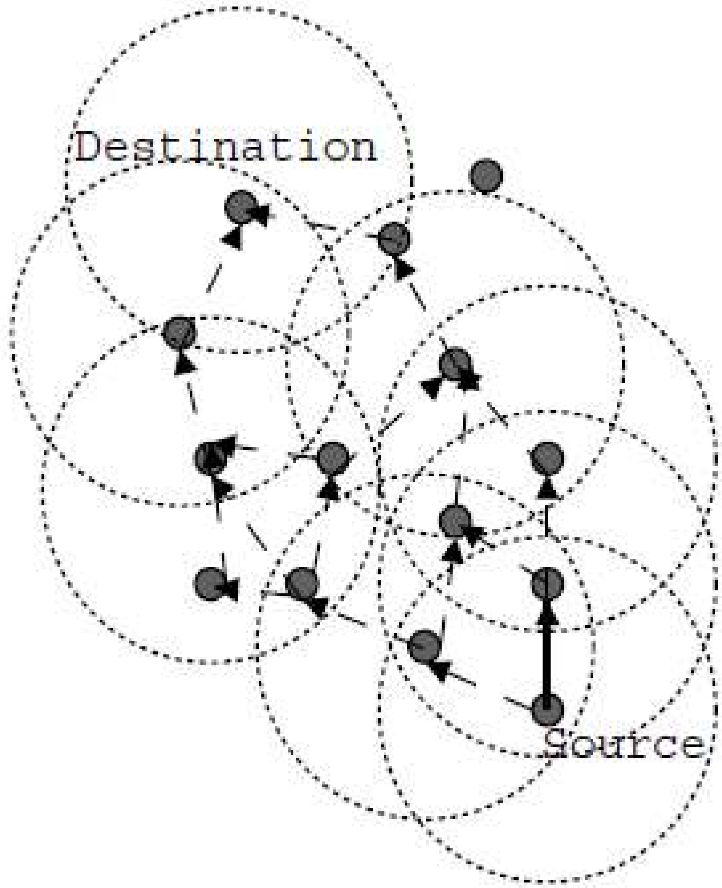
- *3) The Average MAC Layer Delay*

$$\tilde{D}_{i,j} = \frac{a}{\sum D_{i,j}^{t}}, \qquad t \subseteq T_{mac} \qquad (4)$$

- *Routing probability*

$$P_{i,j,d} = \frac{[\tau_{i,j,d}]^{\alpha}[\tilde{D}_{i,j}]^{\beta}[\eta_{i,j}]^{\gamma}}{\sum_{l \in \mathcal{N}_i}[\tau_{i,l,d}]^{\alpha}[\tilde{D}_{i,j}]^{\beta}[\eta_{i,l}]^{\gamma}}, \qquad \tau_{i,j,d} > \mathcal{L} \qquad (5)$$

EARA-QoS(Cont.)



(a) Initial Pheromone Setup

EARA-QoS(Cont.)

- Route Discovery

Node i send RQ > neighbors receive it> p' probability to broadcast it.

$$p' = e^{-\sigma\phi} \quad (6)$$

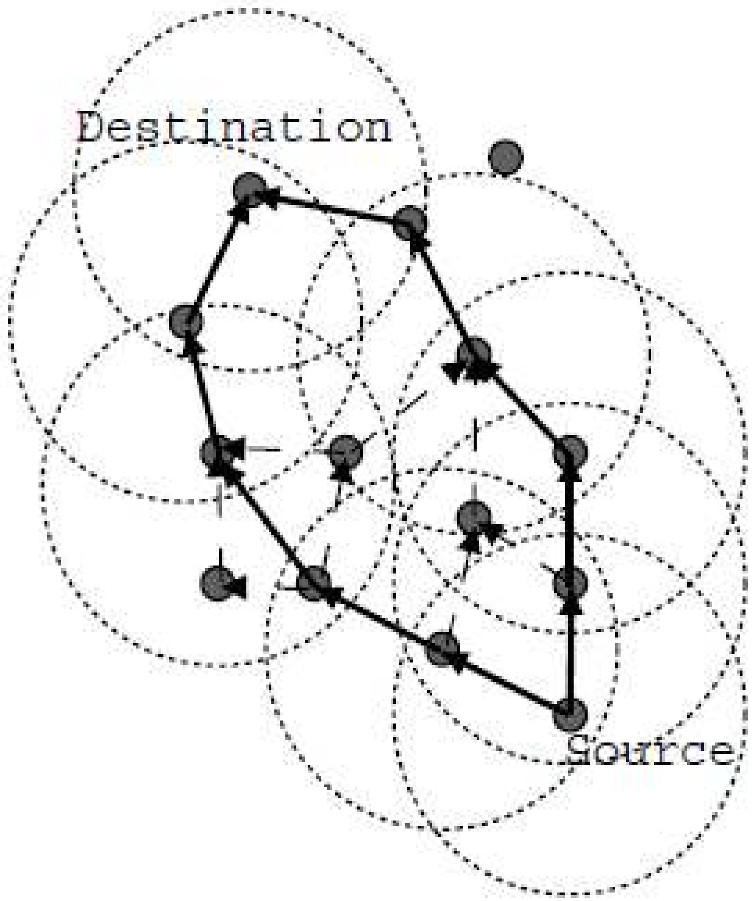
Neighbor node j receive RQ reverse the path to Node i (record previous hop node & source address to message cache)

