A Multi-Copy Delegation Forwarding Based On Short-term and Long-Term Speed in DTNs

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Outline

- **1. Introduction**
- 2. Model Description
- 3. Forwarding Metric
- 4. Forwarding Strategy
- 5. Evaluation

1. Introduction

1.1 Motivation

- The dramatic change of topology and the frequent interruption of connections makes it difficult to forward the message to the destination in delay tolerant networks (DTNs).

- Routing protocols are usually in the store-carry-and-forward paradigm. Nodes prefer maintaining and forwarding messages to some relays with a higher forwarding ability.

- Delegation dorwarding could be used to improve the delivery ratio while reducing the forwarding cost (copy).

1. Introduction

1.2 Problem

- **How to judge the node's forwarding ability:**

  - **Using a utility function, we attempt to determine whether an encounter is better than a message holder; this is referred to as the forwarding metric.**

- **How to decide on the forwarding strategy:**

  - **We use delegation dorwarding for reference, and we propose a multi-copy forwarding strategy according to a new forwarding metric in order to improve the delivery ratio while reducing the forwarding cost.**

1. Introduction

1.3 Challenge

- **The problem becomes how to improve the delivery ratio while reducing the forwarding cost.**

- **Solution： delegation forwarding**

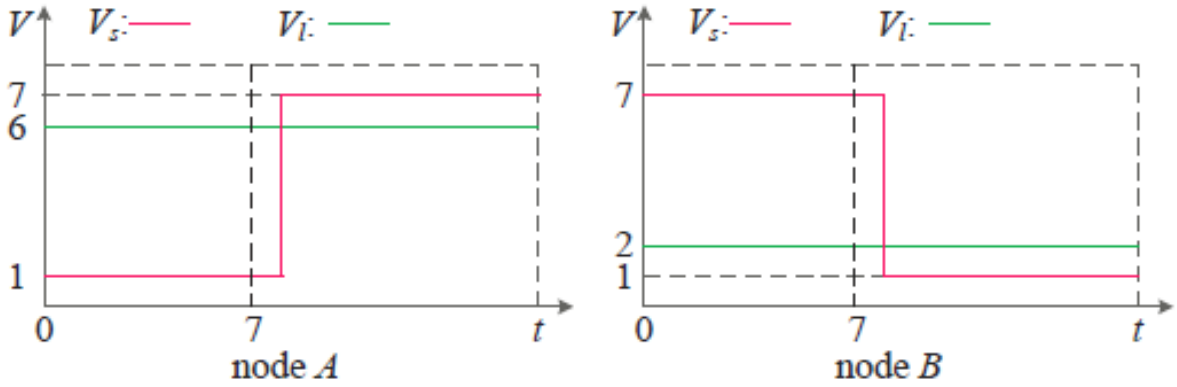
  A node will replicate a message copy only if it encounters another node whose forwarding metric is greater than any seen by the message so far.

- **Usually forwarding metric is average speed or contact frequency.**

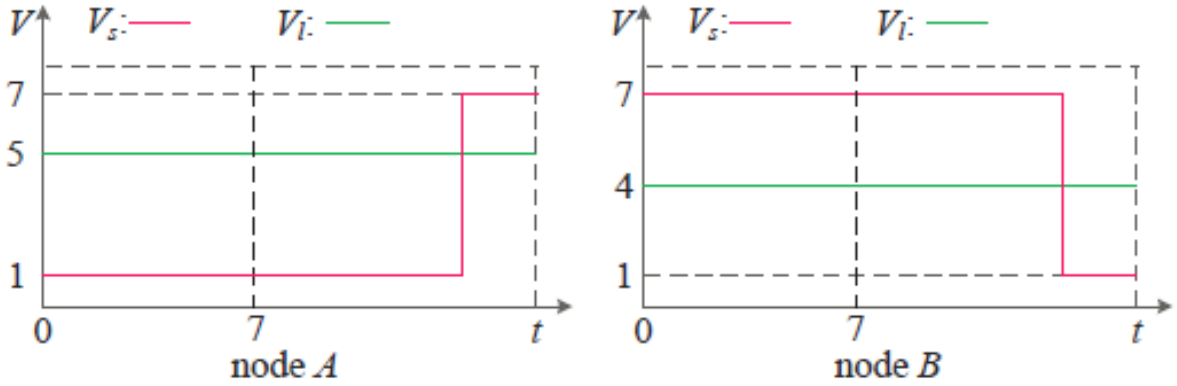
1. Introduction

1.3 Challenge: which average speed should be used?

- **It is necessary to determine a mapping function from the short-term V_s and long-term V_l speeds. A quantified forwarding metric reflects the actual forwarding ability.**



