Mobility Entropy and Message Routing in Community-Structured Delay Tolerant Networks

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Asia Future Internet (AsiaFI) 2009
12th-16th January 2009. Beijing, China.
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• Introduction
• Mobility Entropy and Routing
• Potential-Based Approach
• Evaluation
• Conclusion
Introduction

• Message delivery in DTNs

• How can they manage routing, when 100 nodes?
• A large number of node mobility patterns

• Contribution of this work:
  – Mobility Entropy, Community-Structured Environment (CSE)
  – Potential-based Entropy Adaptive Routing (PEAR)
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Mobility Entropy and Message Routing

- Mobility Entropy represents uniformity of node distribution.

**Small Entropy**
- Locally Distributed
- Contact with only a small set of nodes
- Message Delivery by Routing

**Large Entropy**
- Widely Distributed
- Contact with many nodes
- Message Delivery by Mobility
Distribution of Nodes

Small Entropy Case

- Short overlapping of node distribution
  ➞ Small Contact Areas
Distribution of Nodes

Large Entropy Case

- Long overlapping of node distribution
  ➔ Large Contact Areas
Message Delivery
Small Entropy Case

Contact Areas

Source

Intermediate Nodes

Destination

Distribution

\( x \)
Message Delivery
Large Entropy Case

Distribution

Source

Destination

A Contact Area

$x$
Community-Structured Environment (CSE)

1. Nodes can communicate with each other when they are in the same community.
2. Nodes move among predefined community set repeatedly.
3. Mobility entropy is given by the number of communities a node belongs to.

Mobility Entropy = \( \log_2 \Omega \)

The number of communities each node belongs to.
If every node belongs to 2 communities.

\[ \log_2 2 \]

Mobility Entropy

If every node belongs to 3 communities.

\[ \log_2 3 \]
When nodes belong to **two** communities.

**Mobility Entropy = 1**
When nodes belong to four communities.

Mobility Entropy = 2
CSE and Mobility Entropy

Mobility Entropy = 0

Mobility Entropy = 1

Mobility Entropy = 2

Mobility Entropy = 3
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Potential-Based Routing

To deliver sensor readings to the Internet GW

○ : Wireless Device
Message Forwarding in Potential-Based Routing

A message goes down the curve until it reaches the destination.
How to develop potential-field in PEAR

Potential-Field Construction

\[ V^d(n, t + 1) = V^d(n, t) + D \min_{k \in \text{nbr}(n)} \left\{ V^d(k, t) - V^d(n, t) \right\} + \rho \]

Boundary Condition

\[ \forall n \in N, (V^d(n, 0) = 0) \quad D(> 0), \rho(> 0) \quad \text{const.} \]

\[ \forall t, (V^d(d, t) = 0) \]

Diffusion Equation

\[ V^d(n, t + 1) = V^d(n, t) + D \sum_{k \in \text{nbr}(n)} \left\{ V^d(k, t) - V^d(n, t) \right\} \]
Potential and Message Routing
Small Entropy Case

Potential

Source
Intermediate
Destination

Message Delivery

\[ V^d(n,t+1) = V^d(n,t) + D \min_{k \in \text{nbr}(n)} (V^d(k,t) - V^d(n,t)) + \rho \]

Distribution

Source Node
Intermediate Nodes
Destination Node

\( x \)
Message Delivery by PEAR
Small Entropy Case
Potential and Message Routing
Large Entropy Case

\[ V^d(n,t+1) = V^d(n,t) + D \min_{k \in \Omega(n,t)} \{ V^d(k,t) - V^d(n,t) \} + \rho \]
Message Delivery by PEAR
Large Entropy Case
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Evaluation

- Evaluation of Delivery Rate and Total Transmissions on Mobility Entropy

- PEAR in comparison with:
  - Epidemic Routing
  - Spray and Wait
  - Link-State Routing
    - Minimum Expected Delay (MED)
    - Maximum Delivery Probability (MDP)

- Java-based CSE simulator
  - Ignored: link-bandwidth, radio properties, message-partitioning, storage size, etc...
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Conclusion

• Mobility Entropy
  – The new metrics that describes mobile environment.
    • Small entropy: Nodes are locally distributed.
    • Large entropy: Nodes are widely distributed.
  – Community-Structured Environment

• PEAR achieved high delivery probability
  – Small entropy: hop-by-hop routing
  – Large entropy: multiplying messages
Thank you..

Small Entropy Case

Large Entropy Case

Mobility Entropy