EARA-QoS(Cont.)

- Node j find a route to destination with pheromone trail > lower bound .

- Node j generates RP , RP routes back to i(source) by reverse route.

EARA-QoS(Cont.)



(b) Path Reinforcement

EARA-QoS(Cont.)

- *Route Reinforcement*

(a)"destination d" send RS to nodes

(b) Node n receives a RS , update its pheromone table and forward RS(based on message cache)

$$\Delta\tau^{\pi}_{n,d} = \mathcal{U} \cdot e^{-(\alpha' \Delta h_s + \beta' \hat{n})} \quad (7)$$

$$\Delta\tau^{\pi}_{i,j,d} = \max(\tau_{j,k,d}) \cdot e^{-(\alpha' \Delta h_{s,j} + \beta' \hat{n}_{j,d} + \gamma' \eta_j)} \quad (8)$$

EARA-QoS(Cont.)

- Negative reinforcement

(Within every time interval T_{decay})

$$\tau_{i,n,d} := (1-\rho) \cdot \tau_{i,n,d}, \qquad \rho \in (0.1]$$

EARA-QoS(Cont.)

- *Local Foraging Ants(LFA)*

Local launches LFA with a time interval Tant search for new route(all pheromone trails below threshold)

- *Local Connectivity Management*

(1)Failure to receive packets form neighborhood in $T_{hel(time)}$, broadcast HELLO packets.

(2)Failure to forward packet to next hop, send RS (set ROUTE_RERR) inform upsteam node failure.

RS assign the link the lower(pheromone) bound.

EARA-QoS(Cont.)

- The QoS Provision Scheme

Admission control at source node

Service classification (use token bucket scheme)

