Opportunistic Routing Based Scheme with Multi-layer Relay Sets in Cognitive Radio Networks

Ying Dai and *Jie Wu*

Department of Computer and Information Sciences

Temple University

Motivation

- Cognitive radio networks (CRNs)
  - *Primary users* VS *secondary users.*

- Routing challenges: stability
  - Unpredictable PU activities and uncontrollable break links.
  - Dynamic channel availability.

Motivation

- Advantages of opportunistic routing
  - Improvement of stability
- Challenges of applying opportunistic routing
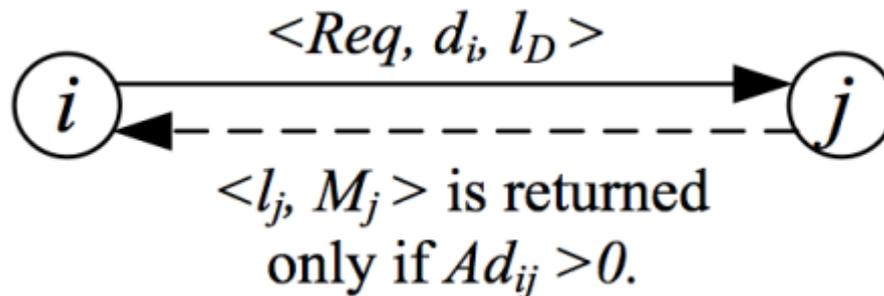 - Relay node set selection
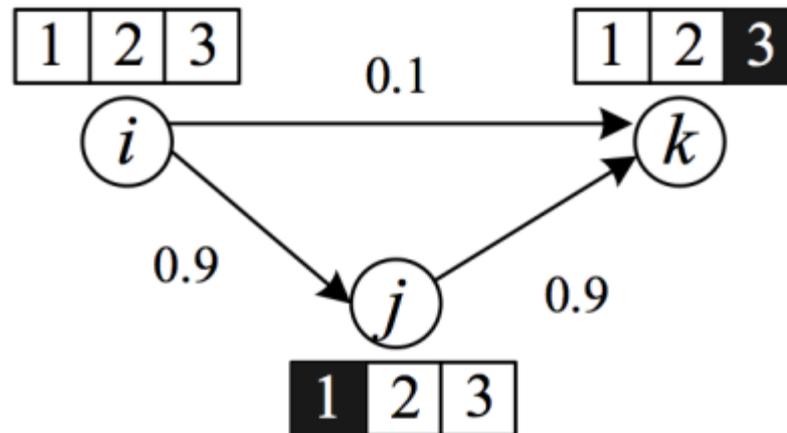
Overview

- We propose an efficient routing framework based on multi-layer relay sets.

- We give the algorithm for the selection of relay sets and transmission channels together.

- We design an adaptation approach with fewer interruptions to the data transmission when facing the suddenly-active PUs.

Multi-layer Opportunistic Routing Framework

- Framework overview:

  - Information exchange

  - Multi-layer relay set selection

  - Routing scheme and relay set adaptation

Multi-layer Opportunistic Routing Framework

- Information exchange
  - Goal: The sender gains the channel availabilities and the location information of its neighbors.

$$<Req, d_i, l_D>$$

$\quad i \longrightarrow j$

$<l_j, M_j>$ is returned only if $Ad_{ij} > 0$.

Multi-layer Opportunistic Routing Framework

- ## Multi-layer Relay Set Selection
  - Multi-layer => Multi-channel

  - Definition: Relay set on one layer
    - For a node j in a relay set on one layer of node i, with channel m, it must satisfy two conditions: 1) Channel m must belong to both available channel sets of nodes i and j; 2) Node j is closer to the destination than node i.

Multi-layer Opportunistic Routing Framework

- ## Multi-layer Relay Set Selection
  - ### Definition: Relay node weight
    - The weight of a relay node is defined by the distance advance to the destination node times the transmission rate, with a weight factor.

