QoS Multicast Routing and Transmission Scheduling in Multi-hop Cognitive Radio Networks

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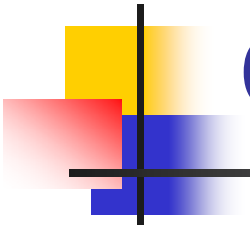
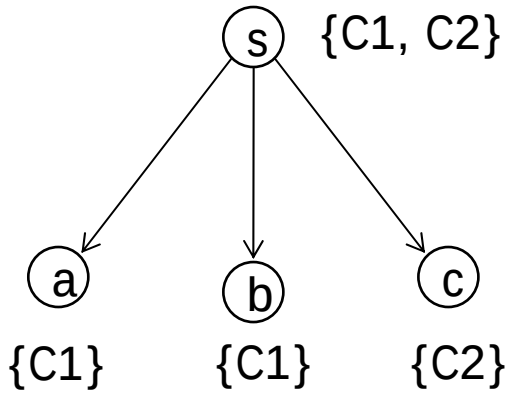


Overview

- Introduction
- Problem Formulation
- QoS Multicast Routing Protocol
- Simulation Results
- Conclusion

Introduction

- Cognitive Radio (CR) networks
  - Different users may have different available channels.



- QoS multicast in CR networks
  - Purpose: Minimize the bandwidth consumption
  - QoS Requirement: bandwidth and delay

System Model

- Assumptions
  - Two radios
  - A common control channel
- An undirected graph *G(V;E)*
- The protocol interference model
  - R_u : the set of nodes that are interfered by *u*
  - Node *w* is interfered by link *(u,v)* iff $w \in R_u \cup R_v$
  - Link *(x,y)* is interfered by link *(u,v)* iff

    $x \in R_u \cup R_v$ or $y \in R_u \cup R_v$

System Model

- TDMA scheme
  - Resource unit: slot *(c, t)*
  - A slot *(c, t)* is free for a node *u*
    - Node *u* does not transmit or receive in timeslot *t*
    - None of the nodes in R_u occupies slot *(c, t)*
  - A slot *(c, t)* is free for a link *(u, v)*
    - The slot is free for both node *u* and *v*

Problem Statement

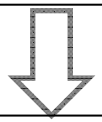
- Give a connection request with a source *s*, a set of destinations *D*, a bandwidth requirement *B* (number of timeslots in a frame) and a delay bound Δ (number of hops).
- Set up a multicast connection, which starts from *s* and spans all the nodes in set *D*, so that the total bandwidth consumption of the multicast is minimal while the QoS requirements are satisfied.

Problem Analysis

- For delay requirement
  - Shortest Path Tree (SPT)
- For bandwidth requirement
  - B_u: The bandwidth consumption of a multicast at node u (the number of transmission slots required by node u)
  - B: The total bandwidth consumption of a multicast tree

    $B=\{\sum B_u \mid u \text{ is a non-leaf node in the multicast tree}\}$

Obj: Minimize the bandwidth consumption of a multicast tree



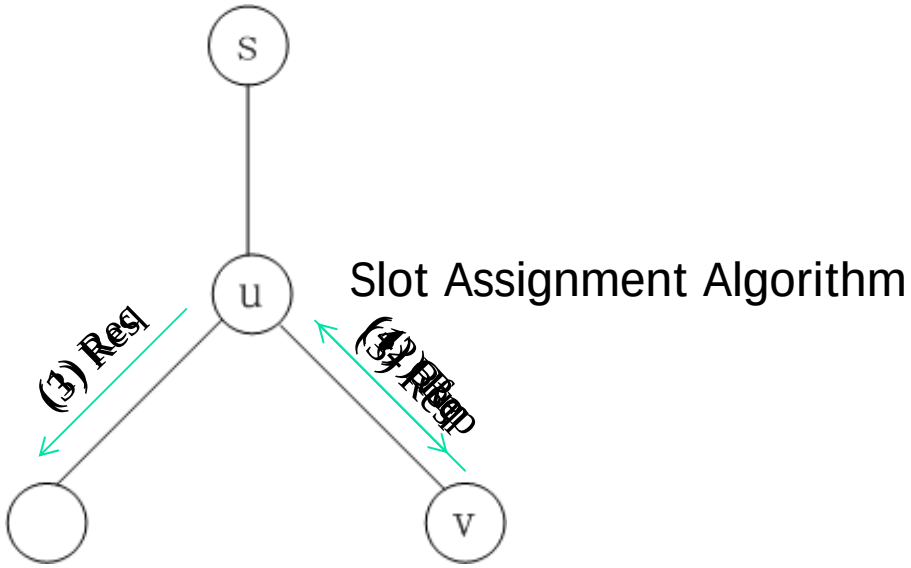
Minimize the total number of transmission slots required by all non-leaf nodes

