Simple ant routing algorithm strategies for a (Multipurpose) MANET model

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Ad Hoc Networks(2010)

Outline

- Introduction
- SARA architecture
  - Route discovery
  - Route maintenance
  - Route selection
  - Route repair
- Simulation
- Conclusions

Introduction

- Ant colony optimization
  - Real ants can converge on the shortest path that connects their nest to a source of food.
  - While moving, the ants deposit the "pheromones" and tend to follow the paths with the highest intensity of pheromones

SARA architecture - route discovery

- In the traditional ACO
  - The source node starts a route discovery process by sending Forward ANT (FANT) packet
  - The destination node will send another packet back, the Backward ANT (BANT)
- CNB (controlled neighbor broadcast)
  - Each node broadcasts the FANT to all of its neighbors, but only one of them broadcasts the FANT again
  - The policy used is to select different nodes each time a FANT is generated using a probabilistic approach.

SARA architecture - route discovery

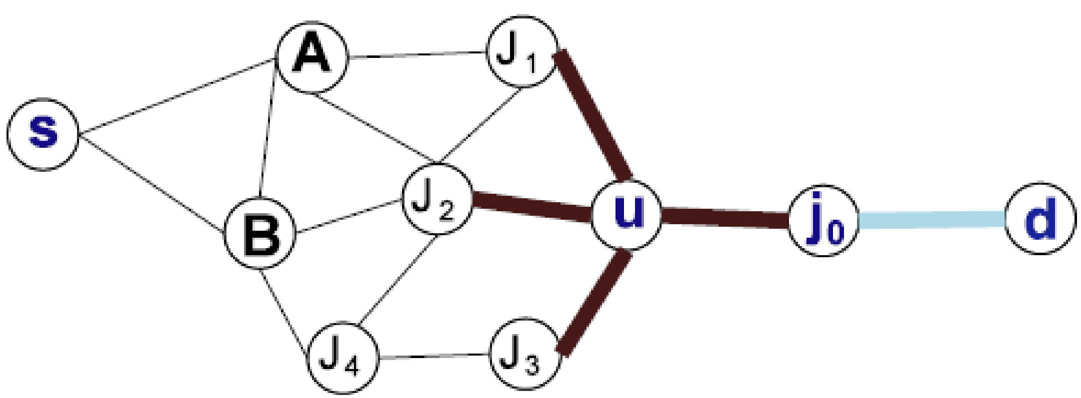
The probability

$$\forall j_i \in Adj[u], \exists p_{(u,j_i,d)} :$$

$$p_{(u,j_i,d)} = \frac{C_{(u,j_i,d)}}{\sum_{k=0}^{k=M} C_{(u,j_k,d)}} \wedge C_{(u,j_i,d)} = \frac{1}{1+n},$$

