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

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Overview

Literatures Review

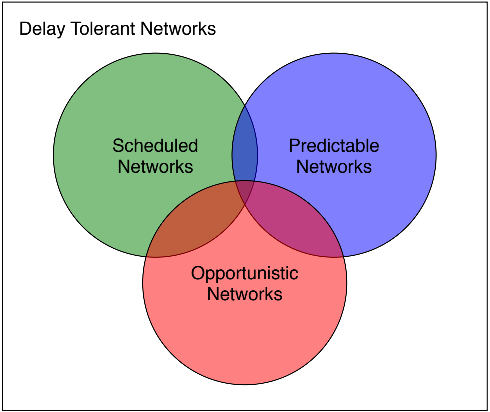


Figure: Types of DTN

What is OppNet?

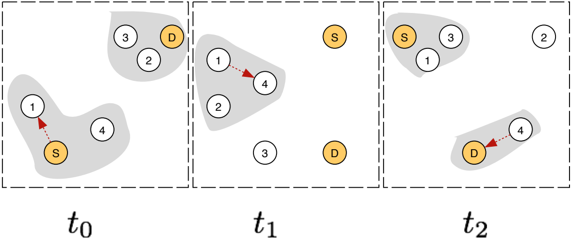


Figure: Store-Carry-Forward (SFC) protocol

- 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 [6]

Applications for OppNet

Wildlife Monitoring

ZebraNet [7], SWIM [4]

Battlefield Network

Military tactical networks [1] [3]

Disaster Monitoring Network

Help Me [2]

Literatures Review

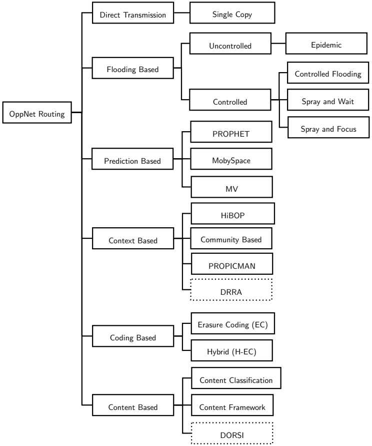


Figure: Classification of Opportunistic Routing

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 [5]
- Low delivery ratio in sparse network environment
- Limited power resource