Proposed Protocol

- Find a multicast tree which meets the delay bound requirement. (SPT)
- Assign minimum slots along the tree links so that the bandwidth requirement can be satisfied.
  - *Slot Reservation*: After the multicast tree is constructed, each non-leaf node in the tree should reserve transmission slots for the multicast request

Proposed Protocol

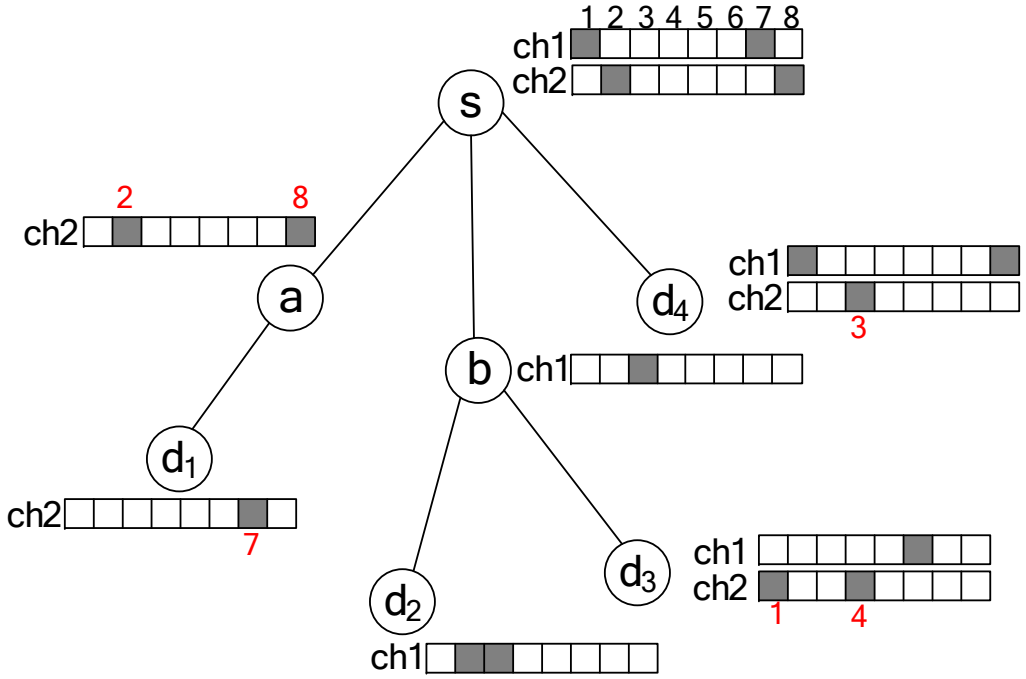
- Slot reservation process



- Start from the source, and go down along the tree hop by hop

Proposed Protocol

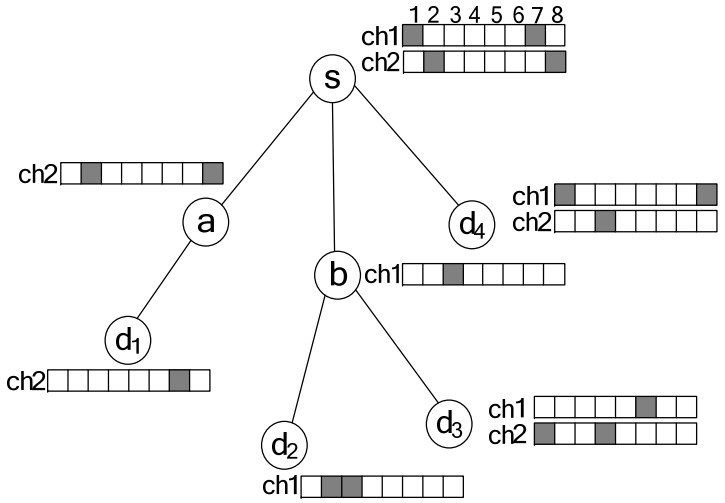
- How to assign transmission slots to a node *u*?
  - F_u : free timeslots set for node *u*