n is number of times the link was selected

M is the number of adjacencies of node u



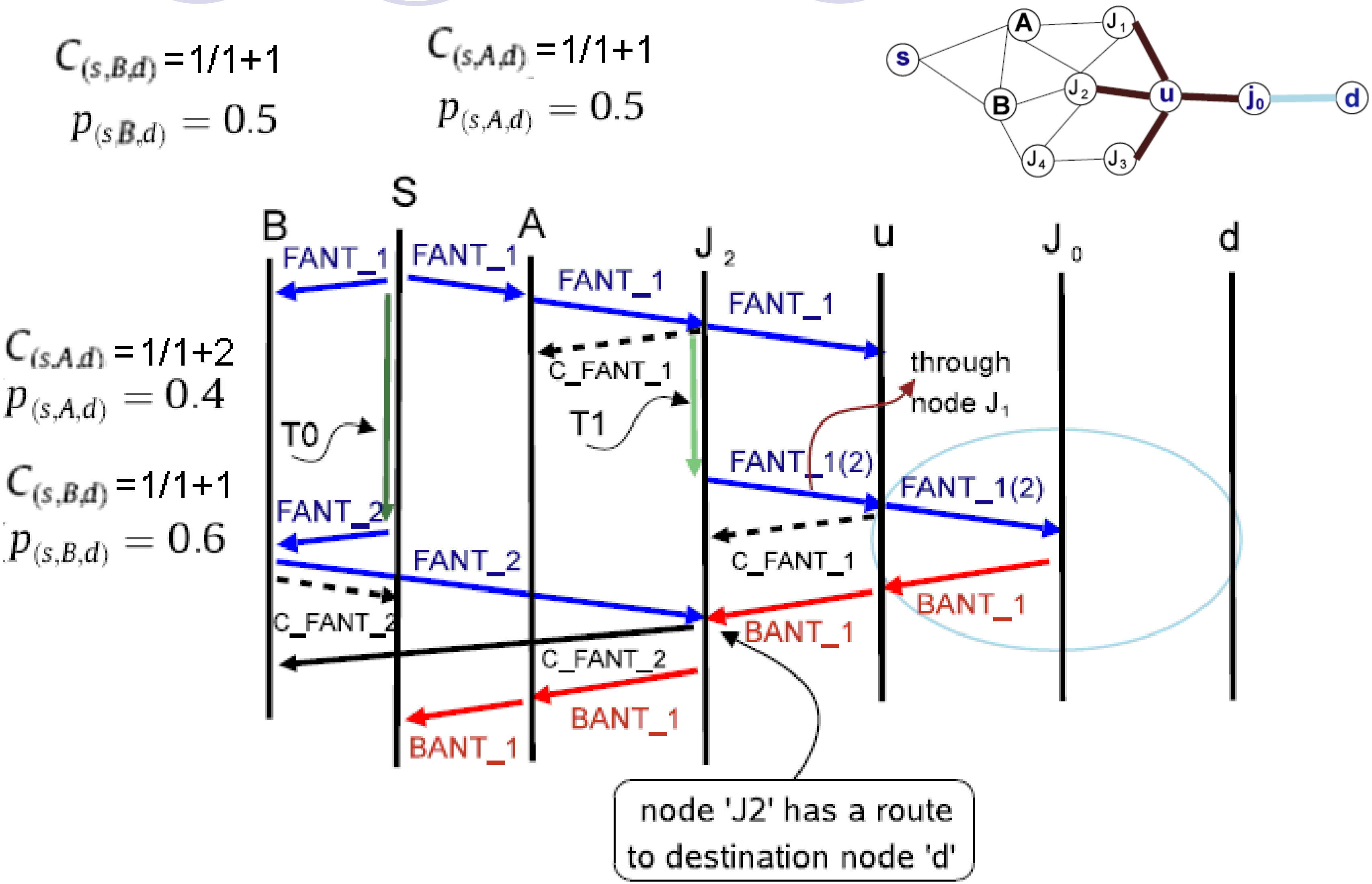
SARA architecture - route discovery

- Two timers
  - Route discovery confirmation timer (T0)
    - The timer is initiated by the source node
    - If the timer ends and the source node does not have a route to the destination, a new FANT is created
  - FANT confirmation timer (T1)
    - The timer is initiated by all network nodes which are responsible for forwarding the FANT
    - The timer is cancelled upon the reception of an acknowledgment packet (C_FANT_n) sent by the next forwarding node
    - If the timer expired, a copy of the FANT is transmitted.

SARA architecture - route discovery

- When receiving the FANT message, any node with destination route information must generate a BANT
- The FANT message continues traveling in the network until
  - It reaches the destination node
  - The node responsible to forward the FANT has a valid route to the destination node
- All nodes that received the FANT have the responsibility to update the source node route entry, this is used to form the network topology

SARA architecture - route discovery



SARA architecture - route maintenance

- Pheromone level
  - An indicator of the activity and the quality of a link
- Increase pheromone intensity
  - Every packet (data or control) that crosses a link increases the pheromone intensity by α
- Decrease pheromone intensity
  - As time goes, the pheromone level decreases automatically by γ

