ChitChat: An Effective Message Delivery Method in Sparse Pocket-Switched Networks

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Outline

1. Introduction
   - Introduction: Pocket-Switched Networks
   - Shortcomings of Past Work

2. Our Contribution
   - The ChitChat System
   - Simulation Results

3. Related Work and Closing Remarks
   - Related Work
   - Closing Remarks
Introduction

Introduction: Pocket-Switched Networks
Shortcomings of Past Work

Our Contribution

The ChitChat System
Simulation Results

Related Work and Closing Remarks

Related Work
Closing Remarks
What is a Pocket-Switched Network?

- **A type of Delay Tolerant Network**
- **Nodes are smart devices carried by people**
- **Close proximity nodes can connect and exchange messages**
- **Goal**: Efficient and reliable message delivery over multiple hops w/o reliance on Internet
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Unaddressed Challenges of Sparse Networks
- Past work is evaluated using dense datasets
- Sparse networks not evaluated

What is Needed
- Many real-world applications reside within sparse PSNs
- Needed: A system to detect multi-hop, transient connections
Motivating Applications

- Internet access to isolated communities
- Military reconnaissance in hostile battlefields
- Word-of-Mouth coupon and ad sharing
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ChitChat adheres to constraints of PSNs

- External knowledge only available through encountered nodes (i.e. no global knowledge)
- Connections are opportunistic and fleeting
- Past encounters do not guarantee future encounters
ChitChat adheres to constraints of PSNs
Modeling of a node’s multi-hop, transient social relationships based on social interests
Relationship weights grow and decay to reflect time-evolving social interactions
Ultimately used for encountered-node message forwarding decisions
Social relationships are modeled by Transient Social Relationships

### Definition

A Transient Social Relationship (TSR) is a key-value pair associating a social interest key with a weight between 0 and 1

- Weight describes connectivity to others with interest in, or association to, the key
Example of Transient Social Relationships

**Strong TSR Weight**

1-hop distance

2-hop distance

3-hop distance

**Weak TSR Weight**

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ChitChat: Message Delivery in Sparse PSNs
Nodes *chitchat* and share TSRs with neighbors.

Each neighbor incorporates the node’s TSRs into their own, either by inducing new TSRs or aggregating them into pre-existing TSRs.

Then, these neighbors propagate the aggregated TSRs to others encountered later on.

Propagation of TSRs informs nodes of their social connections to others, even to those with multiple degrees of separation.
Growth and Decay of Transient Social Relationships

- As time passes, social connections evolve
- To maintain TSR freshness, TSRs grow and decay in real time
  - Growth through connections to others
  - Decay due to extended disconnection
- Impact of growth and decay depends on...
  - duration of connections and disconnections
  - residency of TSRs in the two interacting neighbors
- See paper for formal modeling of TSR growth and decay
Neighbor evaluation depends on . . .

- topics covered in the message; and
- the neighbor’s TSRs corresponding to the message’s topics
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ChitChat system performance was evaluated via simulation:

- The ONE Simulator v1.5.1 RC2
- Node mobility from the GeoLife GPS Trajectory Dataset
- Synthesized social profiles and messages

**Figure**: GUI of the ONE Simulator
ChitChat system performance was evaluated via simulation:

- Comparison to...
  - Epidemic
  - SANE [Mei et al. TPDS 2015]
  - SEDUM [Li and Shen. TC 2013]
Objective of Simulations

How well do these systems handle in a Sparse Network?

Metrics to Review

- Delivery path length (aka hop-count)
- Delivery ratio
- Overhead costs
Message Penetration in a Sparse Network

![Graph showing message penetration and number of hops for ChitChat, SANE, Epidemic, and SEDUM systems.](image)

- **Transmission Radius (meters):**
  - ChitChat: Blue line
  - SANE: Green triangles
  - Epidemic: Red crosses
  - SEDUM: Cyan triangles

- **Message Lifetime (hours):**
  - ChitChat: Blue line
  - SANE: Green triangles
  - Epidemic: Red crosses
  - SEDUM: Cyan triangles

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ChitChat: Message Delivery in Sparse PSNs
Successful Deliveries vs. Replication Overhead

- Deeper penetration pays off with more deliveries
- Epidemic maxes out all possible deliveries
- ChitChat comes in second, more than SANE, SEDUM
Successful Deliveries vs. Replication Overhead

- **Delivery Ratio**
  - ChitChat
  - SANE
  - Epidemic
  - SEDUM

- **Cost**
  - ChitChat
  - SANE
  - Epidemic
  - SEDUM

**ChitChat: Message Delivery in Sparse PSNs**
Deeper penetration also results in higher costs

ChitChat consumes less than Epidemic without significant delivery failures

SANE, SEDUM only able to deliver directly or through one relay

Results in lower costs
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Epidemic Flooding

Copy message to everybody encountered

- PRoPHET
- BUBBLE Rap
- SEDUM
- SANE
PRoPHET

- Epidemic Flooding

PRoPHET [Lindgren et. al. LNCS/SAPIR 2004]

- Utility with destination based on frequency of past contacts
- Transitive propagation accounts for indirect contacts
- Message forwarding to higher-utility nodes

- BUBBLE Rap
- SEDUM
- SANE
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Related Work

Closing Remarks

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**BUBBLE Rap**

- Epidemic Flooding
- PRoPHET

**BUBBLE Rap [Hui et. al. TMC 2011]**

- Centrality-based utilities
- Forward message to more popular nodes towards destination’s community

- SEDUM
- SANE

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ChitChat: Message Delivery in Sparse PSNs
SEDUM

- Epidemic Flooding
- PRoPHET
- BUBBLE Rap

SEDUM [Li and Shen. TC 2013]

- Utilities based on duration of past contacts
- Similar transitive mechanisms as PRoPHET
- SANE
SANE

- Epidemic Flooding
- PRoPHET
- BUBBLE Rap
- SEDUM

SANE [Mei et. al. TPDS 2015]
- Utilities based on similarity of interests
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Summary and Closing Remarks

- Sparsity in PSNs must be addressed when evaluating solutions.
- The ChitChat system handles sparsity through its modeling of Transient Social Relationships.

Outlook
- Under what conditions does congestion occur?
- Can privacy be preserved?
- How can adversaries attack this network, and how can these be mitigated?
Thank you.

Questions?
Further Reading in PSNs and DTNs I

- Y. Zhu et. al.  
  A Survey of Social-Based Routing in Delay Tolerant Networks: Positive and Negative Social Effects  

- P. Hue et. al.  
  BUBBLE Rap: Social-Based Forwarding in Delay-Tolerant Networks  
Further Reading in PSNs and DTNs II

Z. Li and H. Shen.
SEDUM: Exploiting Social Networks in Utility–Based Distributed Routing for DTNs

A. Lindgren et. al.
Probabilistic Routing in Intermittently Connected Networks

A. Mei et. al.
Social-Aware Stateless Routing in Pocket Switched Networks