HIGH PERFORMANCE OPPORTUNISTIC ROUTING ALGORITHMS FOR POWER CONSTRAINED NODES WITH MESSAGE DELIVERY DEADLINE IN SPARSE NETWORK ENVIRONMENT

Jiradett Kerdsri

Sirindhorn International Institute of Technology, Thammasat University

jiradett.k@dti.or.th

July 22, 2014

Overview

Thesis Structure

Chapter Title

- Signature Page
- Acknowledgments
- Abstract
- Table of Contents
- List of Figures
- List of Tables
- List of Listings
- List of Acronyms

- Introduction
  - Problem Statement
  - Objective and Scope
  - Proposed Approaches
  - Our Contributions
- Background and Related Work
  - Delay Tolerant Networks
  - Opportunistic Networks

Thesis Structure

- Dynamic Rendezvous based Routing Algorithm on Sparse Opportunistic Network Environment
  - Rendezvous Place
  - Simulation Model and Results
  - Summary of Contributions
- Data-wise Opportunistic Routing with Spatial Information
  - Data-wise Routing
  - Simulation Model and Results
  - Summary of Contributions
- Conclusion and Future Work
  - Discussion
  - Conclusion
  - Future Work
- References
- Appendix A: List of Publications

What is OppNet?

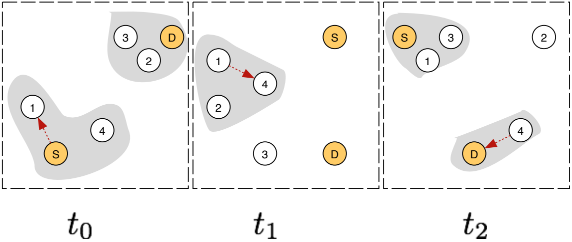

Figure: Store-Carry-Forward (SFC) protocol

- A challenge network where the nodes need to communicate with each other even either direct or indirect routes between them may not permanently exist due to the nodes random movement.
- Using store- carry-forward paradigm

Applications for OppNet

Wildlife Monitoring

ZebraNet [6], SWIM [4]

Battlefield Network

Military tactical networks [3] [2]

Disaster Monitoring Network

Literatures Review

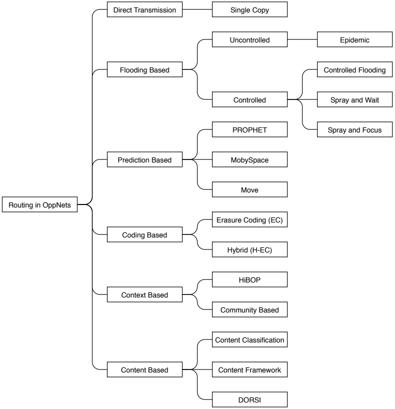

Figure: Diagram of Existing OppNet Routing

Problem Statement

- Existing routing algorithms impractical on some applications
- In this store-carry-forward paradigm, the network suffers the decreasing of performance in the insufficient collaborating nodes environment [1, 5]
- Low delivery ratio in sparse network environment
- Limited power resource

Proposed Approaches

- Dynamic Rendezvous based Routing Algorithm on Sparse Opportunistic Network Environment
- DORSI: Data-wise Opportunistic Routing with Spatial Information

