Hitchhiking in Cognitive Radio Networks: Spectrum Sensing Assisted By Cores and Clusters

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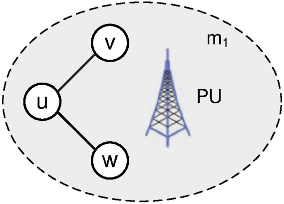
Motivation

- Spectrum sensing in Cognitive Radio Networks (CRNs): protect primary users
- Accuracy requirement + extra time cost
- Question: Can we reduce the sensing cost by having nodes help each other?



Total channel set: $\{m_1, m_2, m_3\}$

Motivation

- Hitchhiker: A node can make use of other nodes' most recent sensing results to benefit its current sensing.
  - Two dimensions: location, time.
- Potential extra time cost during the information exchange among nodes may be harmful.
- Our solution: *Cores and Clusters!*

Overview

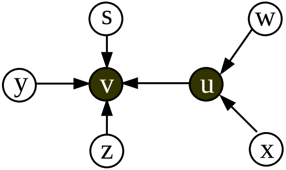
- The phase before spectrum sensing happens: How to select channels for sensing in CRNs.
- Our goal: Reduce the total number of channels that a node needs to sense before finding an available one.
- Core structure: Each node designates a neighbor or itself as its core, and can gain help for the spectrum sensing phase.
- Extension: A 2-layer structure of both clusters and cores, and the corresponding spectrum sensing scheme.

Core Construction

- Information exchange with neighbors.
  - Available channel set.
- Weight Calculation.
  - For a node v, the weight of it is: $W_v = \sum_u |M_u \cap M_v|$, $\forall u \in N_v$.
- Core designation.

Core Construction

An example:



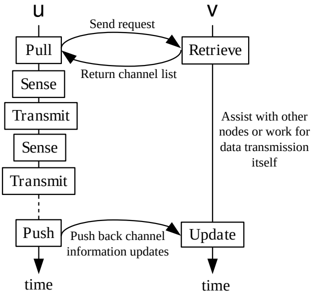
u	v	w	x	y	z	s
{1,2}	{1,2,3}	{2,3}	{1}	{1,2}	{3}	{1,2}
4	7	1	1	2	1	2

$d_u = \{w, x\}$, $d_v = \{u, y, s, z, v\}$.

Spectrum Sensing With Cores

The help gained from the core is the channel list, which sorts the channel according to their available probability.

- On the node side: Pull, Sense, Transmit, Push.
- On the core side: Return, Update.

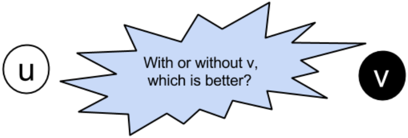


Core Evolution

- What if a node designates a wrong core?
  - The node and its core do not share the similar channel availabilities.
- The core evolution is necessary to fix this situation.
- But... How?
  - We need to find a way to evaluate the assistance provided by the core.

Core Evolution

- The basis for core updates:
- For a node u and its core v ($v = c_u$), u needs to update c_u if and only if $A_{uv} > A_u$.
  - A_{uv} is the estimated average number of channels to sense if u receives assistance from v.
  - A_u is the estimated average number of channels to sense if u senses itself u and gains no assistance from others.



Core Evolution

- The evaluation is performed on the core side.
  - A node is unable to evaluate since it always senses based on the core's information.
- Compare the performance with and without core's information.
  - The core considers the virtual situation that if the node sends a request now, rather than pushing back its current channel information.

Core Evolution

Core reselection:

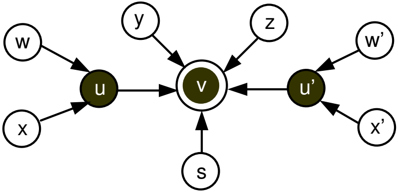
- After a node identifies its core needs to be reselected, it reselects a new core.
- Simply reselect from its remaining neighbors aside from the wrong core.
- Advantage of core structure: Easy to propagate!