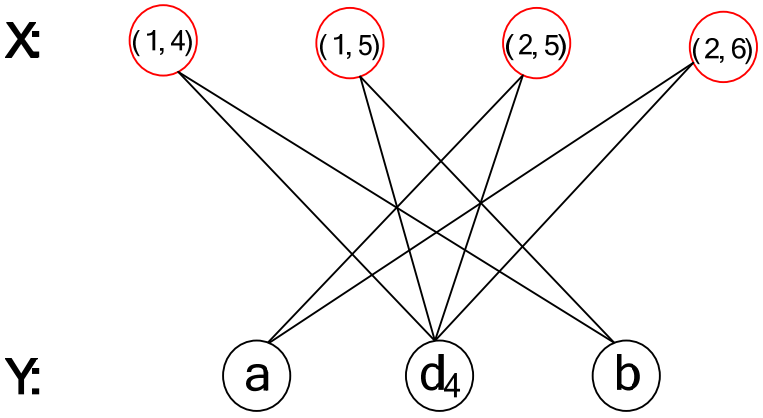


$F_a = \{(2,5), (2,6)\}$
$F_b = \{(1,4), (1,5)\}$
$F_{d_4} = \{(1,4), (1,5), (2,5), (2,6)\}$

Proposed Protocol

- an auxiliary bipartite graph $G_u(X; Y; E)$
  - X: F_u
  - Y: the set of child nodes of u
  - E: link $((c,t), v) \in E$, iff slot (c,t) is free for node v

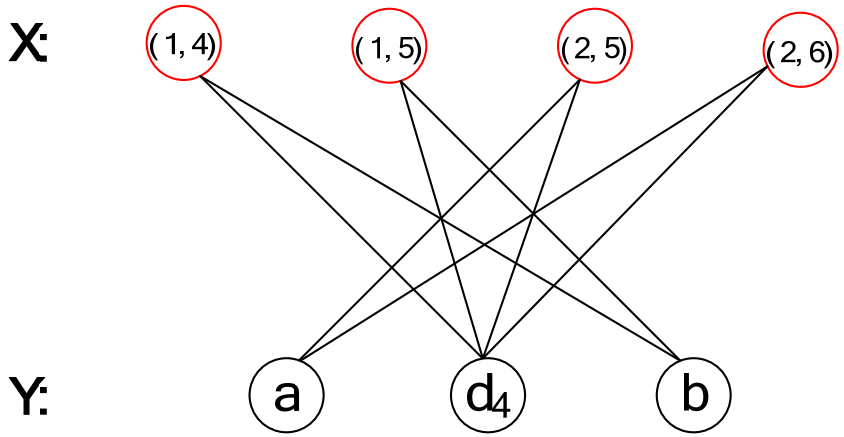




F_s = {(1,4), (1,5), (2,5), (2,6)}

An auxiliary Bipartite Graph for node s: $G_s(X; Y; E)$

Proposed Protocol

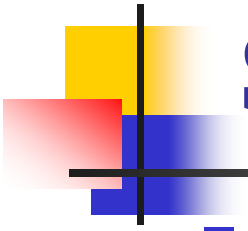


To assign the least number of transmission slots to s

⇩

To select the least number of vertices in X that can dominate all vertices in Y (Minimal Set Cover, if B =1)