Case 1: according to short-term speed V_s



Case 2: according to long-term speed V_l

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2. Model Description

2.1 Mobility Model

- ***N*** **nodes move in a square area.**

- **Each node repeats its own behavior**

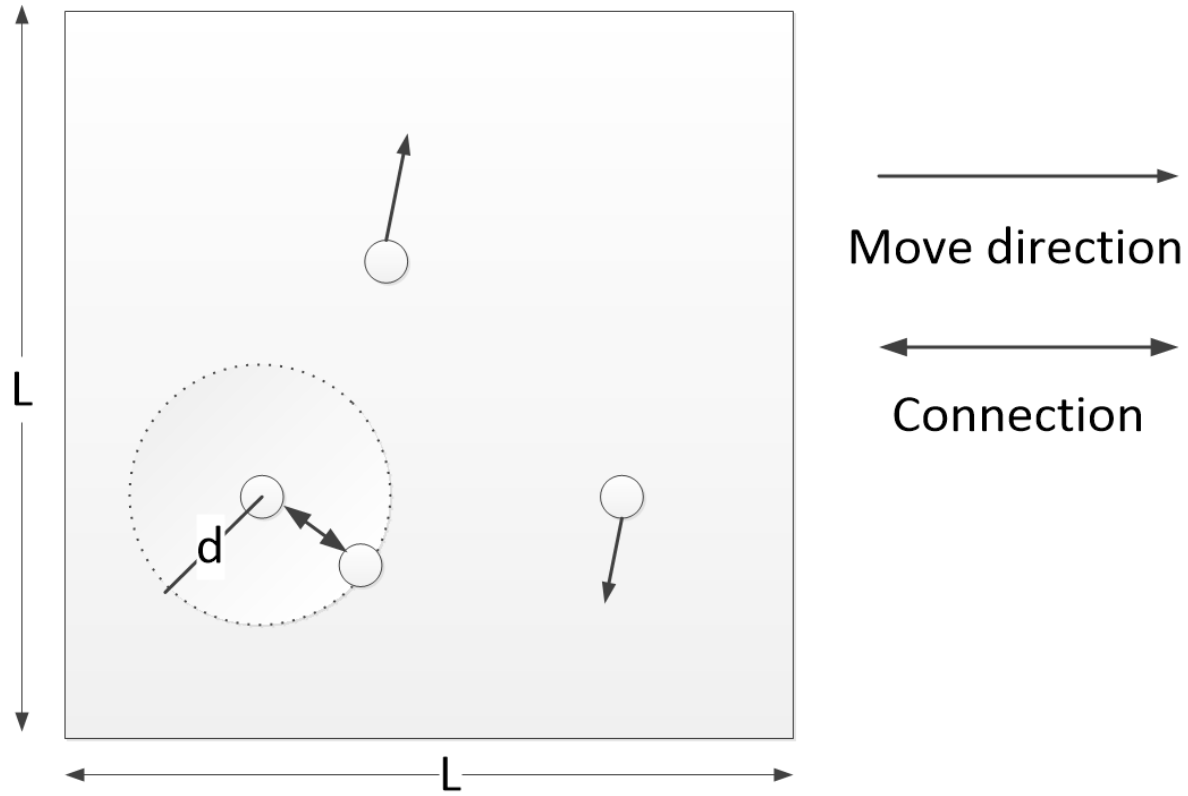
It selects a destination arbitrarily and walks along the shortest path with a fixed speed to reach the destination.

It then stays at the destination for a while.

- **We choose a walking speed with which to reach the destination, and then we stay there to rest. The faster we walk, the longer we may need to rest.**

2. Model Description

2.1 Mobility Model

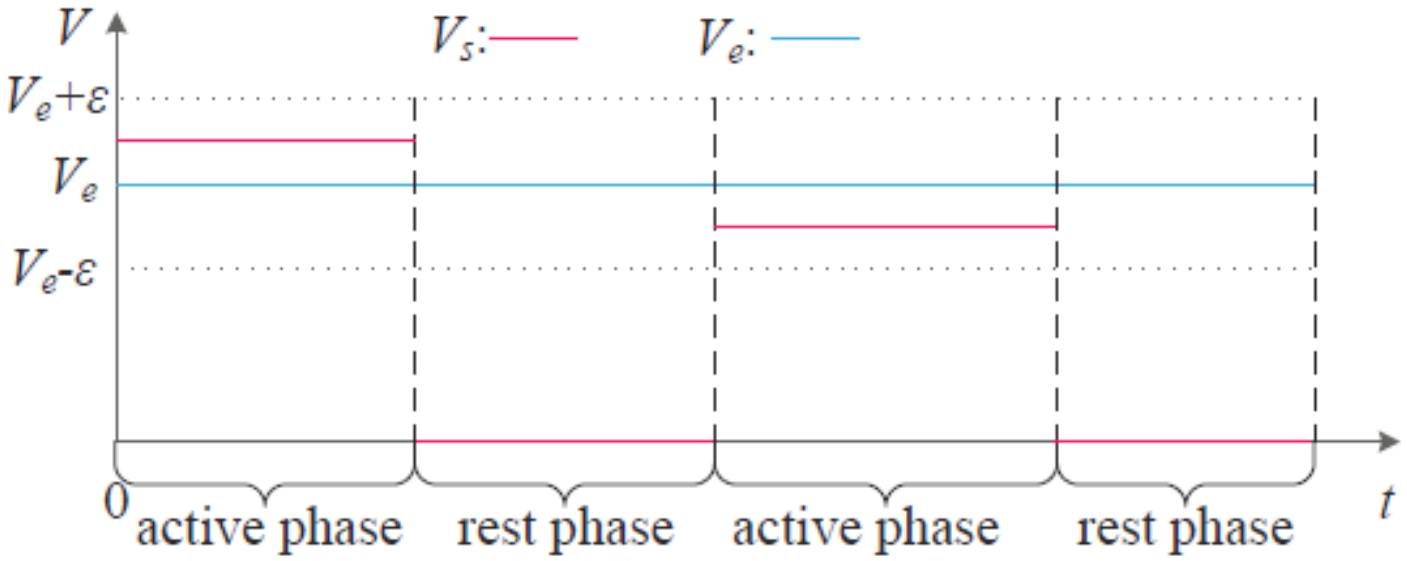


- Each node selects a destination and a speed V_e.
- Walks along the shortest path to reach the destination.
- Rests at the destination for $T_r = \alpha V_e$