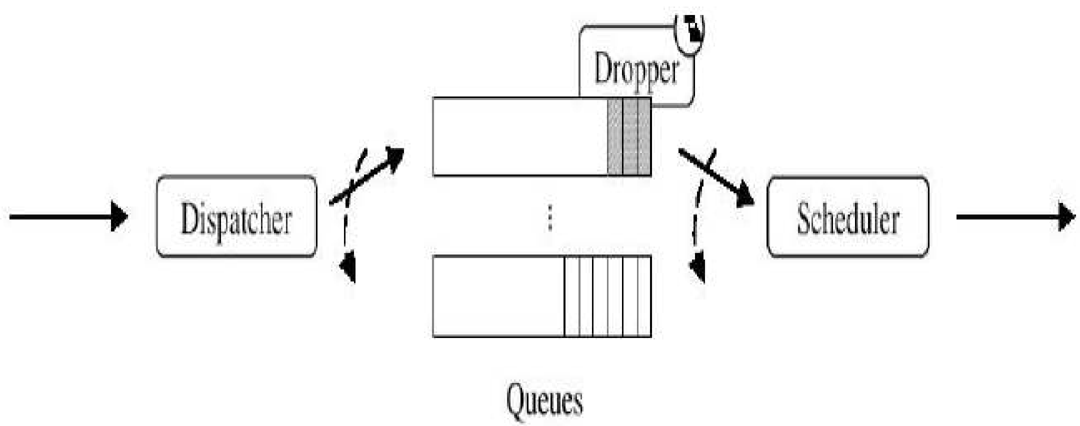


Fig. 3. Overview of Service Differentiation Scheme

Simulations

- Simulation environment
  - ns-2 network simulator(version 2.27)
  - Model simulates Lucent’s WaveLAN:2Mbps bitrate
  - Model transmission range:250 meters
  - Mobility model use Random Waypoint Model
  - Set1: 50nodes in 1000m x 1000m field ,Vmax 2m/s,Vmin 1m/s
  - Set2: 50nodes in 300m x 3500m field ,Vmax 10m/s,Vmin 1m/s
  - Traffic consists
    - Realtime packet: VoIP (CBR 9.6kbits) ,250ms time limit
    - Bulk packet:TCP NewReno , random between 10,000 and 5,000,000 bytes

Simulations(Cont.)

TABLE I

EARA-QoS Parameter Settings

Parameters	Value
Upper Pheromone Bound $\mathcal{U}$	50.0
Lower Pheromone Bound $\mathcal{L}$	0.1
Initial Pheromone Value τ_0	1.0
Pheromone Trail Weight α	1.0
MAC Delay Weight β	1.0
Shortest Hop Weight α'	1.0
Relative Packet Weight β'	1.0
Reinforcement Queue Weight γ'	1.0
Pheromone Decay Factor ρ	0.05
MAC Delay Coefficient a	1.0
Flooding Coefficient σ	1.0
Route Error Timer T_{err}	5.0 sec
Ant Sending Interval T_{ant}	1.0 sec
Contention Window T_{mac}	10.0 sec
Pheromone Decay T_{decay}	1.0 sec
Hello Timer T_{hello}	1.0 sec
Route Discovery Timeout	1.0 sec
Route Expiration Timeout	10.0 sec
Reverse Route Timeout	3.0 sec
Number of Retransmissions	10

Simulations(Cont.)

Packet delivery ratio

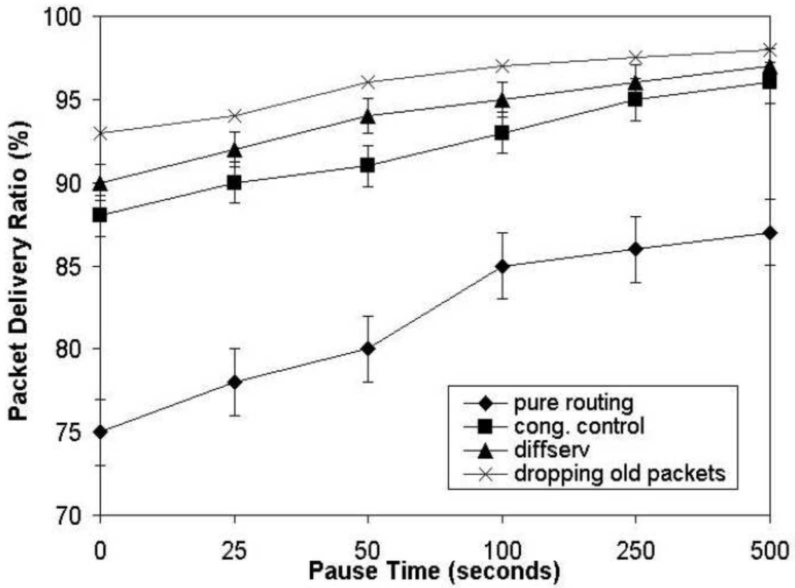


Fig. 4. Simulation of 50 nodes in an area of 1000m×1000m with $v_{max} = 2$ m/sec