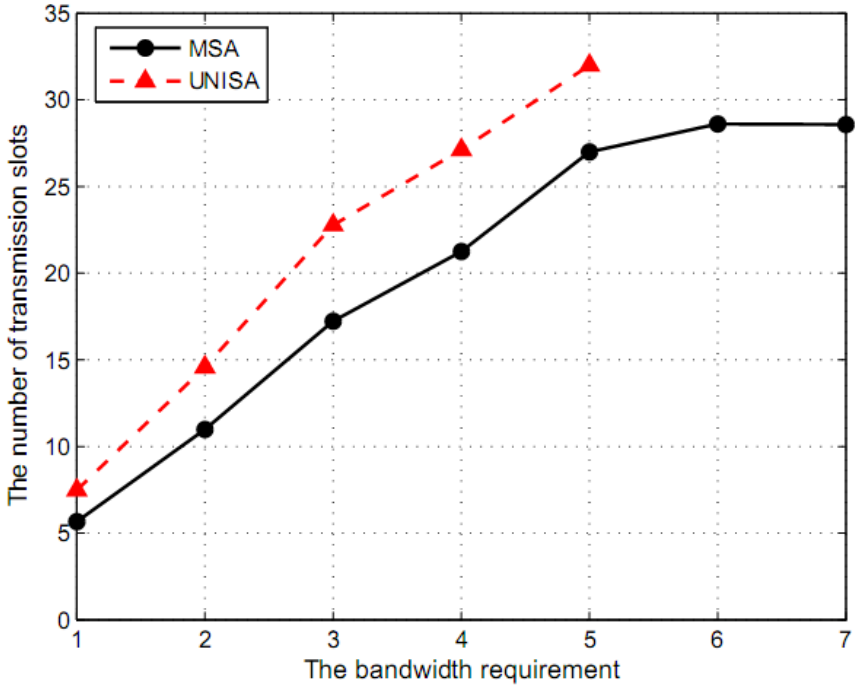
- Greedy algorithm: pick the vertex in X that dominates the most number of remaining undominated vertices in Y