  - ### Definition: Relay set weight
    - The weight of a relay set is defined as the expected relay node weight, based on the successful transmission probability.

Multi-layer Opportunistic Routing Framework

- Multi-layer Relay Set Selection

  - Multi-layer relay set selection is based on the relay set weight.

    - Main relay set: the one with the max weight
    - Backup relay set: the one with the second max weight

Multi-layer Opportunistic Routing Framework

- Multi-layer Relay Set Selection
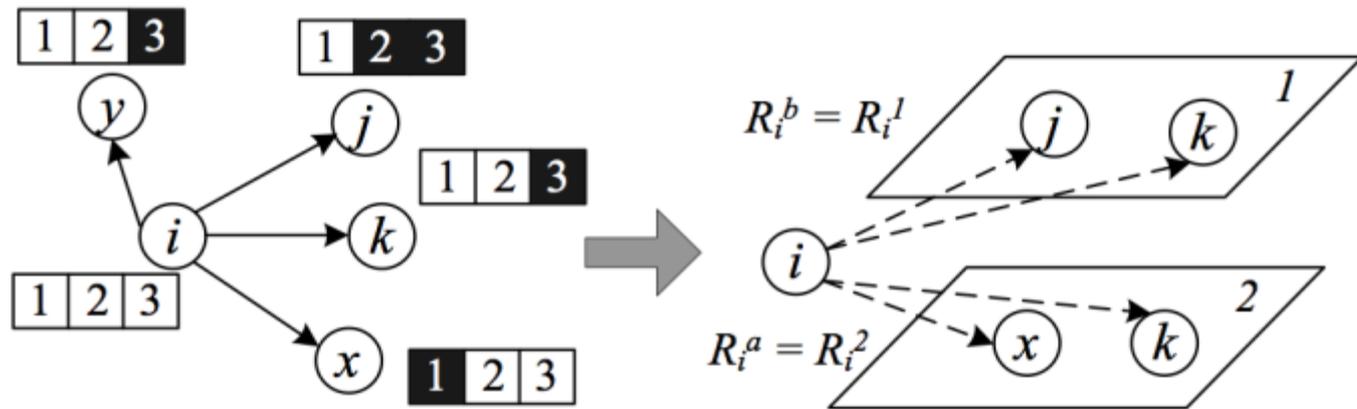
Nodes in N_i	y	j	k	x
Advanced distance to destination	-0.5	0.6	0.8	0.7
Maximum transmission rate	10	9	6	8

Routing Scheme and Relay Set Adaptation

- Channel dynamics make the main relay set fail.


Algorithm 2 Relaying process for sender i.

Input: R_i^a, R_i^b, M_i;

1. i uses R_i^a and calls $Proc$;
2. **if** No ack is received within time γ **then**
3. $R_i^a = R_i^b$; i calls $Proc$;
4.   **if** No ack is received within γ **then**
5. i runs Algorithm 1 with $M_i = M_i - \{a, b\}$;
6.   Update R_i^a, R_i^b, and go to Step 1;
7.   **else**
8. i runs Algorithm 1 with $M_i = M_i - \{a\}$;
9.   Update R_i^a, R_i^b;

Performance Evaluation

- Simulation settings
  - Network parameters:
    - number of nodes, number of channels, PU off duration.