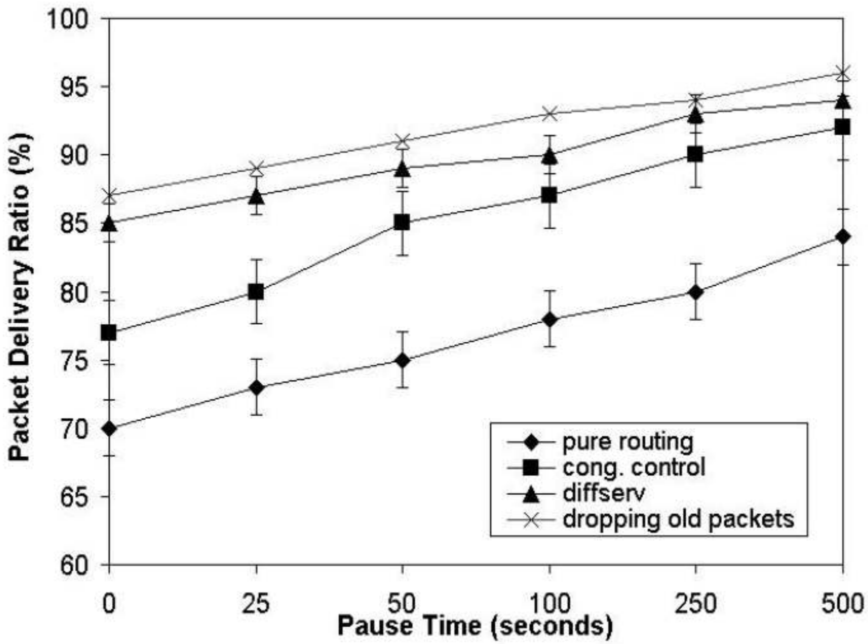


Fig. 5. Simulation of 100 nodes in an area of 300m×3500m with $v_{max} = 10$ m/sec

Simulations(Cont.)

Average Delay

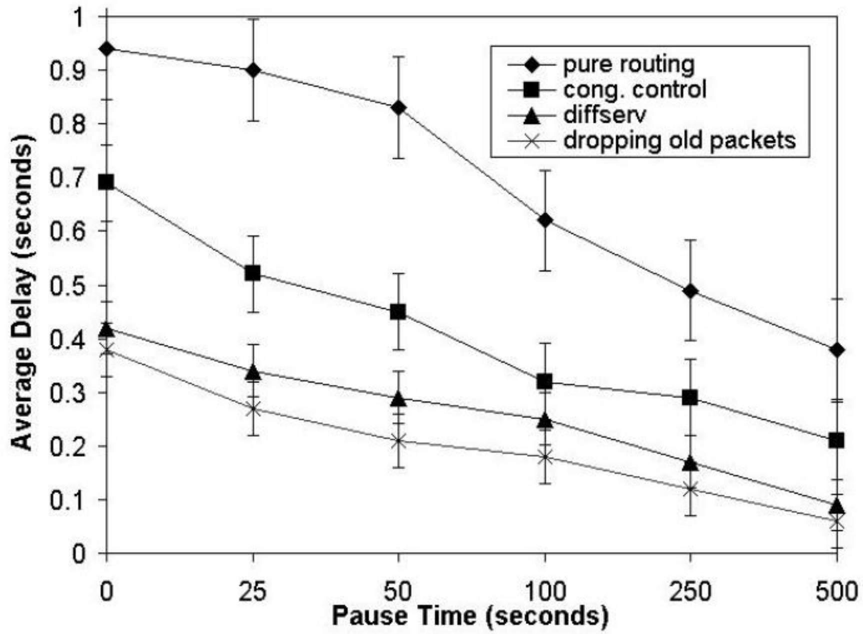


Fig. 6. Simulation of 50 nodes in an area of 1000m×1000m with $v_{max} = 2$ m/sec

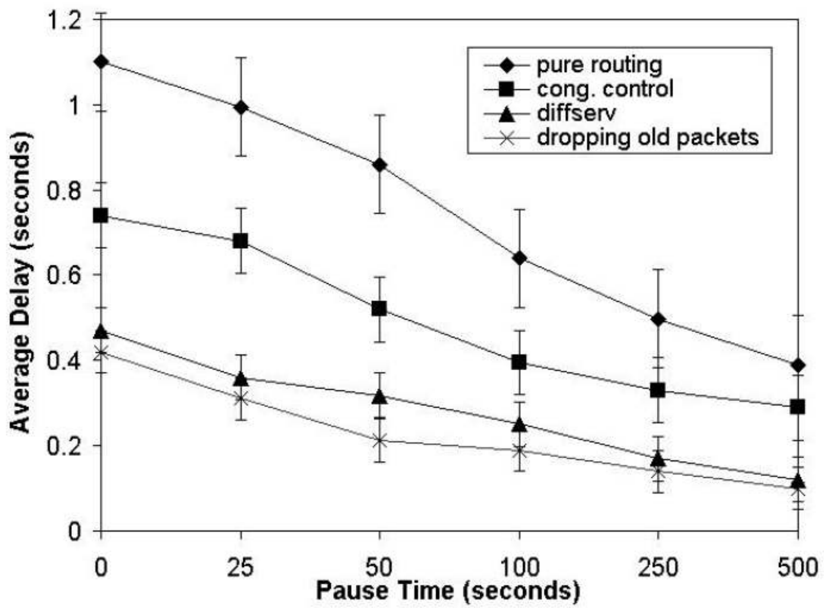


Fig. 7. Simulation of 100 nodes in an area of 300m×3500m with $v_{max} = 10$ m/sec

Simulations(Cont.)