2. Model Description

2.1 Mobility Model

- **An example to illustrate the changes of *Vs* and *Ve* during the active and rest phases:**



- ***V_s* is short-term speed from V_e-ε to V_e+ε**
- ***V_e* is uniform distribution from *V_d* (low-bound) to *V_u* (up-bound)**

2. Model Description

2.1 Mobility Model

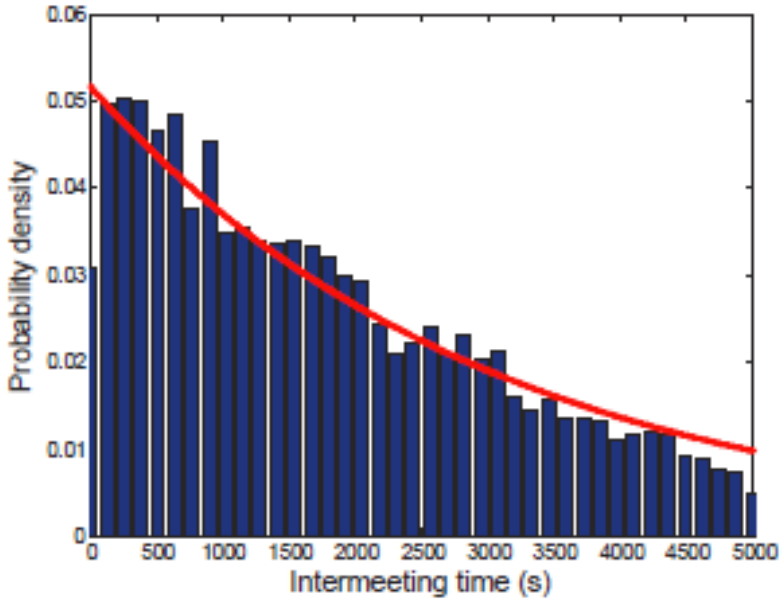


Fig. 4. The intermeeting time's distribution under the improved random-waypoint mobility pattern.

- **λ is the parameter for the exponential distribution of intermeeting times.** $f(x) = \lambda e^{-\lambda x} (x \geq 0)$
- **The expectation of the intermeeting time：** $T = 1/\lambda$

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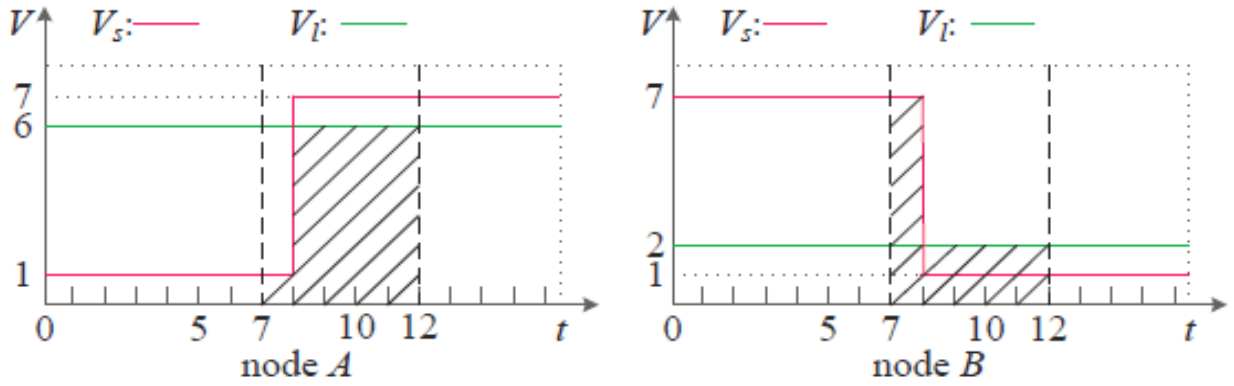
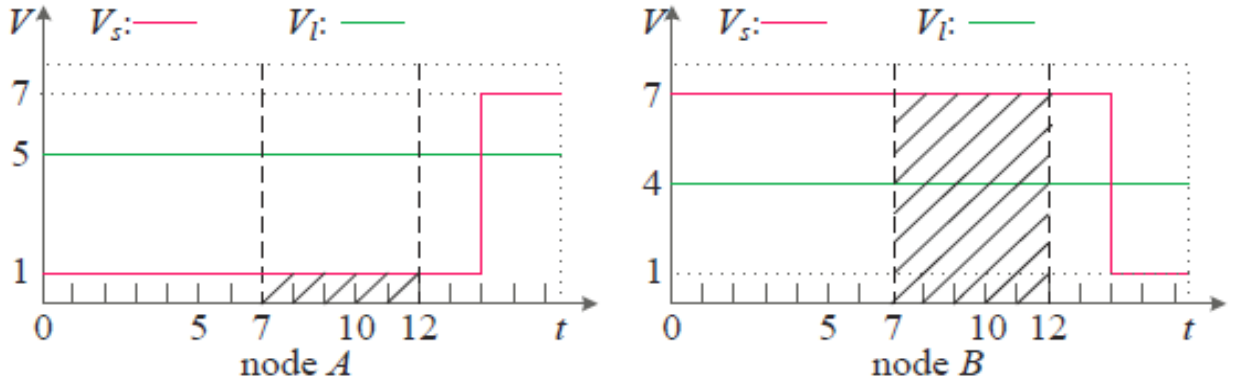
3. Forwarding Metric



Case 1: according to both short-term and long-term speed



Case 2: according to both short-term and long-term speed

Node a and b encounter at 7, and they will encounter a node with a better forwarding ability at 12. The forwarding metric is the average speed from 7 to 12.