Rendezvous Based OppNet System Model

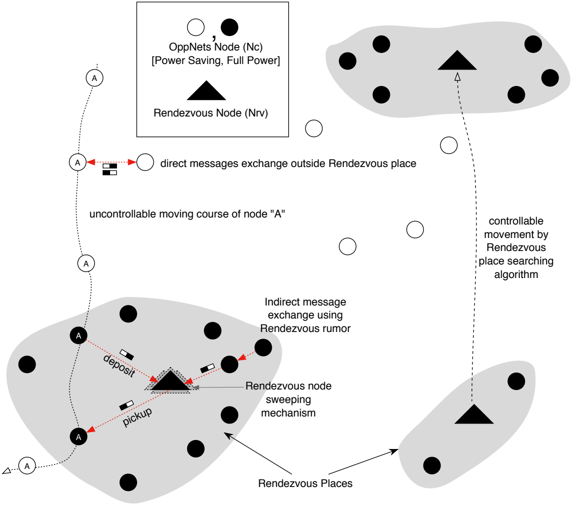

Figure: System Model

OppNet Operation Modes: Full Power & Power Saving

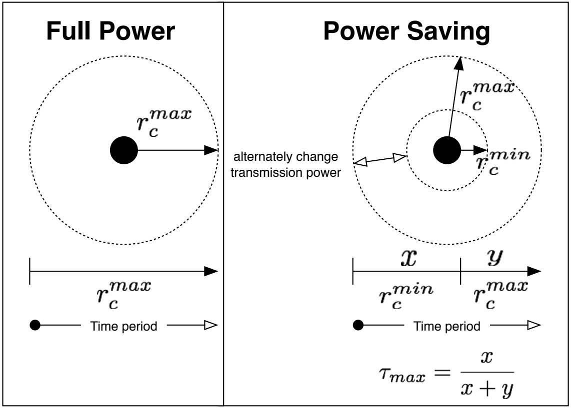

Figure: Operational Modes

Rendezvous place and its Rumor protocol

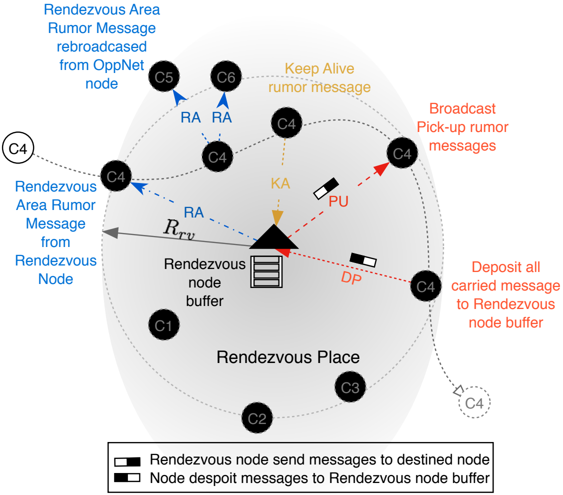

Figure: Rendezvous Place

Rendezvous place searching algorithm

- Predictable behavior OppNet nodes
- Non-Predictable behavior OppNet nodes

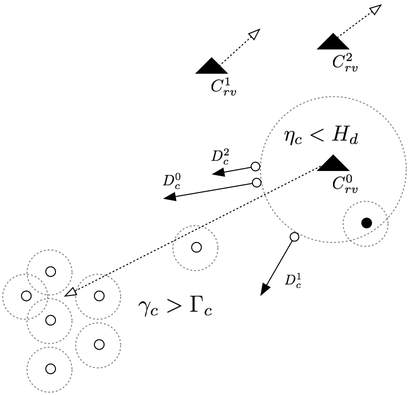

Figure: Rendezvous Place Searching

Simulation Setup

Table: simulation variables

Parameters	N_i	N_c	N_{rv}
Simulation Time	10800 Seconds		
Message Size	500 KB - 1 MB		
Node Buffer	500 MB		10 GB
Radio Range	30 Meters	$r_c = 30$ Meters	100 Meters
Transmission Speed	54 Mbps		
Router	DRRA — Epidemic		
Moving Speed	0.5 - 1.5 m/s		
Movement Model	Group Movement Model		