Average delay Jitter

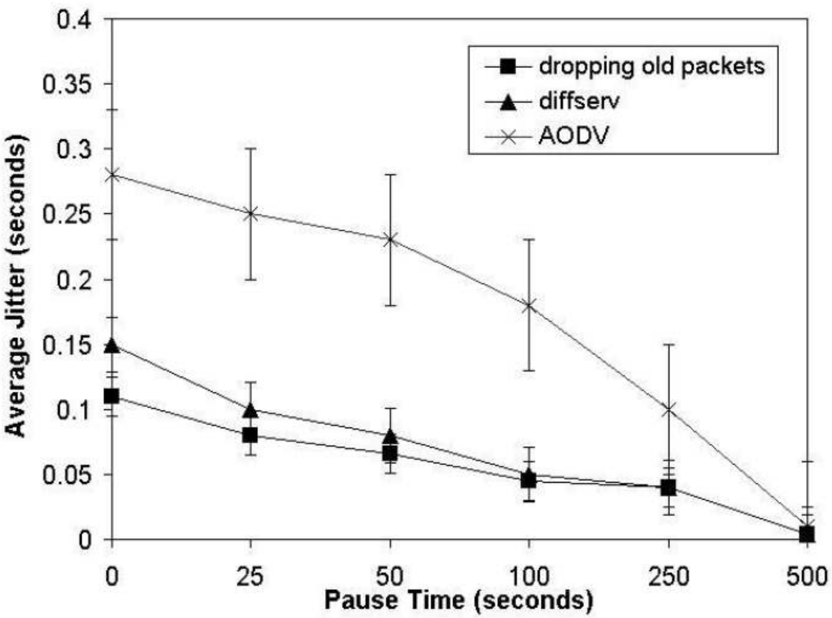


Fig. 8. Simulation of 50 nodes in an area of 1000m×1000m with $v_{max} = 2$ m/sec

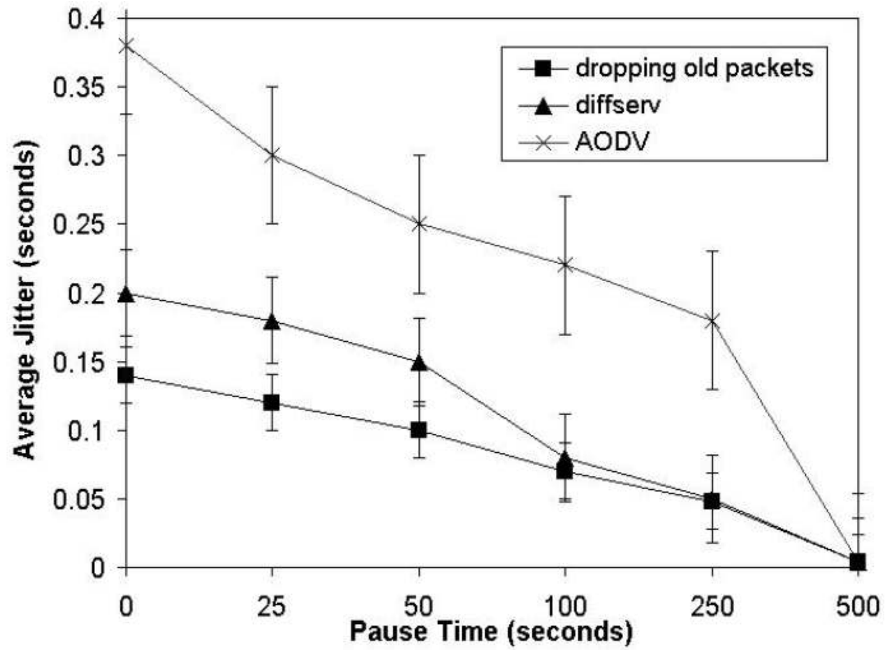


Fig. 9. Simulation of 100 nodes in an area of 300m×3500m with $v_{max} = 10$ m/sec

Simulations(Cont.)