SARA architecture - route maintenance

- Increase

$$\forall pkt(T_i), ph_{(u,j,T_i)} = ph_{(u,j,t)} + \alpha,$$

$$\text{where}:$$

$$t = T_{i-1}, \quad \text{if } T_{i-1} > \tau_{i-1}$$

$$t = \tau_{i-1}, \quad \text{if } T_{i-1} < \tau_{i-1}$$

- Decrease

$$\forall pkt(\tau_i),$$

$$ph_{(u,j,\tau_i)} = \begin{cases} ph_{(u,j,T_i)} - \gamma, & ph_{(u,j,T_i)} > \gamma, \\ 0, & ph_{(u,j,T_i)} \leqslant \gamma. \end{cases}$$

SARA architecture - route maintenance

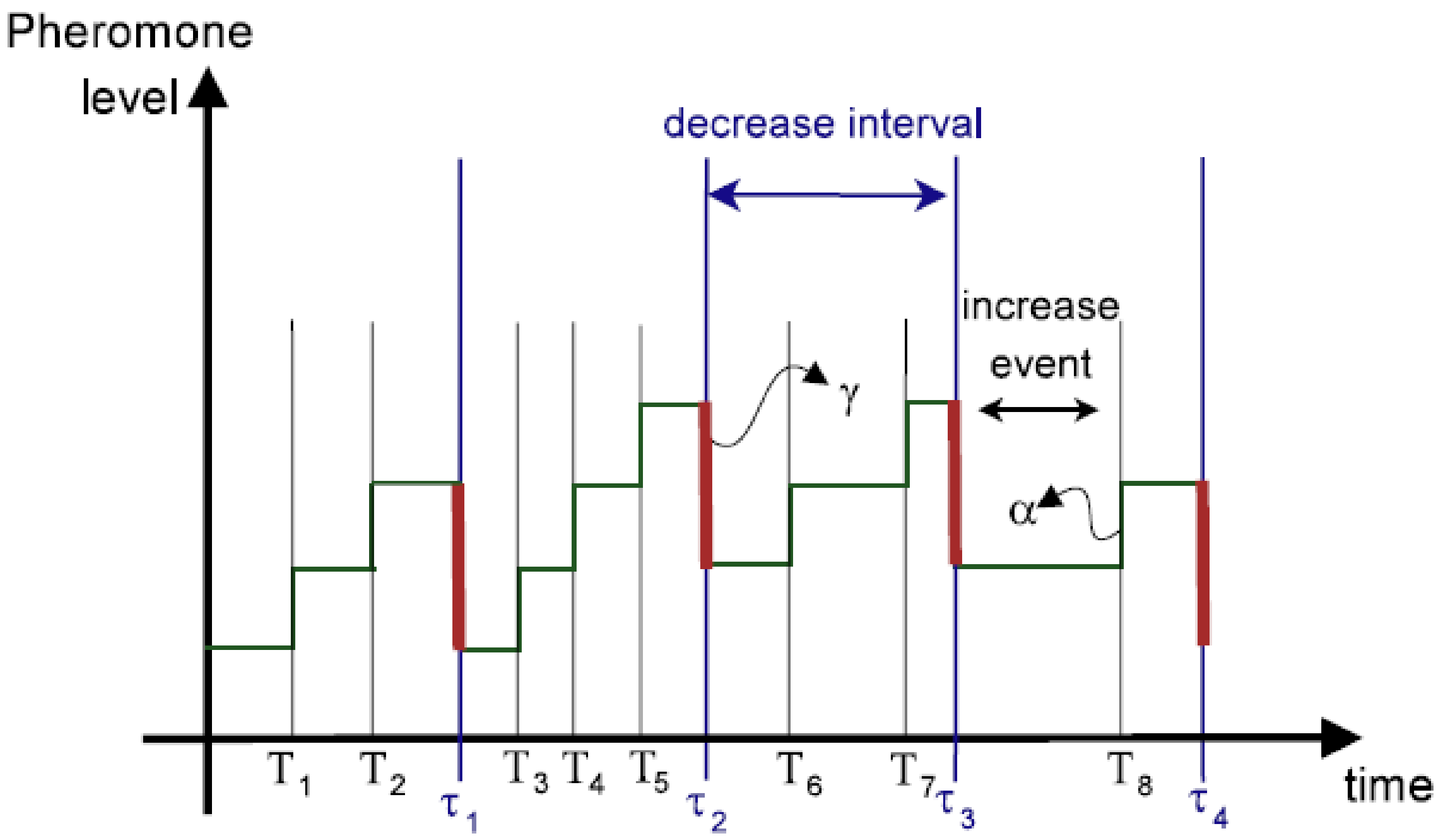


Fig. 3. Pheromone level evaluation.

SARA architecture - route selection

- The route selection is a probabilistic procedure used to choose the next hop to forward traffic to the destination

$$\forall j_i \in Adj[u], \exists p_{(u,j_i,d)} : p_{(u,j_i,d)} = \frac{\Phi_{(u,j_i,d)}}{\sum_{k=0}^{k=M} \Phi_{(u,j_k,d)}}$$

$$\Phi_{(u,j_i,d)} = \frac{(ph_{(u,j_i,d)} + 1)^F}{e^{nh_{(j_i,d)}}}$$

$nh_{(j_i,d)}$ is the number of hops from node j to destination node d

SARA architecture - route repair

- To detect a broken link, SARA calculates MAX_Tx that indicates maximum transmission attempts

$$NTx_{(u,j,t_i)} = \begin{cases} NTx_{(u,j,t_{i-1})} + \lambda & \text{if unsuccessful transmission,} \\ NTx_{(u,j,t_{i-1})} - \delta & \text{if successful transmission.} \end{cases}$$

