Considering Multi-Contact Encounters in Opportunistic Networks [1]

Recent Topics in Computer Networks, WS 2015/16

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Introduction

Opportunistic networks vs. MANETs/WSNs:

- MANETs: interconnected clusters of nodes
- Opportunistic networks: contacts are rare
  - But are they really?
  - If not, can we use this to our advantage?
    - reduce "unneccessary" bundle forwards
    - reduce node energy consumption
    - extensions for Epidemic, Spray & Wait, PRoPHETv2 routing

Multi-Contact Analysis

- Analyze network traces: when do nodes have ≥ 1 connection?

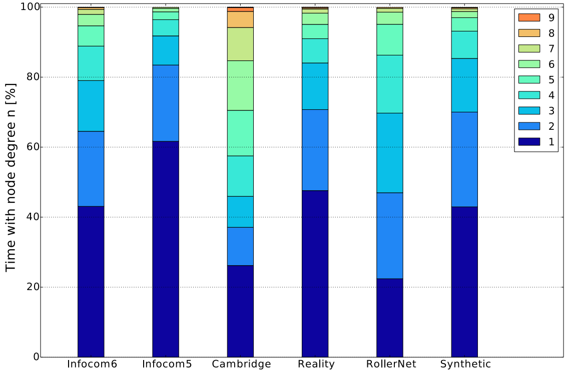

Figure 1: Average amount of time nodes with a connection spend with node degree *n*

$\Rightarrow$ Multiple contacts are quite common!

Routing: Global vs. Local Perspective

Global Perspective

Find the minimal subset of nodes required for satisfied delivery probability

- Forward a message only to a few sufficient nodes
- Save bandwidth for other messages

Local Perspective

Find the optimal way to spread a message

- Use link quality information etc.
- Local loss is easier to handle than global loss.
- Forwarding to nodes with low link quality: local loss increases!
  - Total delivery probability of the network decreases
  - Energy efficiency decreases

Link Quality Simulation: Channel Model

- Estimate path loss with log-distance path loss model:

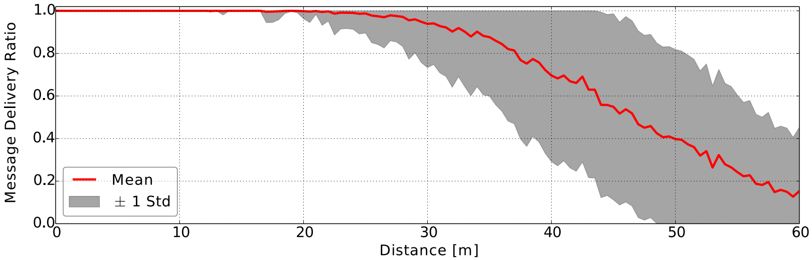

Figure 2: The average Message Delivery Ratio as a function of distance.

- Implement channel model into ONE simulator, measure.

Impact of Lossy Links

Table 1: Result of simulating channel model

	Delivery Ratio	Relays Started	Lost Msgs.
PRoPHETv2			
Perfect Links	88.8 %	924 k	0.5 %
Lossy Links	84.6 %	943 k	26.3 %
	FIFO/Random	*FIFO/Random*	*FIFO/Random*
Epidemic			
Perfect Links	79.6 /80.5 %	942/949 k	0.5/0.5 %
Lossy Links	74.8/77.1 %	948/954 k	24.2/23.9 %
Spray-and-Wait			
Perfect Links	87.8/87.8 %	209/209 k	0.4/0.4 %
Lossy Links	87.2/87.1 %	393/392 k	47.0/46.9 %

$\Rightarrow$ Loss increases, but delivery ratio is about the same.

Routing with Link Quality Information

For each routing decision, consider:

- $RM_{orig}(n_i, m_k)$: *value* of relaying message m_k to node n_i
  - based on the underlying routing protocol
- $Cost(n_i, m_k)$: *cost* of relaying message m_k to node n_i
  - based on probability of failed delivery

Only replicate message to node when $RM_{orig}(n_i, m_k) > Cost(n_i, m_k)$

Epidemic and Spray-and-Wait Routing

- Routing value based on message TTL
  - good for spreading *different* messages
- Node identity is not considered, always try replicating messages in order

$$RM(n_i, m_k) = \frac{TTL_{remaining}}{TTL_{initial}} - Cost(n_i, m_k)$$

PRoPHETv2 Routing

- Routing value based on PRoPHETv2 metric RM_p

$$RM(n_i, m_k) = RM_p(n_i, m_k) - Cost(n_i, m_k)$$

Cost Function

- Based on link quality, e.g. RSSI or Message Delivery Ratio
- Scaling factor α determines aversion to weaker links
  - determine efficient α_{eff} by looking at amount of lost messages

$$Cost(n_i, m_k) = \alpha(1 - MDR_i(m_k))$$

Results of Routing Improvements

Table 2: Results of proposed improvements

	Delivery Ratio	Relays Started	Lost Msgs.
PRoPHETv2			
α=0	84.9 %	939 873	26.3 %
α=1	85.1 %	923 371	19.5 %
α_{eff}=50	84.5 %	777 411	7.2 %
Epidemic			
α=0	89.4 %	981 618	25.6 %
α=1	90.3 %	975 002	20.5 %
α_{eff}=8	90.8 %	592 349	10.5 %
Spray-and-Wait			
α=0	87.2 %	394 985	47.3 %
α=1	86.6 %	346 018	40.8 %
α_{eff}=20	86.6 %	259 001	20.6 %

$\Rightarrow$ Reduced number of lost messages and relays started

Conclusion

- Multiple contacts are mostly the case in WSNs
  - further research!
- Considering link quality in DTN routing can help with:
  - reducing lost messages
  - reducing energy requirements

References

Hjalmar Wennerström, Christian Rohner, and David Smith.
Considering multi-contact encounters in opportunistic networks.
In *Proceedings of the 10th ACM MobiCom Workshop on Challenged Networks*, CHANTS '15, pages 13–18, New York, NY, USA, 2015. ACM.