3. Forwarding Metric

T_e is the expectation of the intermeeting time for a node to contact another node with a higher forwarding ability

$$T_e = \frac{1}{\lambda_e} = \frac{V_u - V_d}{V_u - V_e} \frac{\pi L^2}{8N\omega d V_e}$$

V_e: The expectation of the short-term speed in a uniform distribution [V_d, V_u]

L: The side length of the square network area

N: The total number of nodes in the network

d: Communication radius

ω: a constant specific

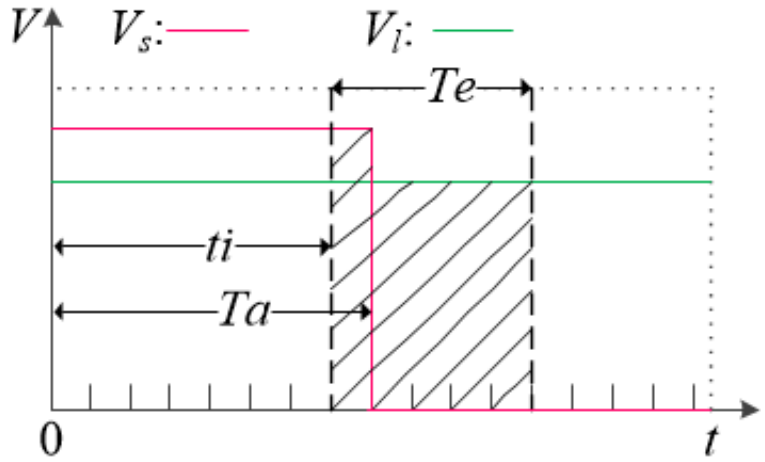
3. Forwarding Metric

3.1 Forwarding metric in the active mode

$$F_a = \begin{cases} V_l & T_a \le t_i \\ V_s & T_a > t_i, T_e \le T_a - t_i \\ \frac{(T_a - t_i)V_s + (T_e - T_a + t_i)V_l}{T_e} & T_a > t_i, T_e > T_a - t_i \end{cases}$$

***Ta*: The expected duration time of the active phase**

***ti*: The interval time between the beginning of the active phase and the current time**



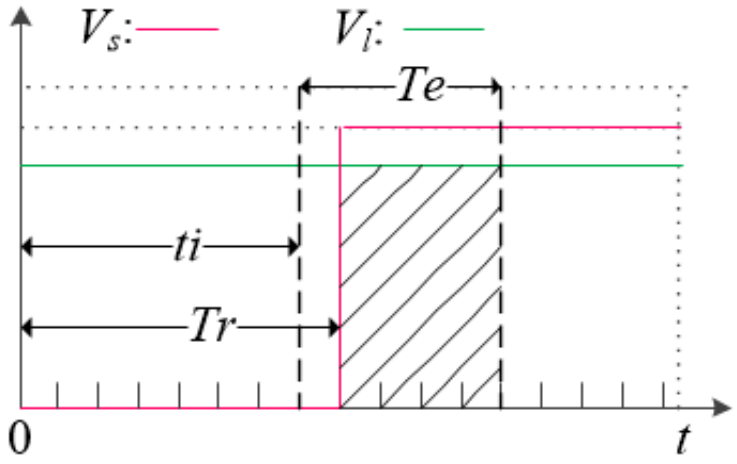
3. Forwarding Metric

3.2 Forwarding metric in the rest mode

$$F_r = \begin{cases} V_l & T_r \le t_i \\ 0 & T_r > t_i, T_e \le T_r - t_i \\ \frac{(T_e - T_r + t_i)V_l}{T_e} & T_r > t_i, T_e > T_r - t_i \end{cases}$$

***Tr*: The expected duration time of the rest phase**

***ti*: The interval time between the beginning of the rest phase and the current time**



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4. Forwarding Strategy

Delegation Forwarding

- **A node will replicate a message copy only if it encounters another node whose forwarding metric is greater than any seen by the message so far.**

DFSL (Delegation Forwarding based on Short-term and Long-term speed): forwarding metric is time sensitive.