$$NTx_{(u,j,t_i)} > MAX\_Tx.$$

SARA architecture - route repair

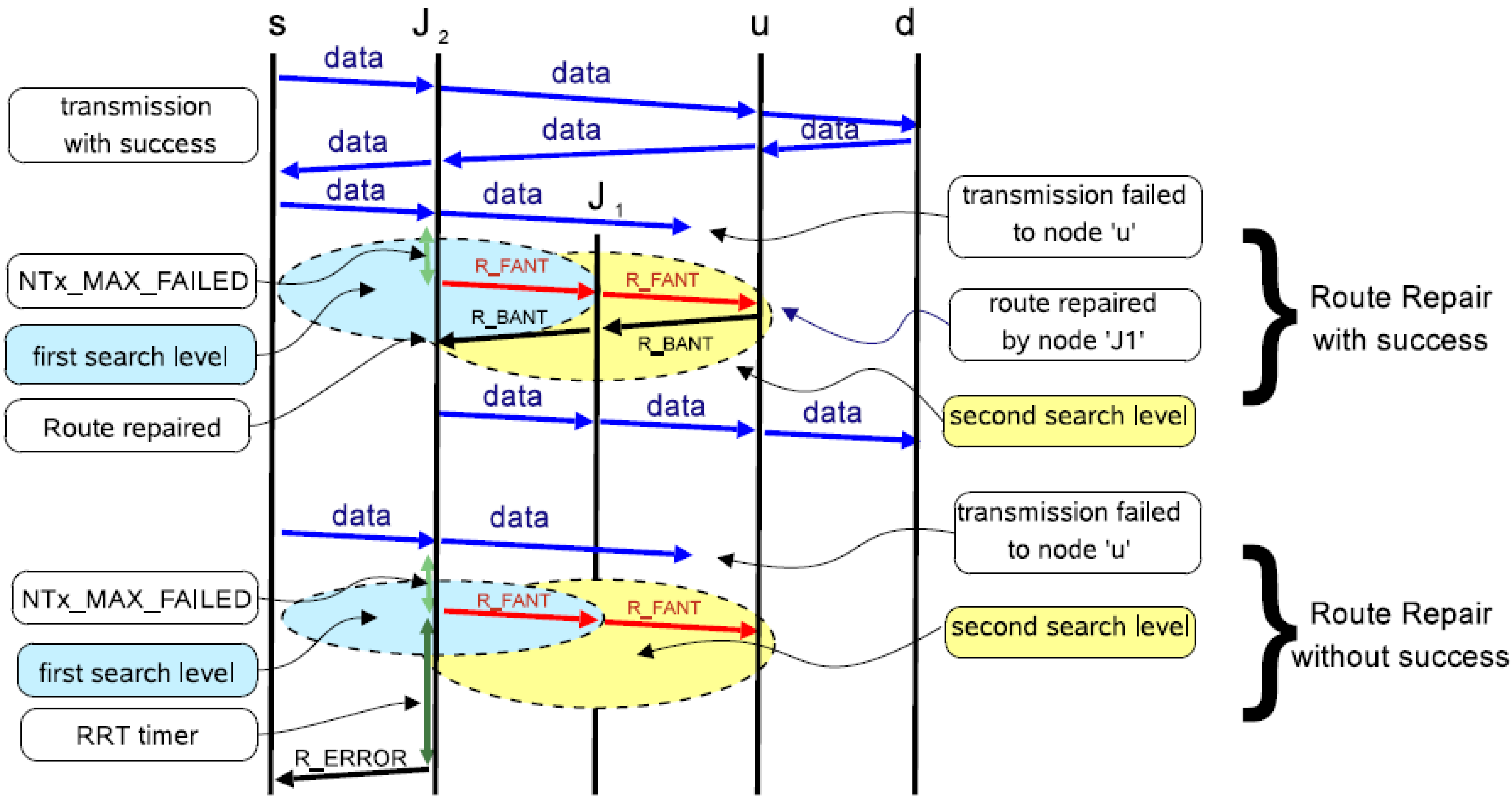


Fig. 4. Route repair procedure.

Simulation

- Setup
  - The simulations were implemented on NS2
  - Transmission range 100 m
  - Transmission rate 2Mbps
  - 1000 m * 1000 m for 104 nodes
  - Simulation time 60 s

Table 2
SARA's reference values.

Parameter	Reference value
F	5
T0	100 ms
T1	100 ms
RRT	100 ms
τ	1 s
δ	1.0
MAX_Tx	5