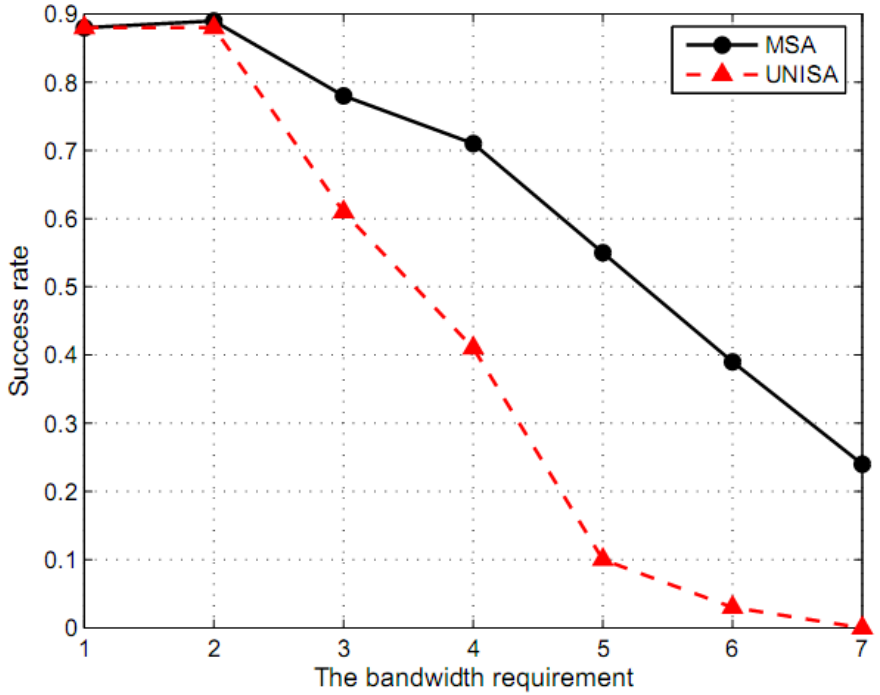


Simulations

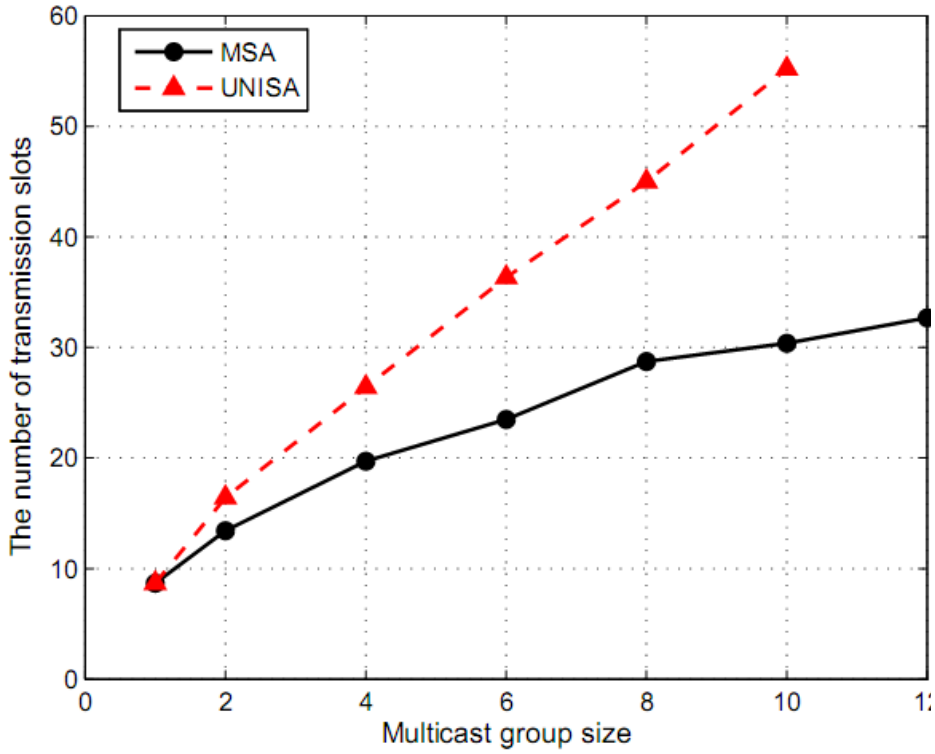
- Compared our method (MSA) with unicast slot assignment (UNISA)
- performance metrics
  - success rate
  - the number of transmission slots
- three parameters
  - bandwidth requirement
  - multicast group size
  - the total number of nodes