- **When node A encounters node B, node A will replicate a message copy to node B if and only if node B's forwarding metric is higher than both node A's current forwarding metric and the highest forwarding metric seen by the message so far.**

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5. Evaluation

5.1 Simulation parameters

TABLE II
SIMULATION PARAMETERS

Parameter	Forwarding Value	
	Metric	Strategy
Simulation Time	5,000s∼10,000s	3,000s∼7,000s
Simulation Area	3,000m×3,000m	
Number of Nodes	60∼140	100∼140
Number of Messages	100	
Transmission Range	10m, 15m, 20m, 25m, 30m	
TTL	5,000s∼10,000s	3,000s∼7,000s
α	0.5	

4. Evaluation

5.2 Five performance metrics

(1) Delivery ratio- The ratio between the number of messages successfully delivered to the destination and the total number of messages generated in the network

(2) Average delay- The average elapsed time of the successfully delivered messages

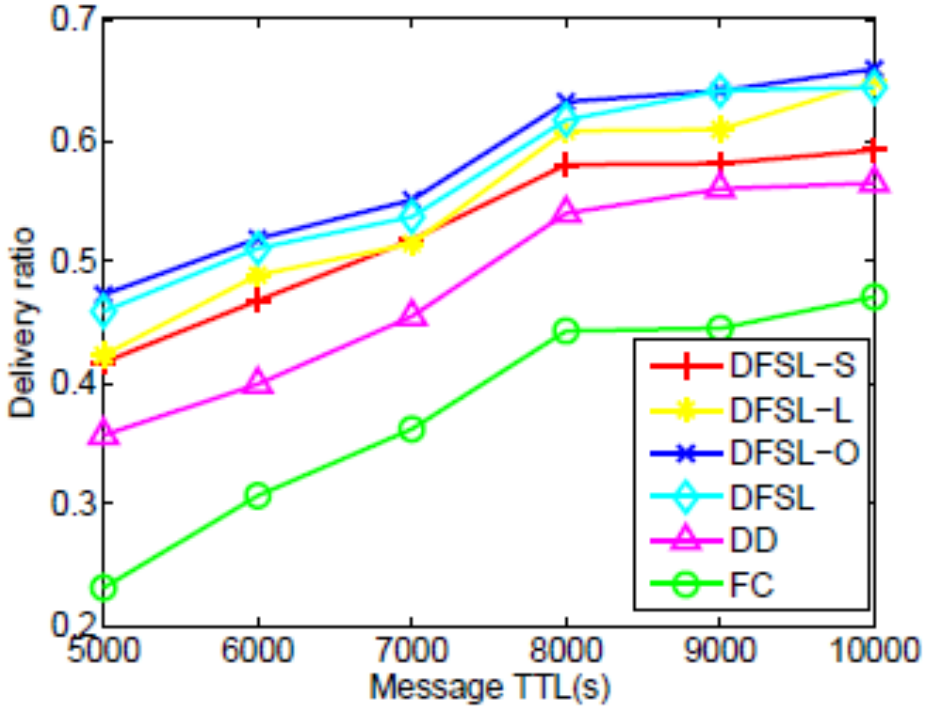
(3) Average hopcounts- The average number of hops for all the messages in a simulation time

(4) Forwarding cost- The average forwarding times for all the generated messages

(5) Forwarding efficiency- The result of the delivery ratio divided by the forwarding cost

4. Evaluation

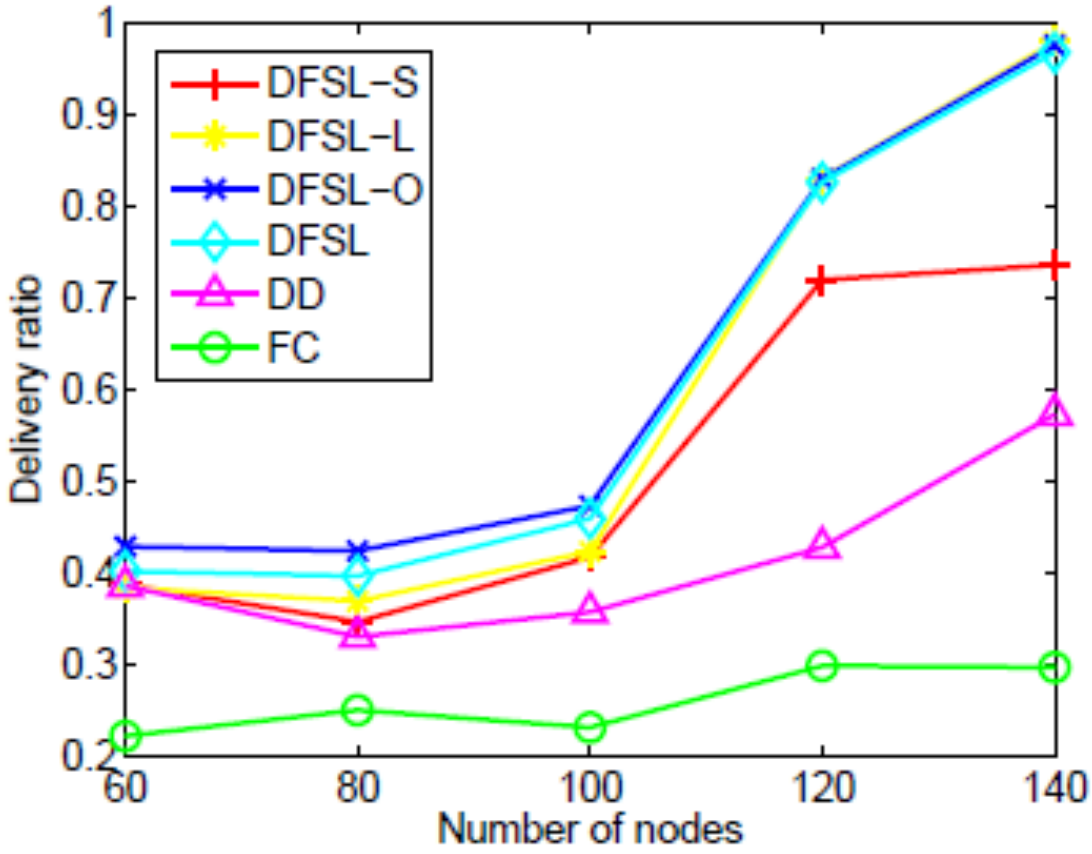
5.3 Single Copy Scheme (Message TTL)