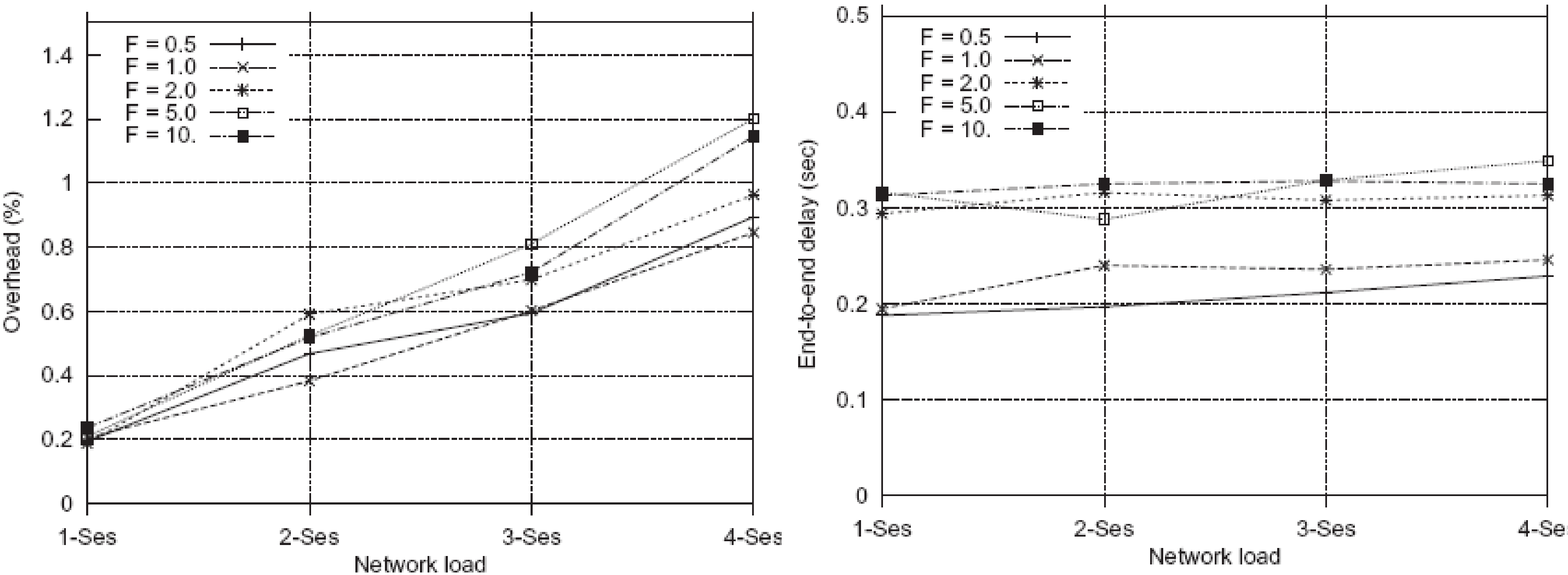
Simulation

- Convergence factor – F
  - It is used by SARA to converge the traffic into one route or to balance the load among multiple routes

Convergence factor (*F*): number of used routes.