Proposed Approaches

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

Rendezvous Based OppNet System Model

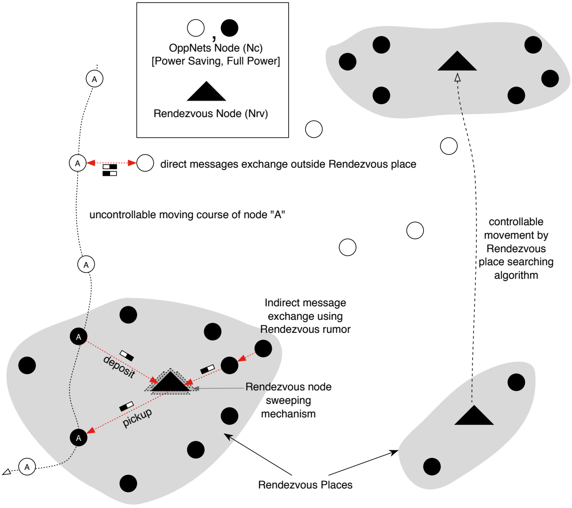


Figure: System Model

OppNet Operation Modes: Full Power & Power Saving

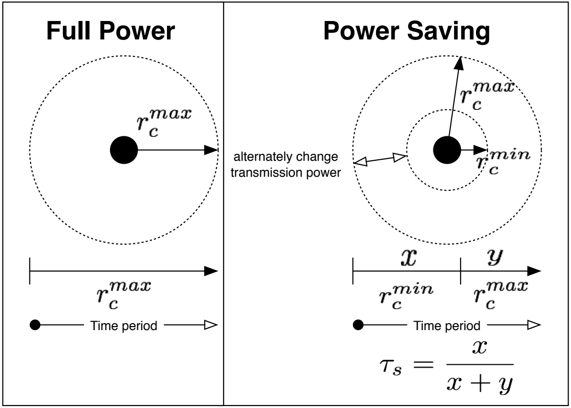


Figure: Operational Modes

Rendezvous place and its Rumor protocol

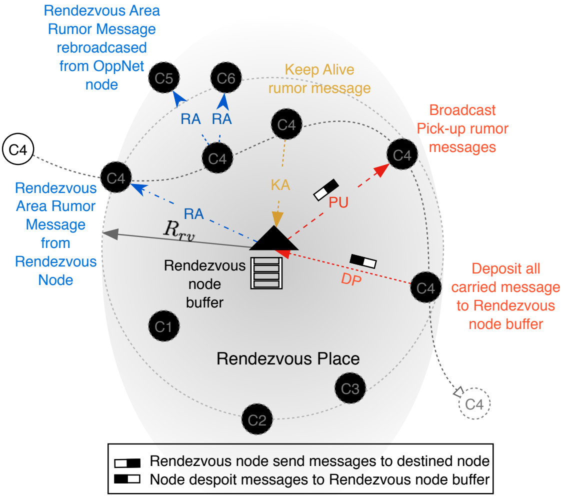
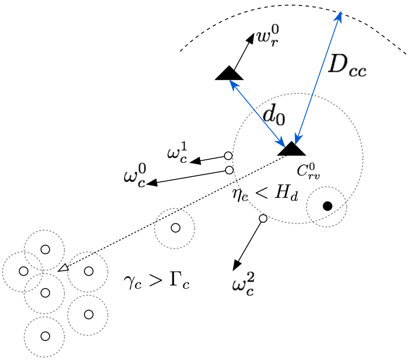


Figure: Rendezvous Place

Rendezvous place searching algorithm

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



$$\vec{\Delta} = \sum_{i=1}^{C} \vec{\omega_c^i} + \varphi \sum_{j=1}^{R} \delta\left(d_j\right) \vec{w_{rv}^j} \tag{1}$$

$$\delta\left(d_j\right) = \begin{cases} 1 & ; \quad d_j \leq D_{cc} \\ 0 & ; \quad d_j > D_{cc} \end{cases}$$

Simulation Setup

Table: DRRA Simulation variables

Parameters	N_c	N_{rv}
Message Size	500 KB - 1 MB	
Maximum Radio Range	30 Meters	100 Meters
Transmission Speed	54 Mbps	
Router	DRRA — Epidemic	
Moving Speed	0.5 - 1.5 m/s	
Movement Model	Group Movement Model	

Metrics

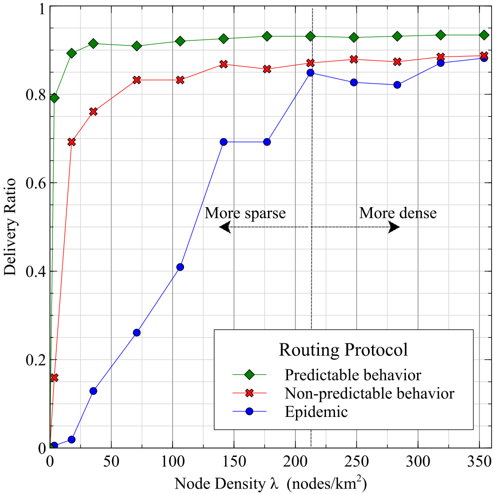
$$D_r = \frac{M_{delivered}}{M_{created}} \tag{2}$$

$$E_P \quad \propto \quad M_P \cdot r_P^2 \tag{3}$$

$$D_P = \frac{D_r^P}{E_{P,B}} = \frac{D_r^P}{\left(\frac{M_P \cdot r_P^2}{M_B \cdot r_B^2}\right)} \tag{4}$$