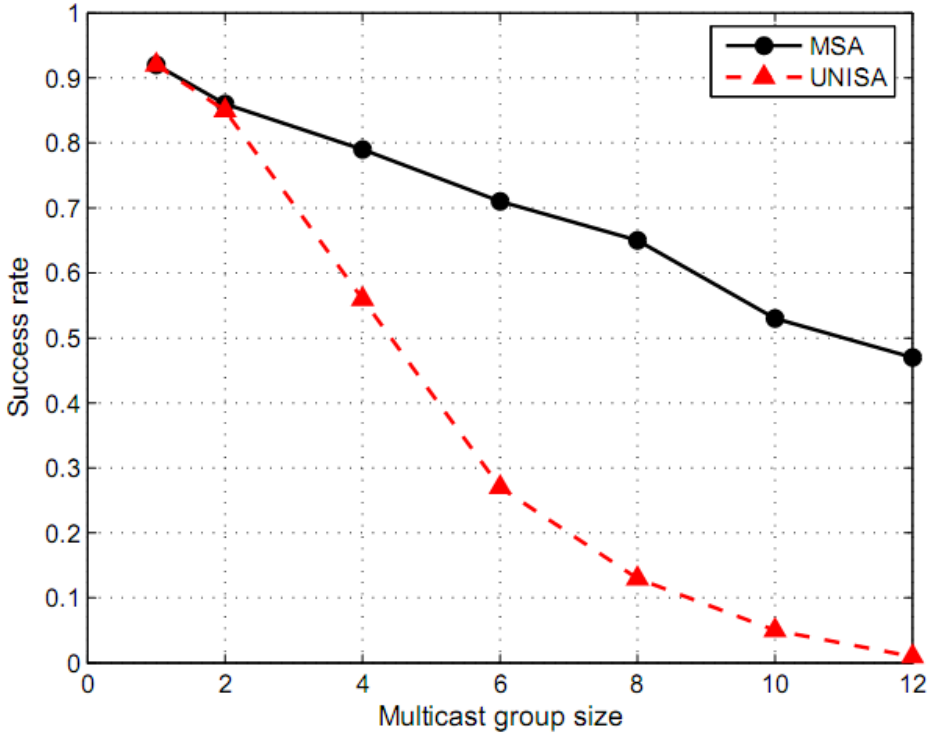
Simulations



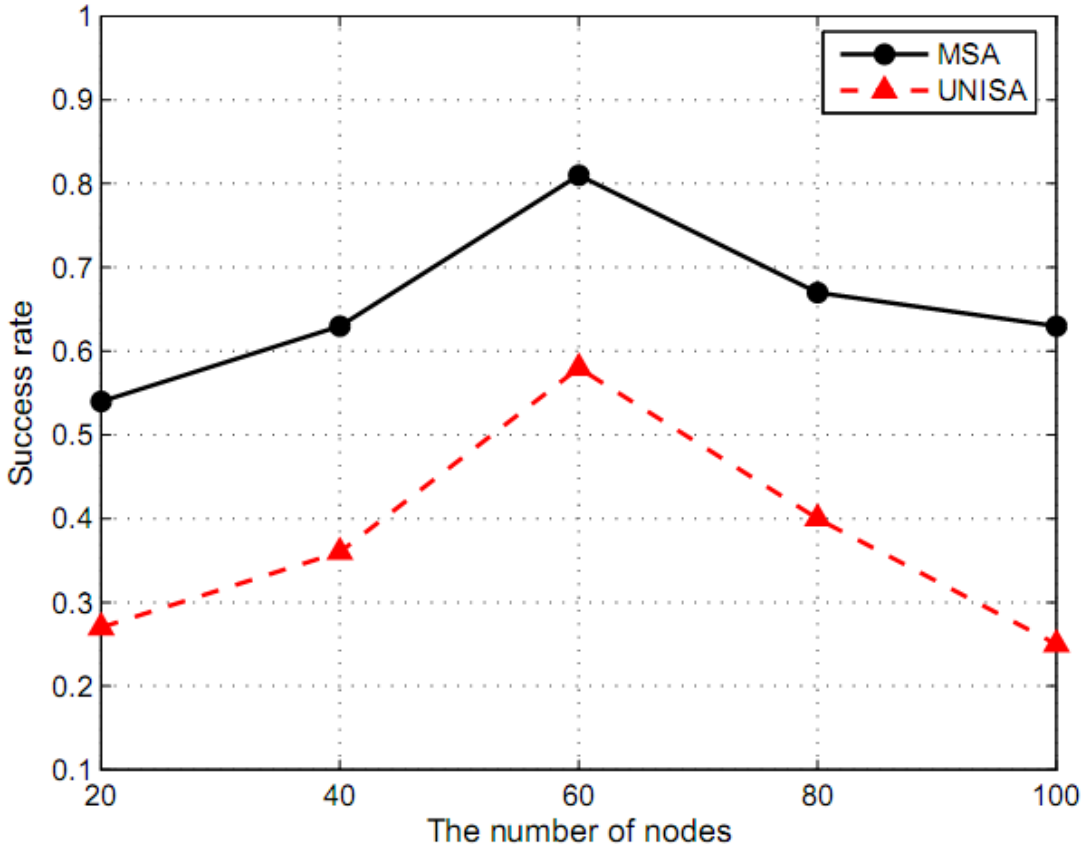


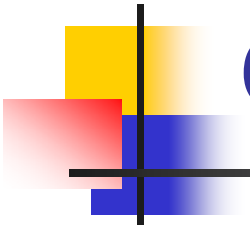
Simulations





Simulations





Conclusion

- Set up a multicast connection so that the total bandwidth consumption of the multicast is minimized while the QoS requirements are satisfied
- Propose a distributed protocol which involves routing and slot assignment

Thank you!