N. sessions	*F*				
	0.5	1.0	2.0	5.0	10.0
1	65	32	8	3	2
2	81	45	21	11	11
3	134	62	35	18	15
4	143	80	39	24	24

Simulation



(a) Overhead

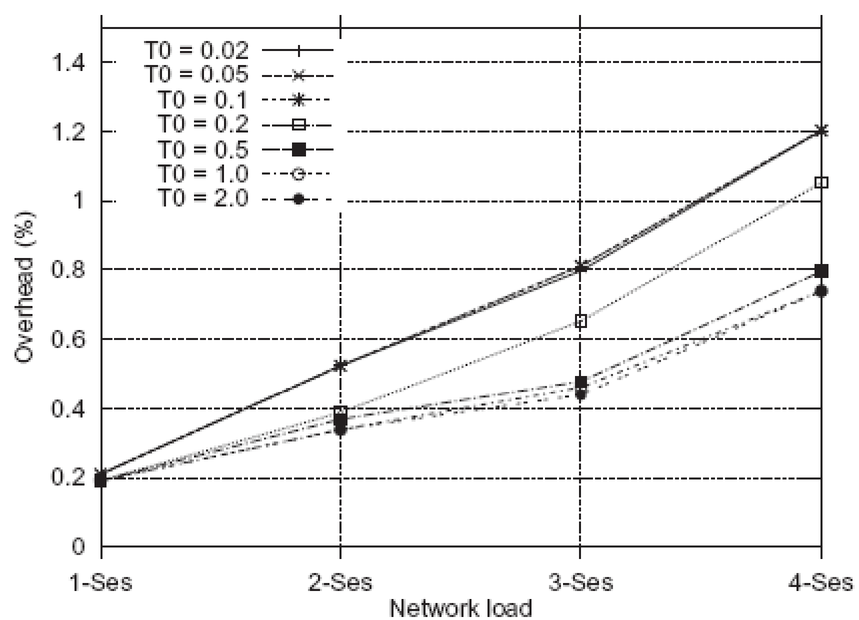
(b) End-to-end delay

Simulation

- FANT generation rate