Simulation Results

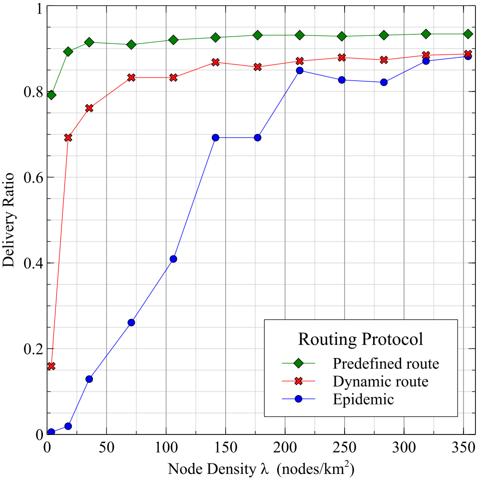

Figure: Delivery Ratio per Node Density

Simulation Results

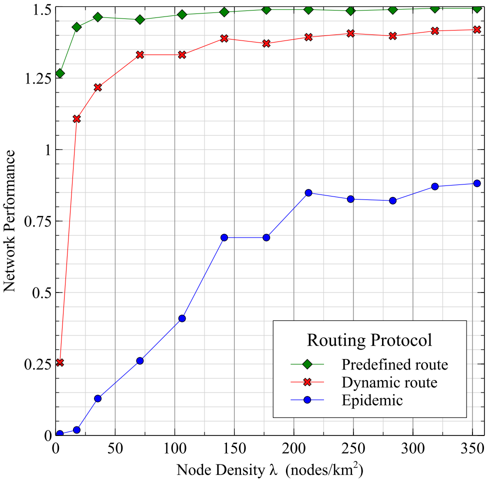

Figure: Network Performance per Node Density

Simulation Results

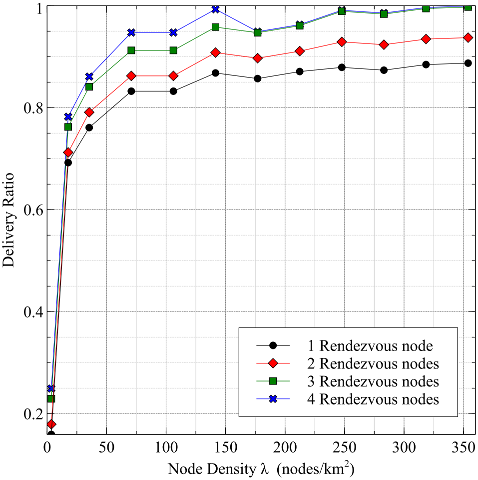

Figure: Multiple Rendezvous Places

Simulation Results

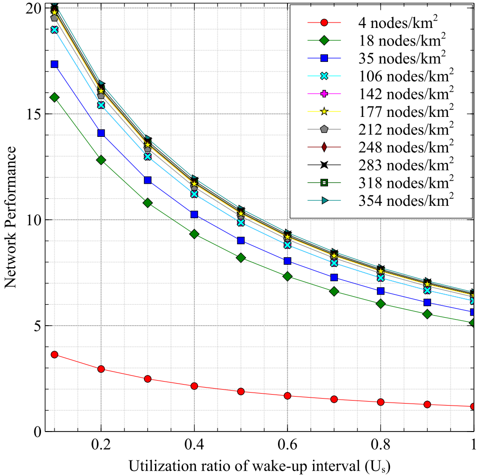

Figure: Network Performance per Utilization Ratio

Conclusion

- Our protocols perform significant higher in network network performance which is the tradeoff of delivery ratio per energy consumption.
- If the location of rendezvous can be predefined, we can achieve highest network performance.
- The carried node can gain higher network performance if the sleep mode is longer than awake mode.

DORSI Routing Algorithm

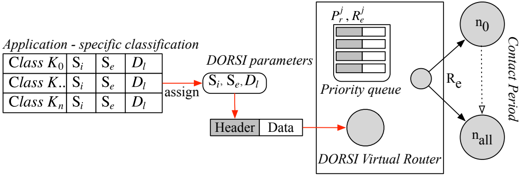

Figure: DORSI System Model

DORSI Routing Algorithm

$$P_r^j = w_p S_i^j + (1 - w_p)\xi(D_l^j, t) \tag{1}$$

$$\text{where } \xi(D_l^j, t) = \begin{cases} 0; \tau_t > \tau_{max} \\ \frac{\tau_{max} - \tau_t}{\tau_{max} - \tau_{min}} & ; \tau_{min} \leq \tau_t \leq \tau_{max} \\ 1; \tau_t < \tau_{max} \end{cases}$$

$$R_e^j = (1 - R_{min})[w_r P_r + (1 - w_r)(1 - S_e^j)] + R_{min} \tag{2}$$

Node Ranking Model

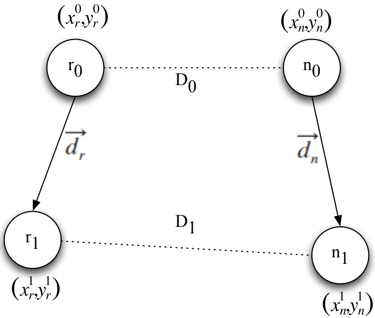

Figure: Node Ranking Model

$$N_r^n = \sqrt{(x_n \cos\theta_n - x_r^t \cos\theta_r^t)^2 - (y_n \sin\theta_n - x_r^t \sin\theta_r^t)^2} - \sqrt{(x_n - x_r^t)^2 - (y_n - x_r^t)^2} \quad (3)$$

Evaluation

Parameters	DORSI	Epidemic
Operation Time	3600 Seconds	
Message Size	500 KB - 5 MB	
Node Buffer	1000 MB	
Transmission Range	150 Meters	
Transmission Speed	54 Mbps	
Node Density	0 - 100 %	
Router	DORSI	Epidemic
Deadline	Relative to data class	
Moving Speed	0.5 - 1.5 m/s	
Movement Model	Random Waypoint	
Wait Time	0 - 180 Seconds	

