

Anonymous DTN routing

October 2, 2013

1 Experimental Result

1.1 Overview

1.1.1 Simulation model

- ONE simulator, modified default scenario/setting
- Map: Helsinki (4500m * 3500m)
- Simulation running time: 12 hours
- Nodes: 246 (160 humans, 80 cars, 6 trams)
 - Packet buffer: Humans and cars (50MB), trams (500MB).
 - Contact interval: Humans (2 mins 30 secs), cars (1 min), trams (40 secs)
- Packet(message) generation
 - Packet size: 500KB - 1MB
 - Packet generation interval: 35sec - 50sec
 - TTL: 5 hours
 - Packet generation stopped when 5 hours (packet TTL) are left.
 - Total number of packets generated: about 575
- Movement: Random way point, map-based movement.
- Network interface: bluetooth, wlan (determine communication distance and bandwidth)
 - Humans, cars: Bluetooth (Bandwidth: 2Mbps, Communication range: 10m)
 - Trams: WLAN (Bandwidth: 10Mbps, Communication range: 100m)

1.1.2 Anonymous DTN routing setup

- # group: 1
- # nodes in a group: [5%, 10%, 15%, 20%, 25%]
- Epoch: [10mins, 20mins, 30mins, 60mins]
- Ephemeral ID duration: [3 epochs, 6 epochs]
- Base routing protocol: epidemic (flooding)

1.1.3 Assumptions & simplification

- Strict time sync
Epoch starts exactly at the same time in all nodes
- No “beacon”, “hello”, “pull” messages
Once two nodes are located within a specific distance, they know ephemeral addresses, packet digest, pulling list of each other without any message exchange.
- “Out-of-group” nodes do not use ephemeral IDs.
Those nodes use permanent IDs which are not changed during the simulation.
- Forwarding policy
On contact, a node first forwards packets whose destinations are either trusted by the next-hop node or in neighbor list of the next-hop node. Then it tries to forward remaining packets in FIFO manner.

1.2 Results

1.2.1 Communication among all nodes

In this test scenario, every node can send packets to any other nodes. Packet generation follows rules below:

- Nodes belong to the group generate and receive about 20% of overall packets generated during the simulation.
- For the rest 80% of packet generation, sender and receiver are randomly selected from all node.

Ephemeral ID duration	Trusted nodes %	Epoch
3 epochs	5%	60 mins
	10%	30 mins
6 epochs	5%	30 mins
	10%	20 mins

Table 1: **Example settings with overall delivery rate of about 90% (Flooding: 92.91%).**

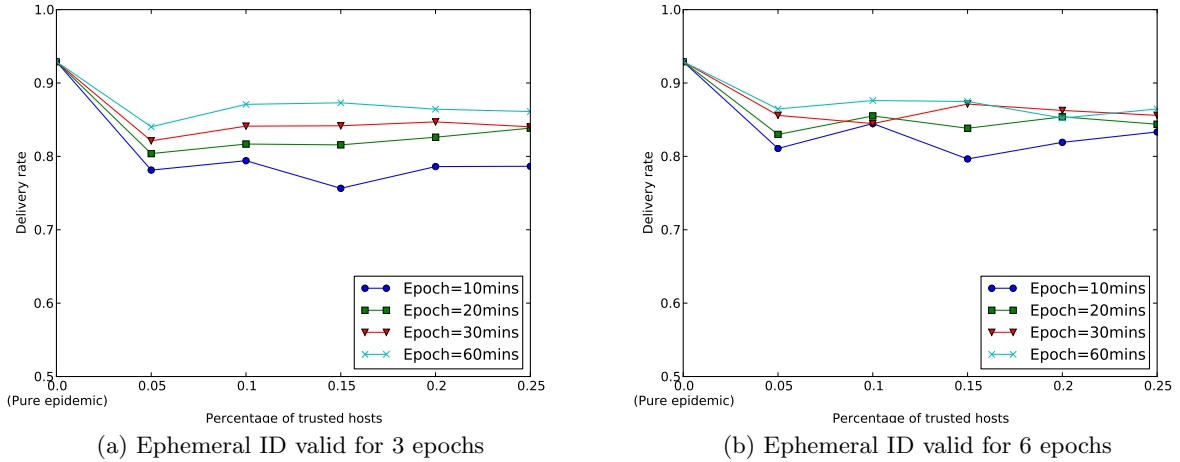
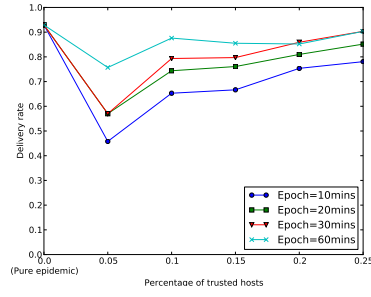
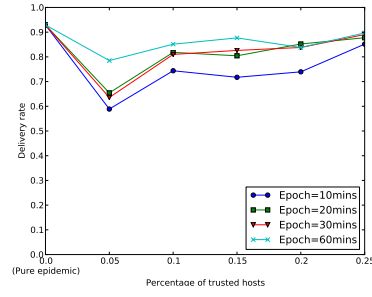