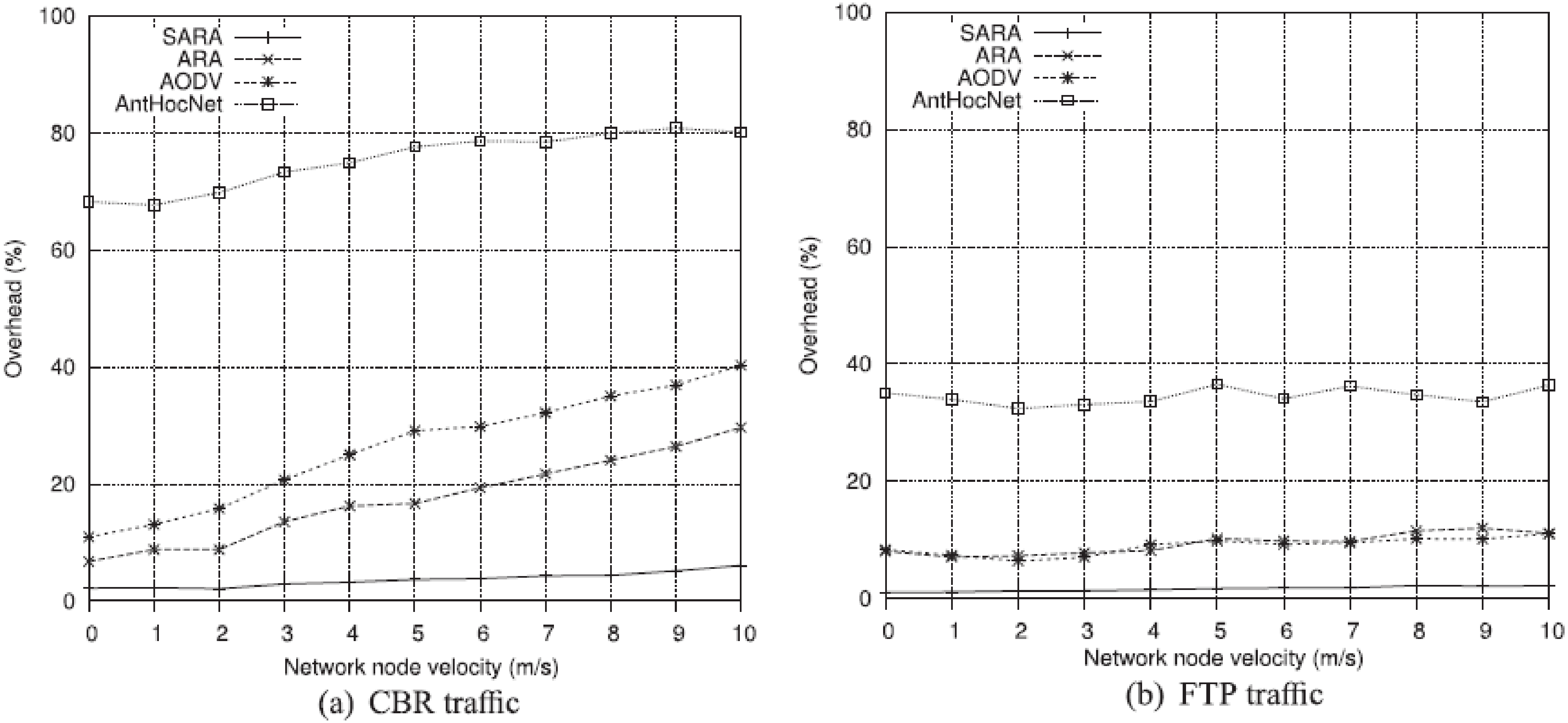
FANT generation rate: number of used routes.

N.sessions	FANT TX rate (T_0)					
	0.1	0.2	0.5	1	2	5
1	3	2	2	2	2	2
2	11	11	11	11	11	11
3	19	17	16	17	17	16
4	23	22	21	21	22	23



