Dynamic Beaconing Control in Energy-Constrained Delay Tolerant Networks

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Outline

- **1. Introduction**
- 2. Model Description
- 3. Beaconing Control Strategy
- 4. Evaluation

1. Introduction

1.1 Motivation

- **Delay-tolerant networks (DTNs) are a type of challenged network in which end-to-end transmission latency may be arbitrarily long due to occasionally connected links.**
- **Beaconing is used to detect probabilistic contacts in DTNs. However, frequent beaconing and message transmission result in quick energy depletion, and make the node stop working.**
- **Otherwise , sparse beaconing and message transmission result in lower delivery ratio.**

1. Introduction

1.2 Problem

- **Optimal beaconing intervals**

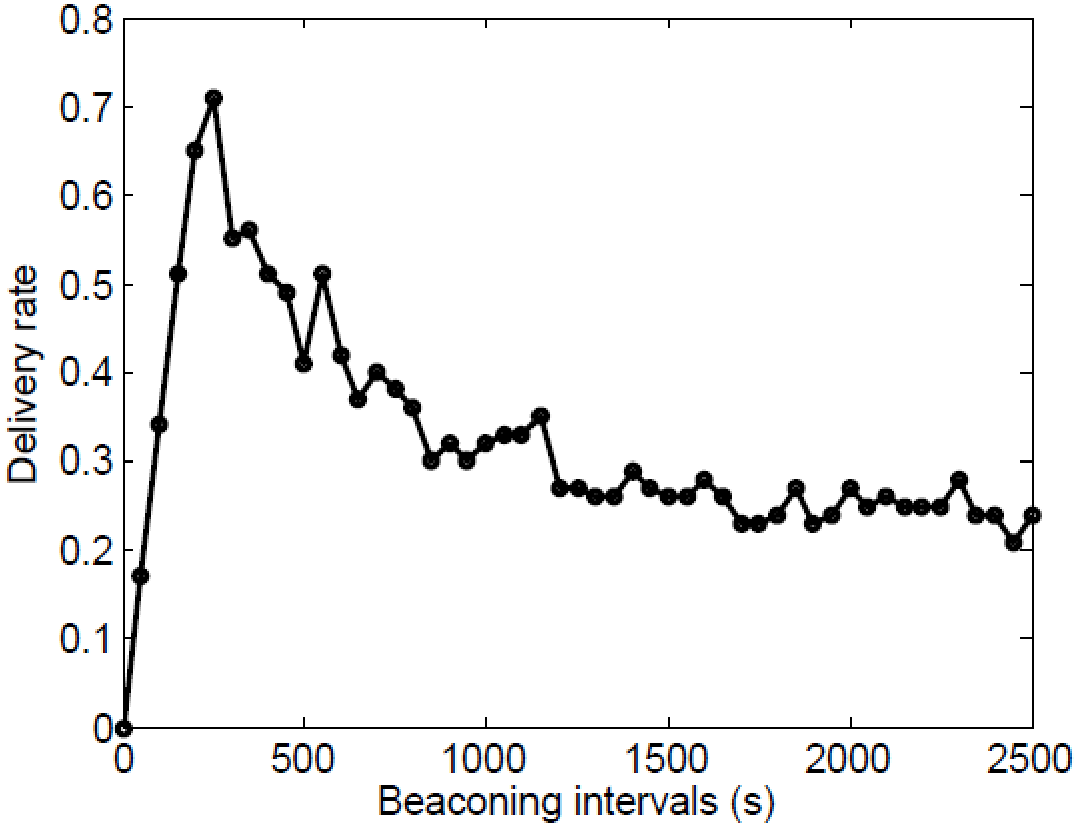

Fig. 1. The relationship between delivery rate and beaconing intervals.