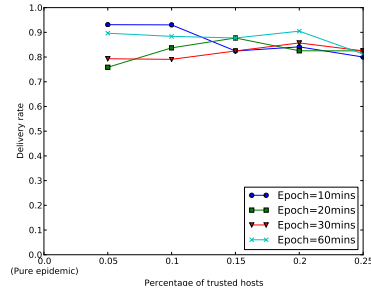
Figure 1: **Overall packet delivery rate.** Delivery rate of pure epidemic routing: 92.91%. With epoch=60 mins, overall delivery rate is almost similar to that of epidemic routing regardless of the percentage of trusted nodes. In Figure 1b, delivery rates with epoch ≥ 20 mins are about 90%, especially when the percentage of trusted nodes $\geq 10\%$.



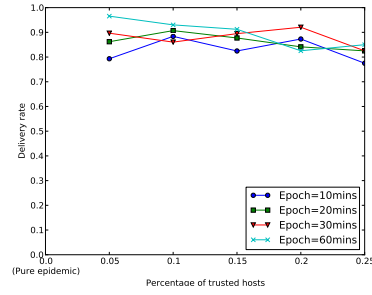
(a) In-group to In-group. Ephemeral ID valid for 3 epochs



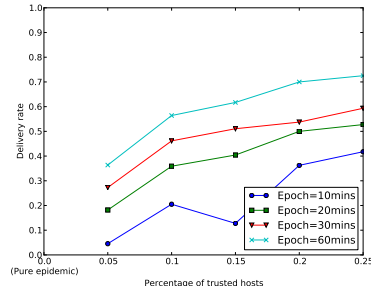
(b) In-group to In-group. Ephemeral ID valid for 6 epochs



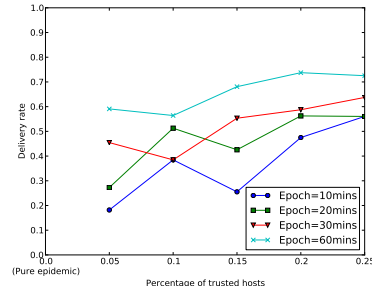
(c) In-group to Out-of-group. Ephemeral ID valid for 3 epochs



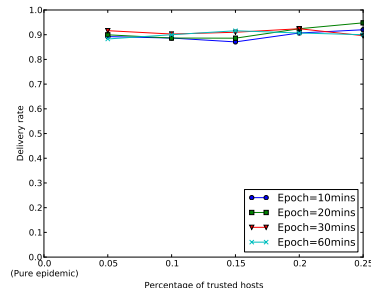
(d) In-group to Out-of-group. Ephemeral ID valid for 6 epochs



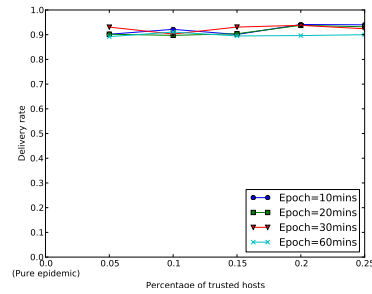
(e) Out-of-group to In-group. Ephemeral ID valid for 3 epochs