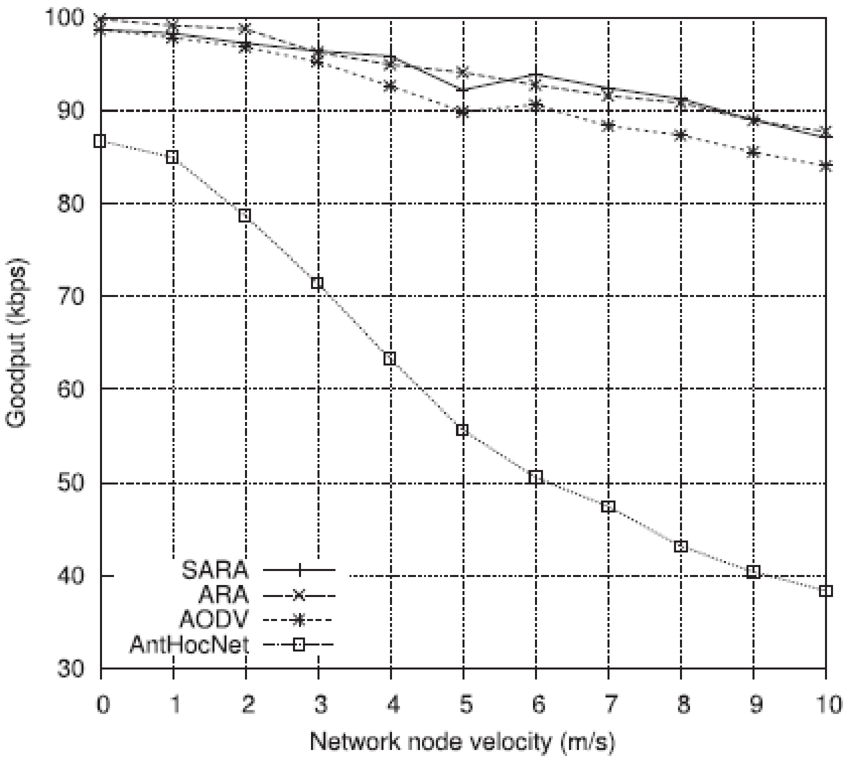
Simulation

Routing protocol overhead

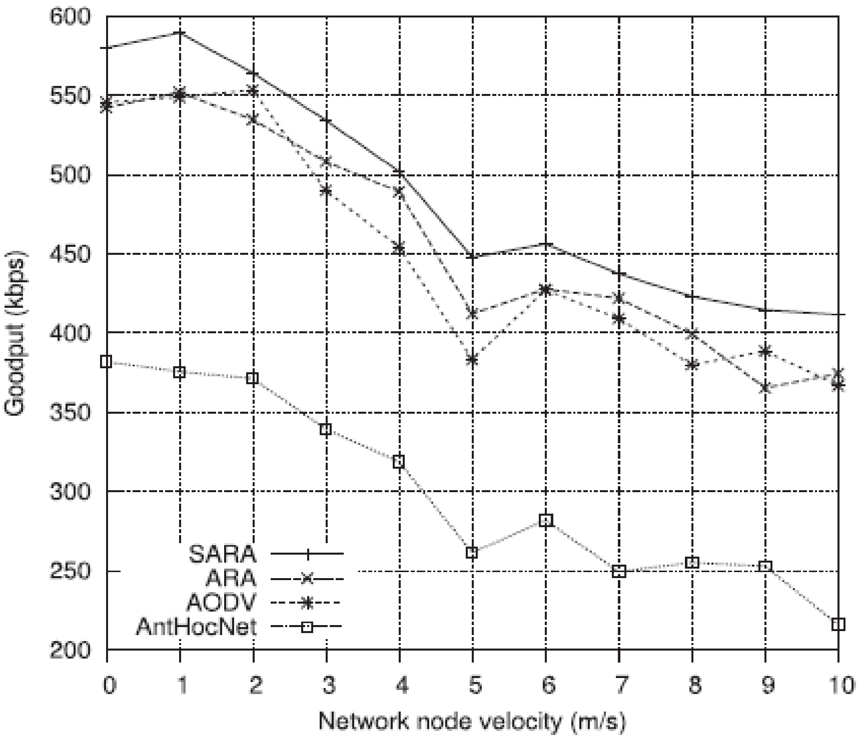


Simulation

Goodput



(a) CBR traffic



(b) FTP traffic

Conclusions

- This paper presents an improved version of the ACO framework, that aims at reducing the overhead by using a new route discovery technique (CNB)

- The results show that small values of F are adequate for heavy loaded networks because of more routes enables load balancing and reduces overhead and collisions

- The future work is to develop an algorithm that can dynamically adapt the convergence factor according to network traffic conditions