  - Evaluation metrics:
    - end-to-end delay, packet delivery ratio, and relay-to-sensing ratio
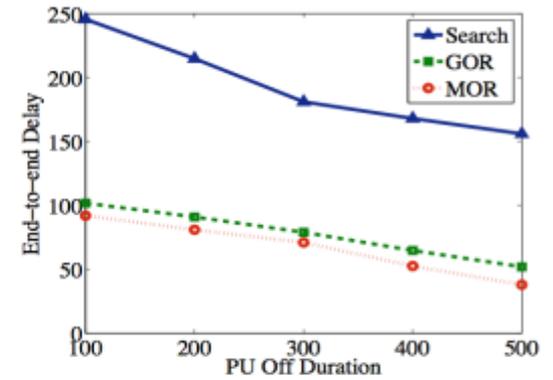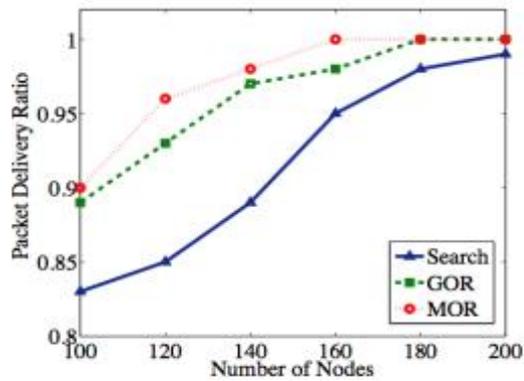
Performance Evaluation
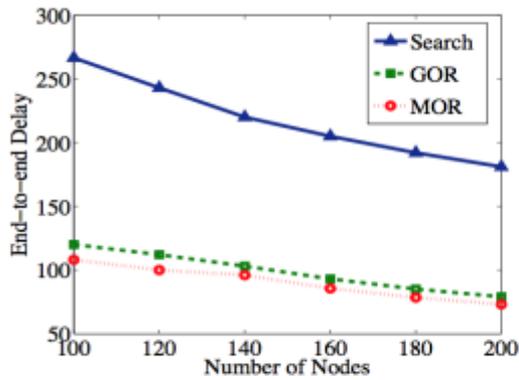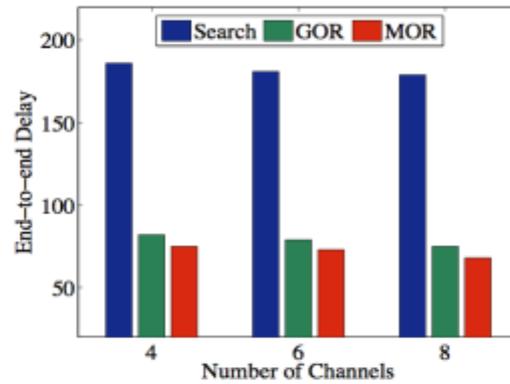
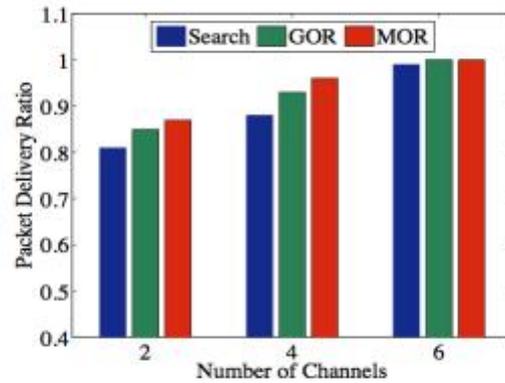
(a) change nodes

(b) change channels

(c) change PU off duration
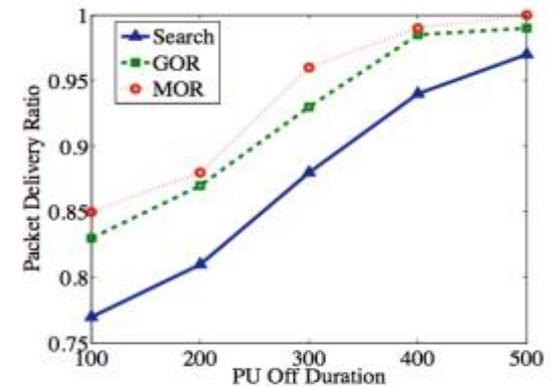
End-to-end delay