Path optimality

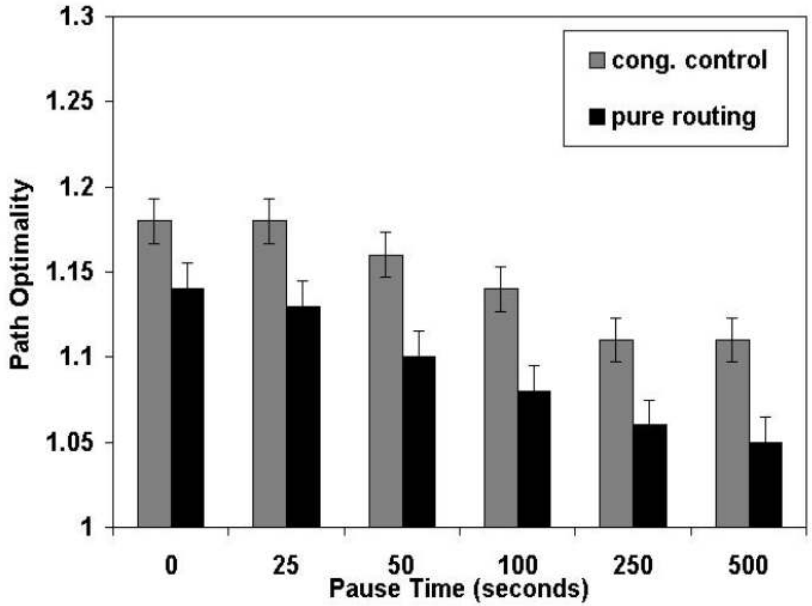


Fig. 10. Simulation of 50 nodes in an area of 1000m×1000m with $v_{max} = 2$ m/sec

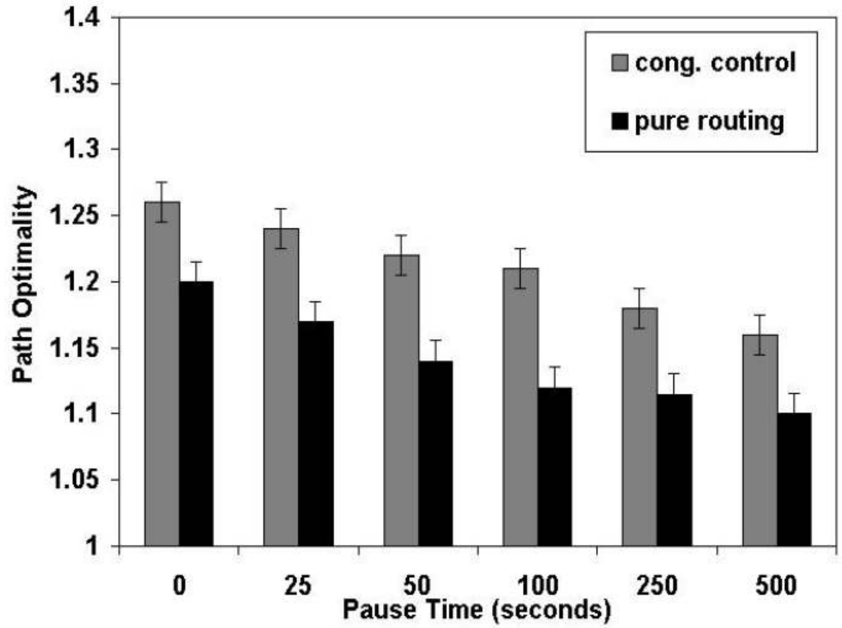


Fig. 11. Simulation of 100 nodes in an area of 300m×3500m with $v_{max} =$ 10 m/sec

Conclusioin

- In this paper we present a biologically inspired routing algorithm for mobile multi-hop ad hoc networks.
- By adopting both the network layer and the MAC layer information it compute routes that avoid the congested areas ; Moreover, a lightweight DiffServ is integrated to provide QoS provisioning exclusively for MANETs.
- Ongoing work seeks to investigate how to optimize the algorithm parameters and how these parameters are related to network environment