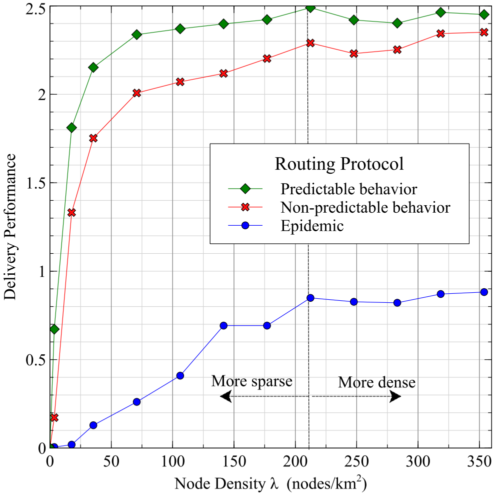
Simulation Results

Delivery Ratio per Node Density



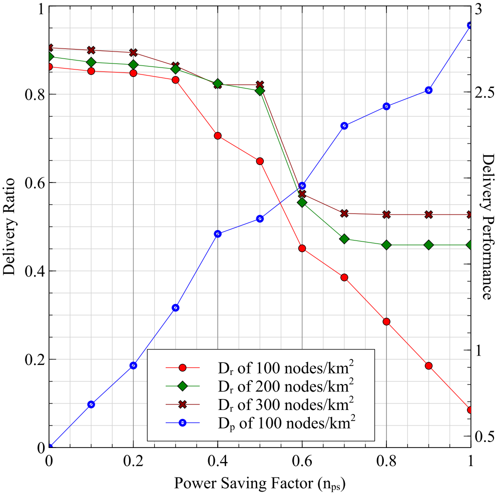
Simulation Results

Network Performance per Node Density



Simulation Results

The Optimum between Delivery Ratio and Delivery Performance



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

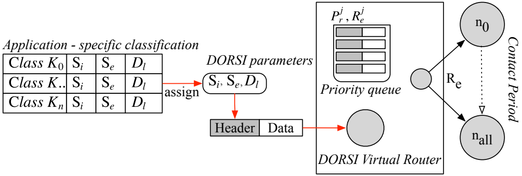


Figure: DORSI System Model

DORSI Routing Algorithm

$$P_r^j = w_p S_i^j + (1 - w_p)\xi(D_l^j, t) \tag{5}$$

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

$$R_e^j = (1 - R_{min})[w_r P_r + (1 - w_r)(1 - S_e^j)] + R_{min} \tag{6}$$

Node Ranking Model

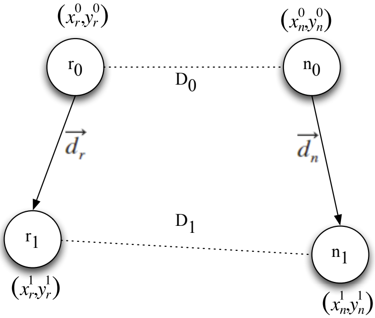


Figure: Node Ranking Model

$$N_r^n = \sqrt{(x_n \cos\theta_n - x_r^t \cos\theta_r^t)^2 - (y_n \sin\theta_n - x_r^t \sin\theta_r^t)^2} - \sqrt{(x_n - x_r^t)^2 - (y_n - x_r^t)^2} \tag{7}$$

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

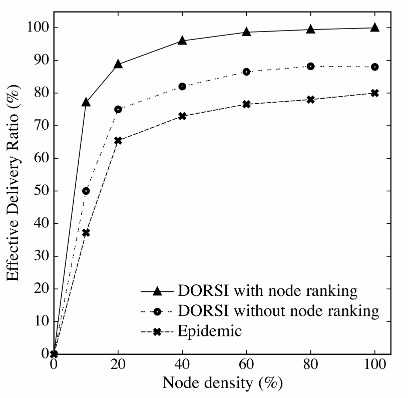


Figure: Effective Delivery Ratio per Node Density

Simulation Results

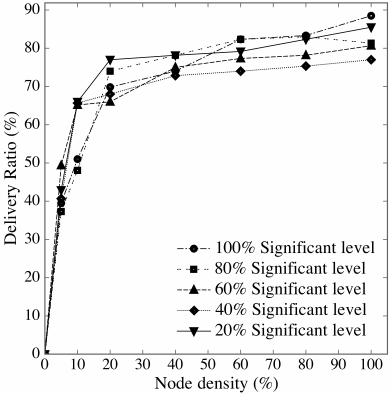


Figure: Epidemic Delivery Ratio on each class

Simulation Results

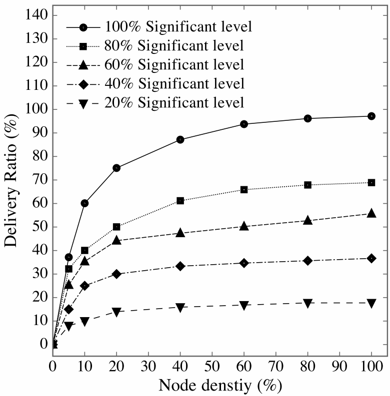


Figure: DORSI Delivery Ratio on each class

Simulation Results

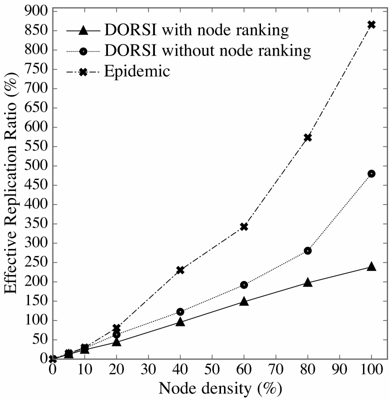


Figure: Effective Replication Ration Comparison

Simulation Results

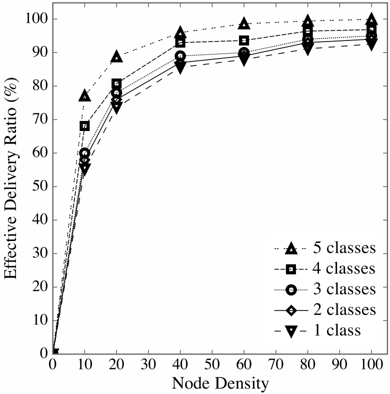


Figure: EDR on different classification scale

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

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