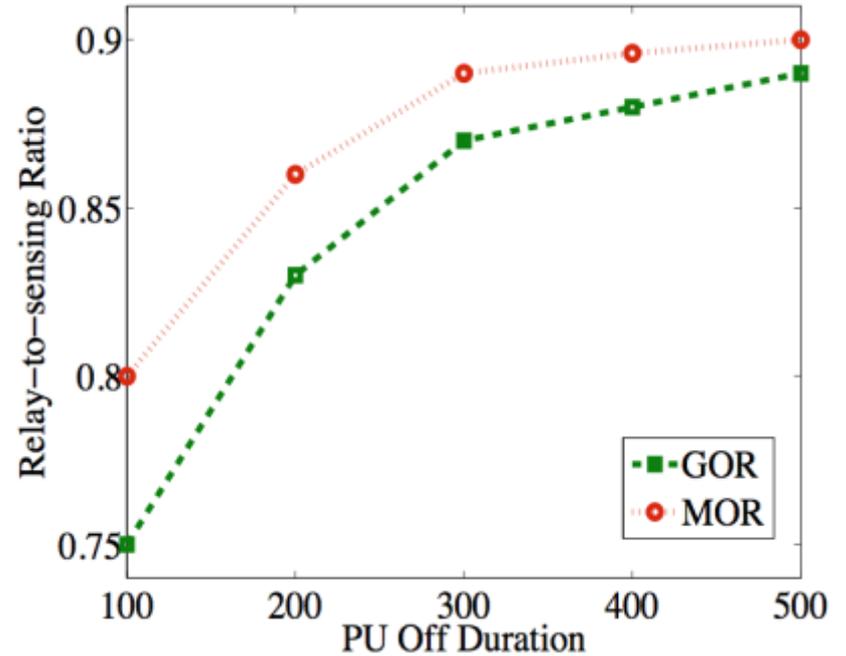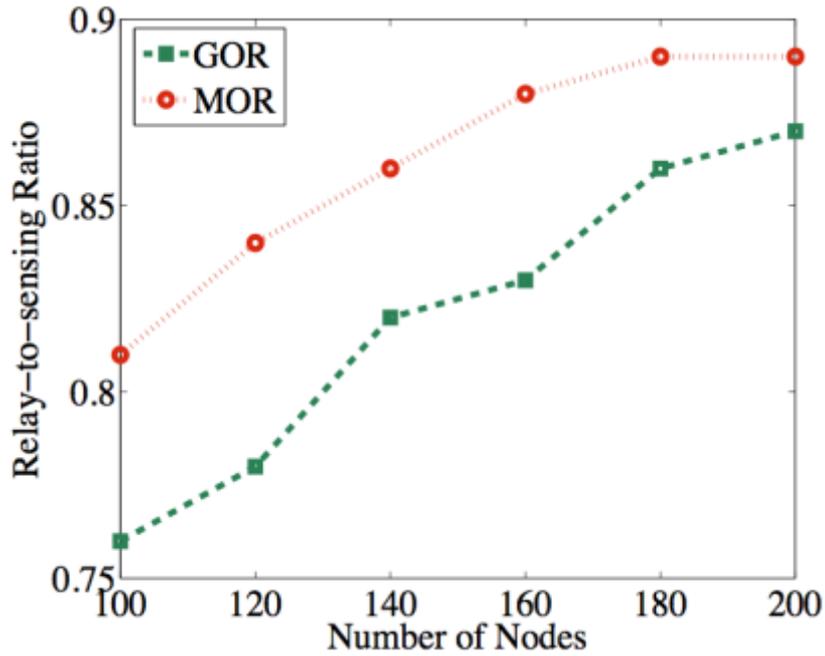# Performance Evaluation

(a) change nodes (b) change channels (c) change PU off duration

Packet delivery ratio

Performance Evaluation

Relay-to-sensing ratio

Conclusion

- Multi-layer relay set selection

- Main and backup relay set

- Adaptation scheme

- Performance evaluation

THANK YOU!