Cluster-core Motivation

- Motivation: In a sparse network, the average help provided by each core is limited.
- To increase the performance, what about having more nodes in a longer distance share information?
- Cluster-core structure: Build clusters on top of the cores.

Cluster-core Construction

- Select cluster heads from current cores, using similar weight definition as for core selections.
  - $WC_v = \sum_u |M_u \cap M_v|$, $\forall u \in NC_v$.
  - NC_v: the set of v's neighbor cores.
- An example of the mixed cluster-core structure is:



Cluster-core Construction

We applies the classical cluster head selection algorithm here:

1. All cores are initially uncovered;
2. An uncovered core becomes a cluster head, if it has the highest weight;
3. The selected cluster heads and their connected 1-hop neighbor cores are marked as covered;
4. Repeat Steps 2 and 3 on all uncovered cores.

Spectrum Sensing With Cluster-core

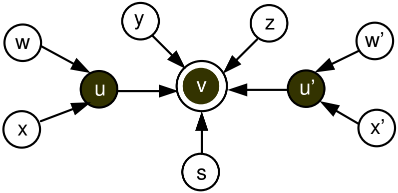
- Cluster head collects information from the cores and shares the information among multiple cores.
- The overview of the process:

  ◦ Cluster heads: periodically collect from and send to the cores in the same cluster.

  ◦ Cores: updates their corresponding channel information, and return the updated information to other nodes.

Spectrum Sensing With Cluster-core

An example of spectrum sensing with cluster-core structure:



Cluster head: v, collects and shares the information.
Cores: u, v, u', update their channel list for other nodes.

Spectrum Sensing With Cluster-core

Some illustrations:

- Under the cluster-core structure, the work on the node side with its core remains unchanged.
- The cluster heads push to their cores, instead of having the cores pull from the cluster heads.
  - A cluster head usually has more members than a core.
- It is not true to claim that one of the core-only and cluster-core structures is always better than the other.

Simulation Settings

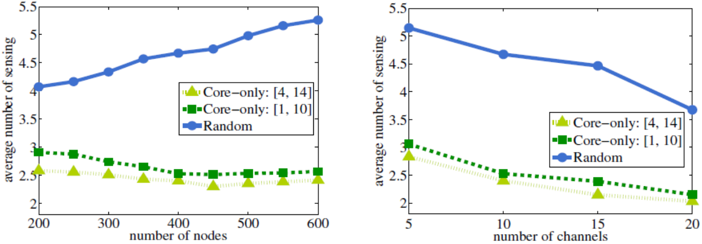
Main parameters:

Number of PUs	10
Number of nodes	$[50, 600]$
Number of channels	$[5, 20]$
Single data task duration	3
Size constraints for cores	$[1, 14]$
Information exchange frequency for cores	$[1, 3]$
Information exchange frequency for clusters	$[3, 9]$

1. Parameters to vary: size constraints of the core-only structures, information exchange frequencies between a node and its core.
2. Performance to compare: the average number of channels to sense

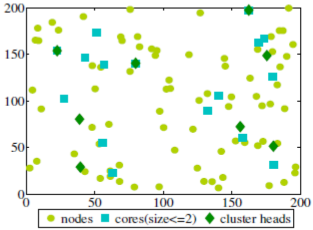
Simulation Results

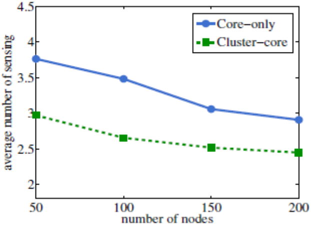
Different size constraints for core-only structures *VS* Random sensing



Simulation Results

Cluster-core structure *VS* core-only structure *VS* Random sensing





Conclusions

- Our focus: how to select channel for spectrum sensing.
- Two structures: core-only and cluster-core structures.
- The evolution process for the core-only structure.
- Two corresponding sensing schemes.

Thank you!

If you have any question, please contact Ying Dai (tuc74224@temple.edu).