(f) Out-of-group to In-group. Ephemeral ID valid for 6 epochs

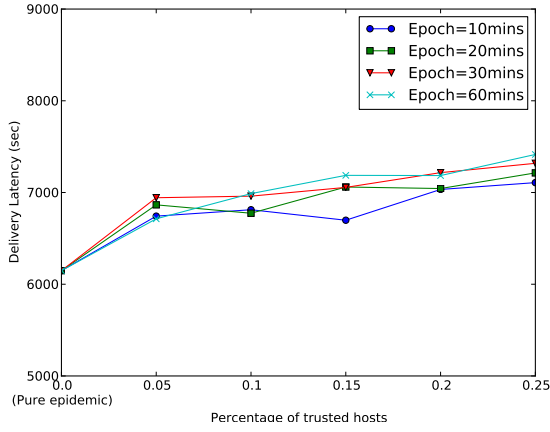


(g) Out-of-group to Out-of-group. Ephemeral ID valid for 3 epochs

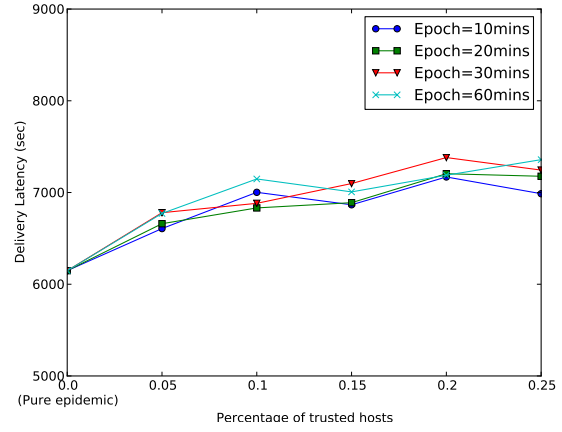


(h) Out-group to Out-group. Ephemeral ID valid for 6 epochs

Figure 2: **Detailed packet delivery rate.** Delivery rate of packets destined for ‘out-of-group’ is almost same to that of epidemic routing, regardless of epoch and percentage of trusted nodes. Delivery rate of ‘Out-of-group’ to ‘In-group’ is relatively low, ranging from 20% to 80%.

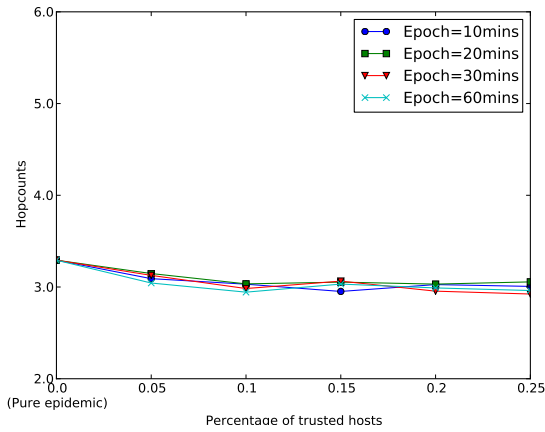


(a) Ephemeral ID valid for 3 epoch

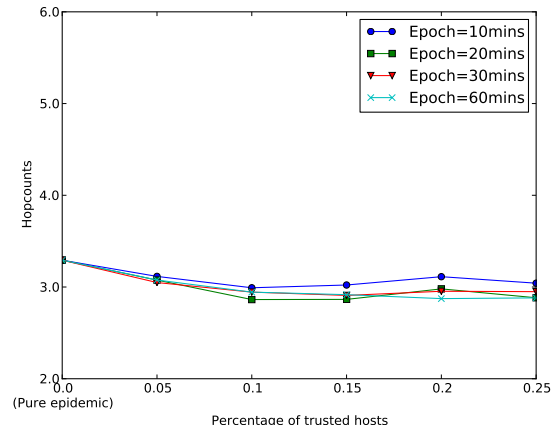


(b) Ephemeral ID valid for 6 epochs

Figure 3: **Overall packet delivery latency.** Overall packet delivery rate is almost same to that of epidemic routing.



(a) Ephemeral ID valid for 3 epochs



(b) Ephemeral ID valid for 6 epochs

Figure 4: **Overall packet delivery hop count.** Overall delivery hop count is almost same to that of epidemic routing.