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2. Model Description

2.1 Mobility Model

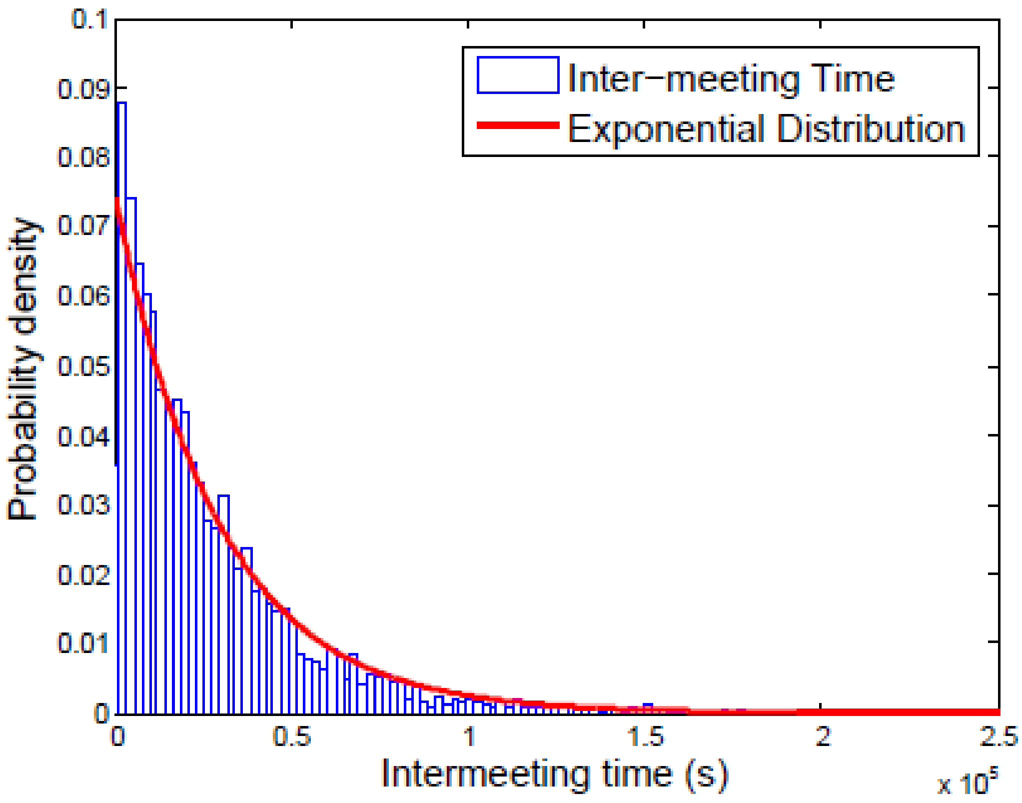
- ***Definition 1*: Intermeeting time: the elapsed time from the end of the previous contact to the start of the next contact between nodes in a pair**

- **Intermeeting times are exponentially distributed under random-waypoint mobility pattern.**

$$f(x) = \begin{cases} \lambda e^{-\lambda x} & x>0 \\ 0 & x\leq 0 \end{cases}$$

2. Model Description

2.1 Mobility Model: random-waypoint



2. Model Description

2.2 Notations

TABLE I. MAIN NOTATION USED THROUGHOUT THE PAPER

Symbol	Meaning
N	Total number of nodes in the network minus one
M	Total number of distinct messages in the network
TTL	Initial time to live for messages
R	Remaining time to live for messages
t	Elapsed time for messages since they are generated
$m(t)$	Number of nodes with the message after t
$F(t)$	Beaconing frequency after elapsed time t
E	Average inter-meeting time between nodes
λ	Parameter in the inter-meeting time distribution
α	Energy consumption of each transmission
β	Energy consumption of each beaconing
Ω	Maximum energy constraint to deliver a message
$P_c(t)$	Probability that nodes can communicate at time t
$P(t)$	Probability that messages can be delivered at time t

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3. Scheduling and Drop Strategy

3.1 Beaconing Control Strategy

- The probability that nodes can communicate at time *t* is shown as follows:

$$P_c(t) = F(t)\lambda$$

$$\begin{aligned} P\{m(t_{n+1}) = i_{n+1} | m(t_k) = i_k; 0 \leq k \leq n\} \\ = P\{m(t_{n+1}) = i_{n+1} | m(t_n) = i_n\} \end{aligned}$$

- Where the sequence of *m(t)* is a continuous-time Markov chain.