Simulation Results

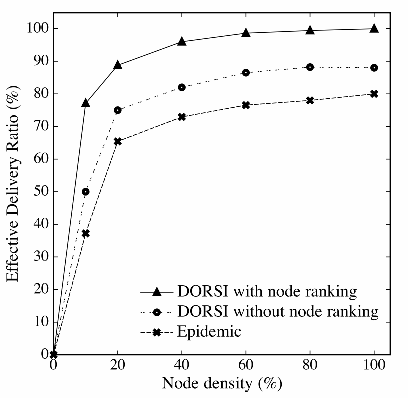

Figure: Effective Delivery Ratio per Node Density

Simulation Results

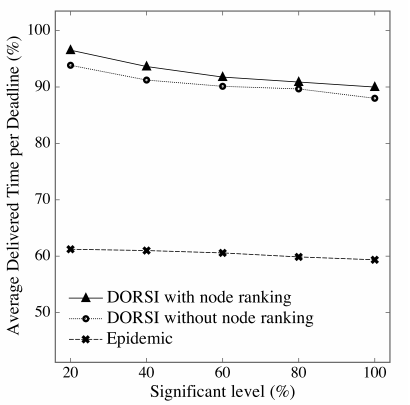

Figure: Average Delivered Time per Deadline on Significant Level

Simulation Results

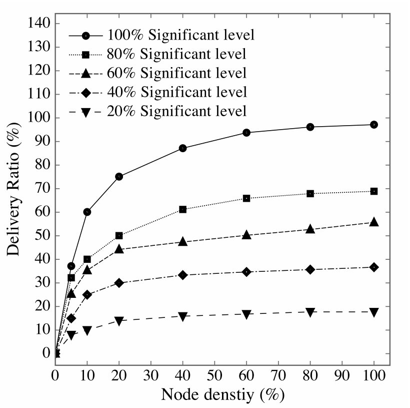

Figure: DORSI Delivery Ratio on each class

Simulation Results

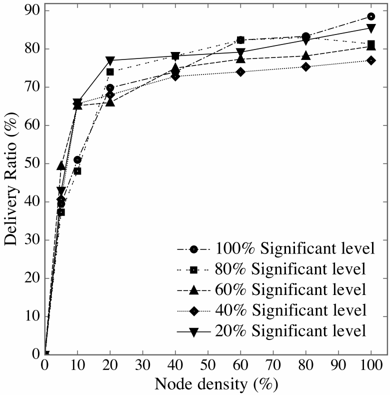

Figure: Epidemic Delivery Ratio on each class

Simulation Results

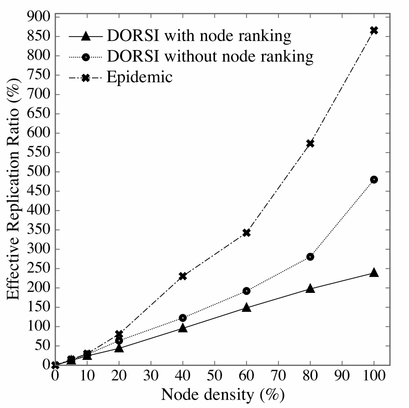

Figure: Effective Replication Ration Comparison

Simulation Results

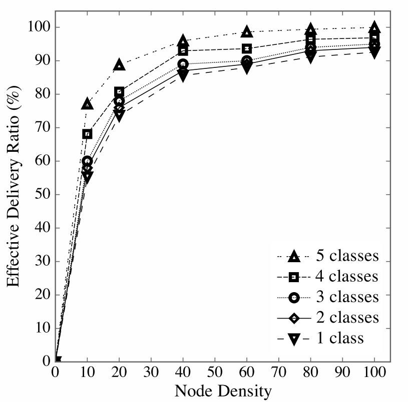

Figure: EDR on different classification scale

Conclusion

- Two key performance indexes (1) effective delivery ratio and (2) effective replication ratio: remarkably improve over the traditional Epidemic routing.
- Delivery ratio of DORSI and Epidemic comparison shows notable overall enhancement of the network routing efficiency.
- DORSI protocol can guarantee higher delivery ratio on more important data while limiting the replication of data with higher security level.

Conclusion

- With these two novel proposed OppNet routing algorithms, the delivery ratio of network can be improved especially on the sparse network environment
- Rendezvous based routing can optimize the power utilization among mobile nodes.
- DORSI can improve the deliverable of important messages thus the network gains higher delivery ratio

References

Y. Cao and Z. Sun.
Routing in delay/disruption tolerant networks: A taxonomy, survey and challenges.
Communications Surveys Tutorials, IEEE, 15(2):654–677, Second 2013.

J. Kerdsri and K. Wipusitwarkun.
DORSI : Data-wise Opportunistic Routing with Spatial Information.
Journal of Convergence Information Technology, 8(August):91–103, 2013.

K. Scott.
Disruption tolerant networking proxies for on-the-move tactical networks.
In *Military Communications Conference, 2005. MILCOM 2005. IEEE*, pages 3226–3231 Vol. 5, 2005.

T. Small and Z. J. Haas.
The Shared Wireless Infostation Model - A New Ad Hoc Networking Paradigm (or Where there is a Whale , there is a Way) .
pages 233–244, 2003.

T. Spyropoulos, R. Rais, T. Turletti, K. Obraczka, and A. Vasilakos.
Routing for disruption tolerant networks: taxonomy and design.
Wireless Networks, 16(8):2349–2370, 2010.