DFSL-S uses the short-term speed as the forwarding metric
DFSL-L uses the long-term speed as the forwarding metric
DFSL-O uses the average speed of an optimal time slice
DFSL Delegation Forwarding based on Short-term and Long-term(DFSL)
DD direct forward to the destination
FC forward to the first encounter

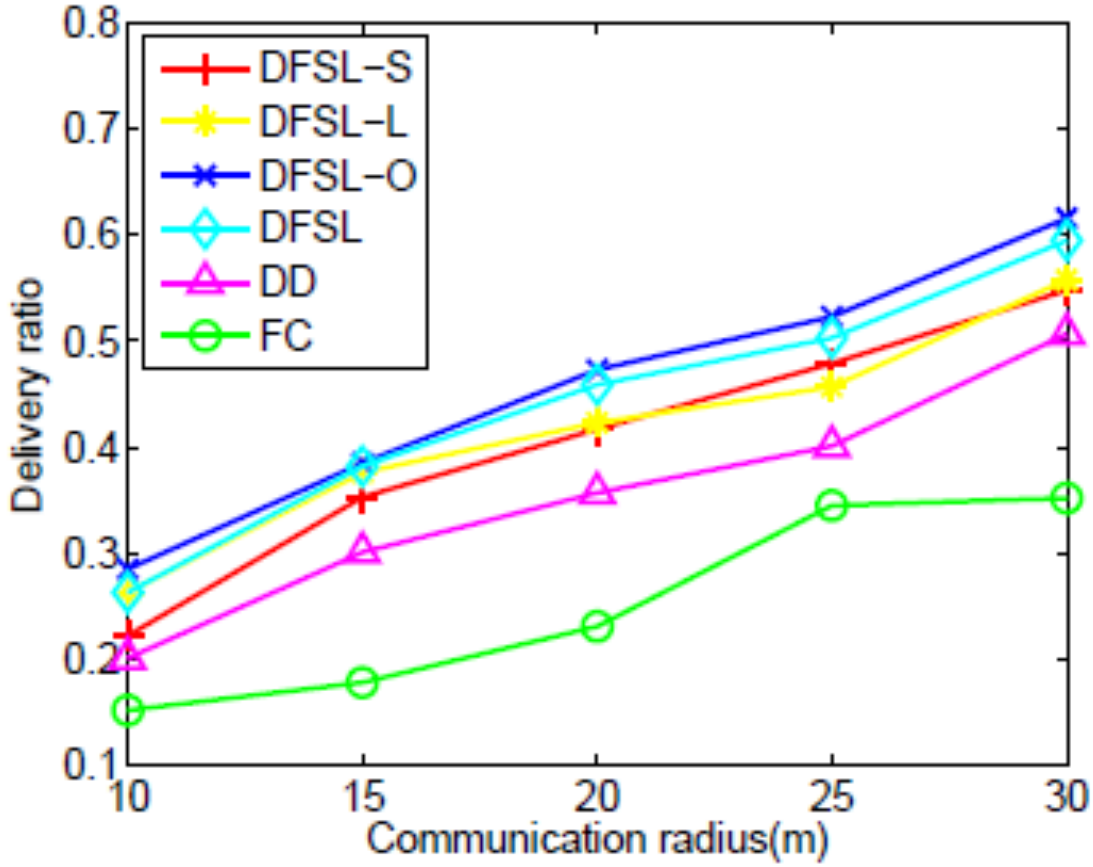
4. Evaluation

5.3 Single Copy Scheme (Number of nodes)