3. Scheduling and Drop Strategy

3.1 Beaconing Control Strategy

- The number of nodes with the message after *t* could be achieved as follows:

$$\frac{\mathrm{d}m(t)}{\mathrm{d}t} = P_c(t)(N - m(t))m(t)$$

$$m(t) = \frac{N}{(N-1)e^{-N\lambda \int_0^t F(t)\mathrm{d}t} + 1}$$

3. Scheduling and Drop Strategy

3.1 Beaconing Control Strategy

- We could solve *P(t)* and also obtain the energy constraint as follows:

$$P(t) = \frac{m(t)}{N} = \frac{1}{(N-1)e^{-N\lambda \int_0^t F(t)\mathrm{d}t} + 1}$$

$$\alpha(m(t)-1) + \beta N \int_0^t F(t)\mathrm{d}t \leq \Omega$$

3. Scheduling and Drop Strategy

3.1 Beaconing Control Strategy

- The above problem can be expressed as the following optimization problem:

$$Max\ P(TTL)$$
$$s.t.\quad \alpha(m(TTL)-1)+\beta N\int_0^{TTL}F(t)\mathrm{d}t \leq \Omega$$

- we can get the optimal beaconing frequency as follows:

$$f=\frac{(-\beta\cdot \mathrm{lambertw}(\frac{1}{N-1}\lambda\frac{\alpha}{\beta}e^{\frac{(\Omega+\alpha)\lambda}{\beta}})+(\Omega+\alpha)\lambda)}{TTL\cdot\lambda\beta N}$$

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4. Evaluation

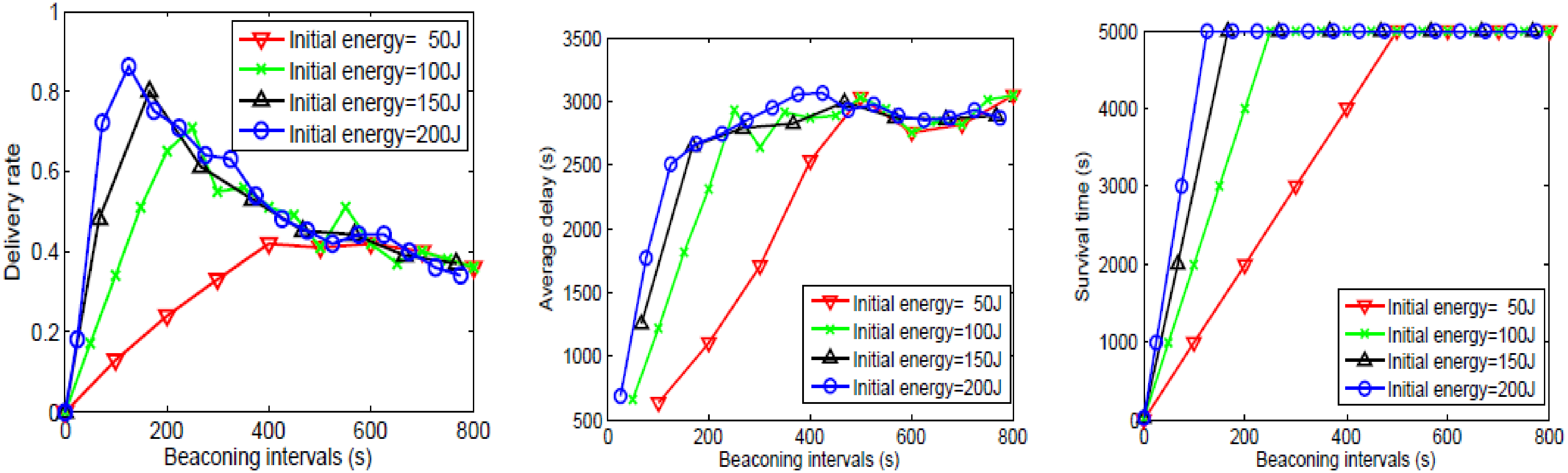
4.1 Simulation parameters (random-waypoint)