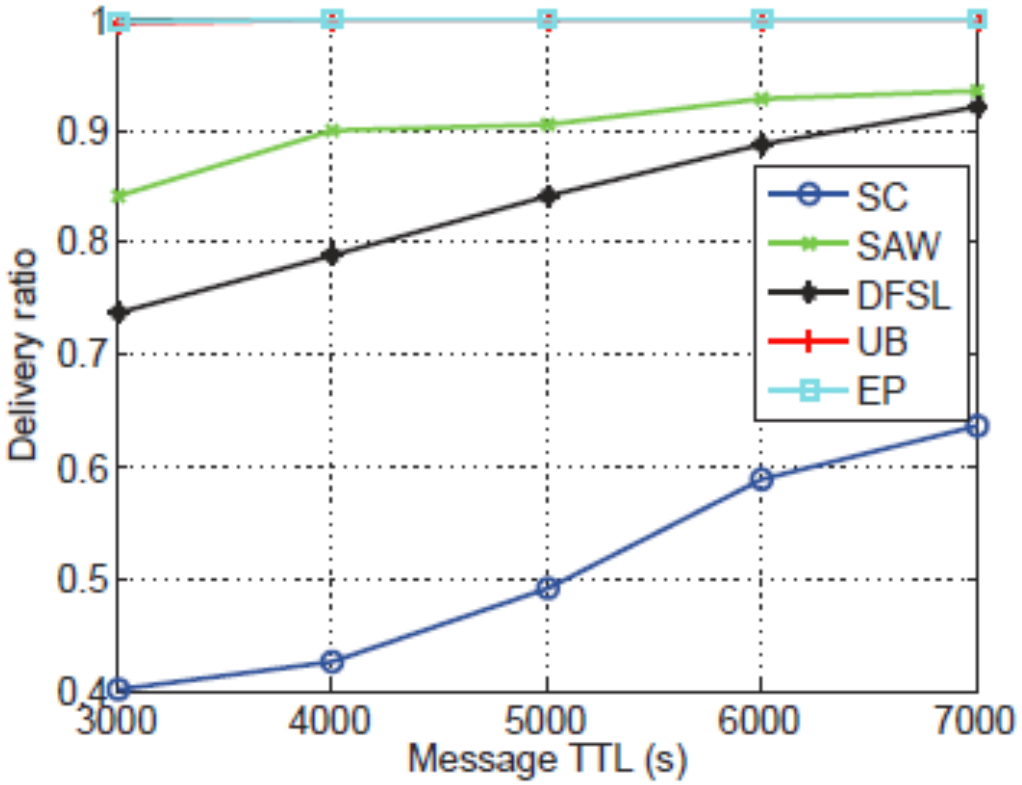
4. Evaluation

5.3 Single Copy Scheme (Communication radius)



4. Evaluation

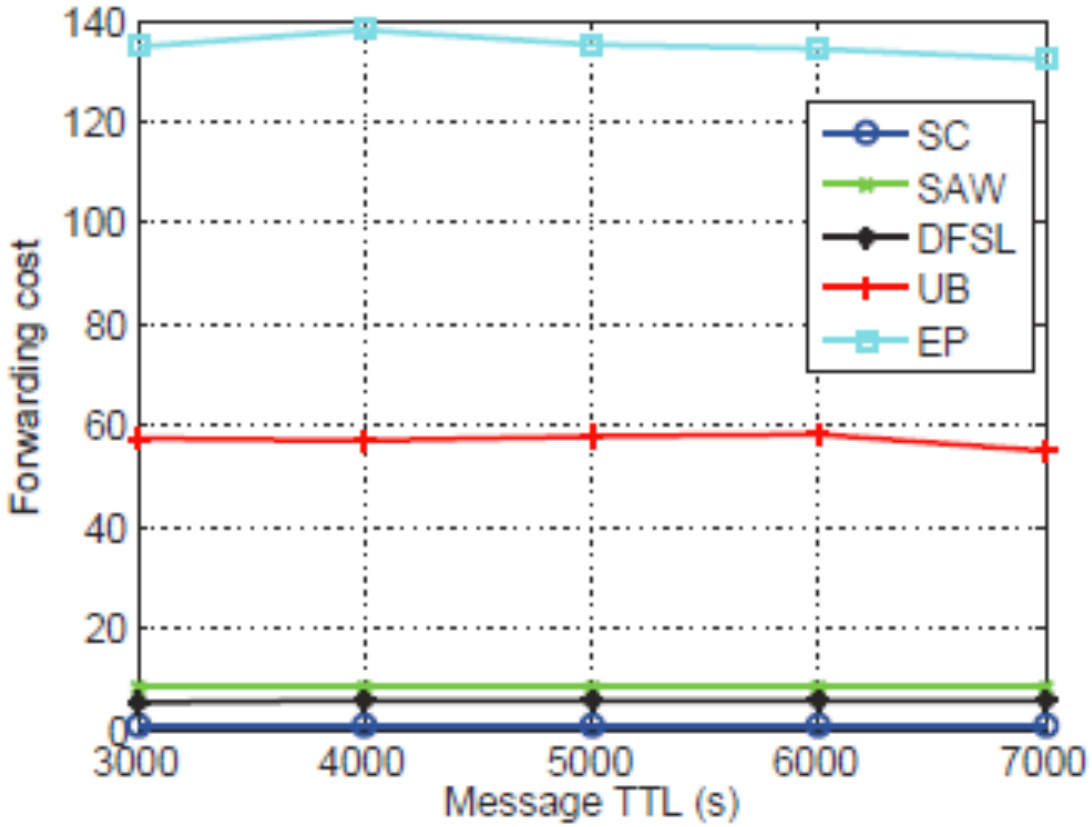
5.4 Multiple Copy Scheme (Random-waypoint)



SAW: Spray and Wait, spray half of the copies to the encounter
DFSL: Delegation Forwarding based on Short-term and Long-term(DFSL)
UB: Delegation Forwarding according to the current node's ability
EP: Epidemic, copy to every encounter