TABLE II. SIMULATION PARAMETERS UNDER RANDOM-WAYPOINT SCENARIO

Parameter	Value
Simulation time	5000s
Simulation area	4500m×3400m
Number of nodes	100
Moving speed	2m/s
Transmission speed	250kBps
Transmission range	100m
Buffer size	500M
TTL	5000s
Message size	250kB
Transmission consumption	1J
Beaconing consumption	5J
Energy constraint for each node	50J, 100J, 150J, 200J

4. Evaluation

4.2 Simulation Results



(a) Delivery rate (b) Average delay (c) Survival time

4. Evaluation

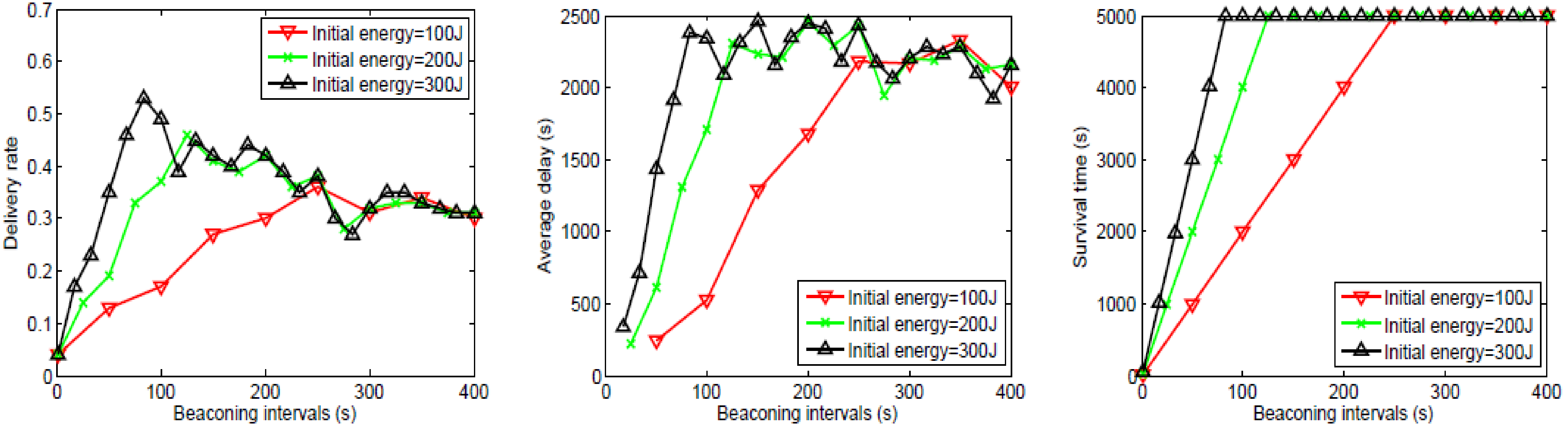
4.3 Simulation parameters (Epfl real trace)

TABLE III. SIMULATION PARAMETERS UNDER EPFL SCENARIO

Parameter	Value
Simulation time	5000s
Number of nodes	200
Transmission speed	250kBps
Transmission range	100m
Buffer size	500M
TTL	5000s
Message size	250kB
Transmission consumption	1J
Beaconing consumption	5J
Energy constraint for each node	100J, 200J, 300J

4. Evaluation

4.4 Simulation Results



(a) Delivery rate (b) Average delay (c) Survival time

Thank You

Questions are welcome: wangen0310@126.com