4. Evaluation

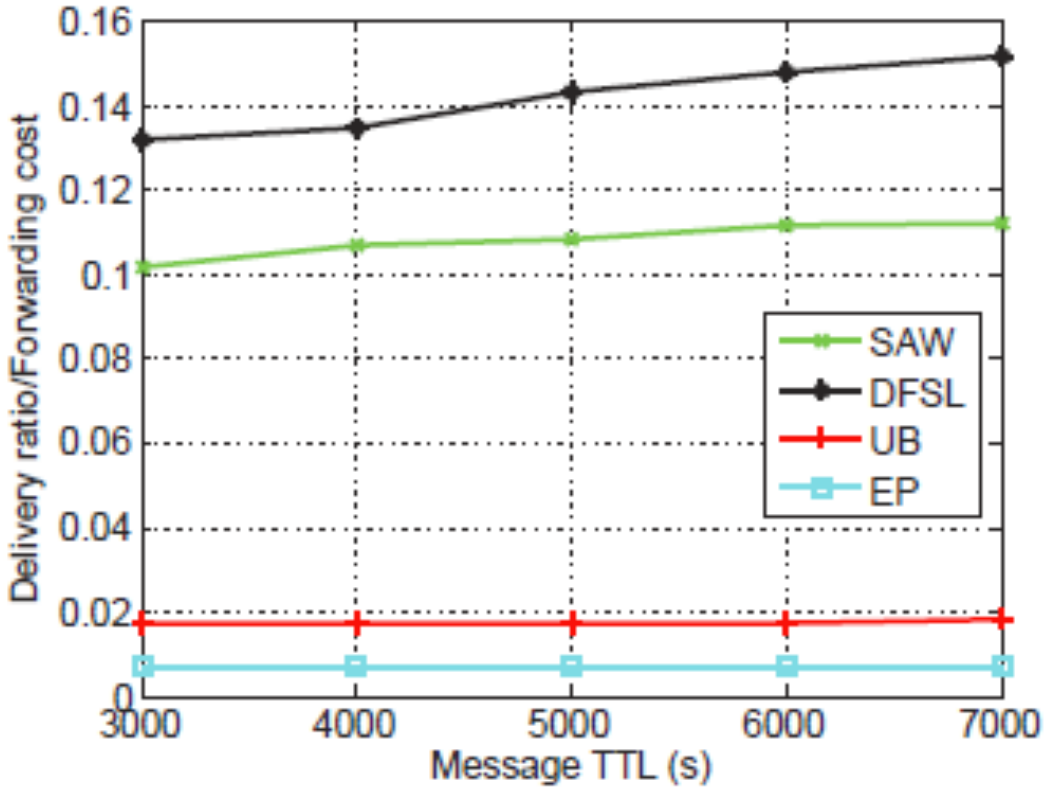
5.4 Multiple Copy Scheme (Random-waypoint)



(b) Forwarding cost

4. Evaluation

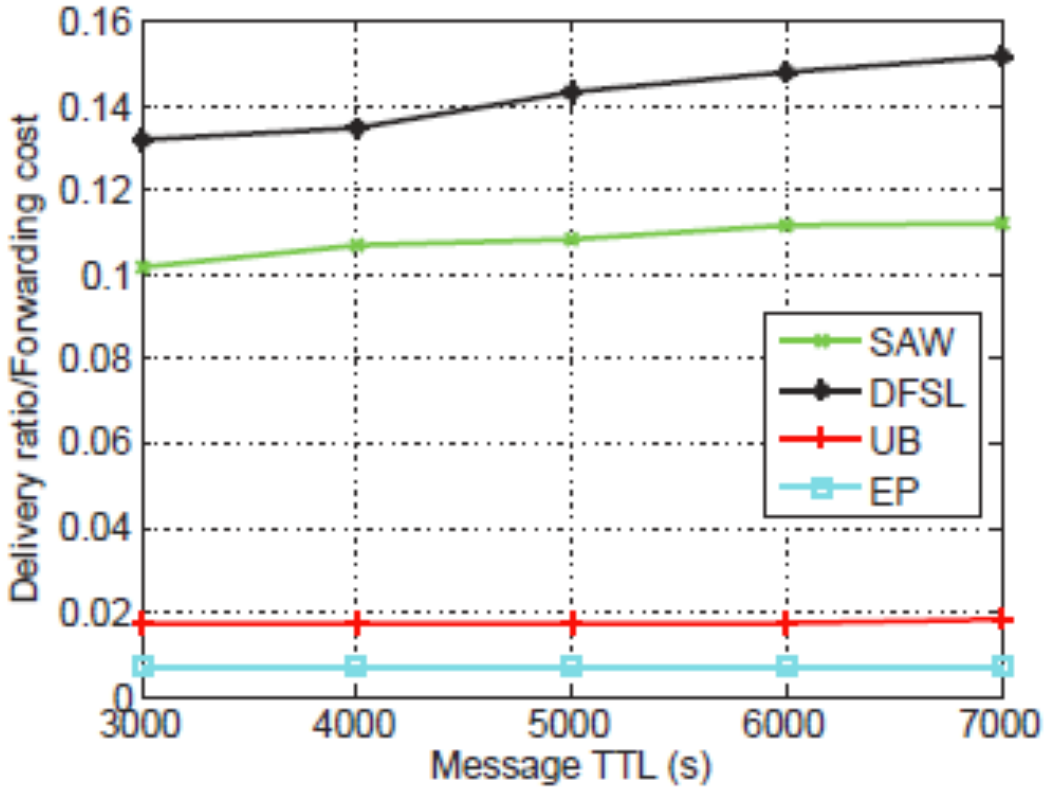
5.4 Multiple Copy Scheme (Random-waypoint)



(c) Forwarding efficiency

4. Evaluation

5.4 Multiple Copy Scheme (Real trace pmtr [1])



(c) Forwarding efficiency

[1] Downloaded from http://crawdad.org/unimi/pmtr/, Dec. 2008

Conclusion

We present a mapping function from the short-term and long-term speed to a quantified forwarding metric, which is the average speed from current time to the time of meeting another node with a higher forwarding ability.

In the combination of the forwarding metric and Delegation Forwarding strategy, a multi-copy delegation forwarding based on short-term and long-term speed is proposed in DTNs.

Thank you.

Questions are welcome!