Virtual Backbone Construction for Cognitive Radio Networks without Common Control Channel

Ying Dai, Jie Wu, and ChunSheng Xin

Virtual Backbone

Definition and Usage.

- Virtual Backbone is a connected subset of nodes in the network where every node is either in the subset or a neighbor of a node in the subset.
- Advantages in traditional networks:
    - End-to-end data transmission, routing, ...

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Possible applications in cognitive radio networks.

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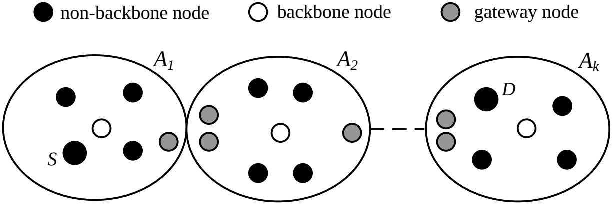

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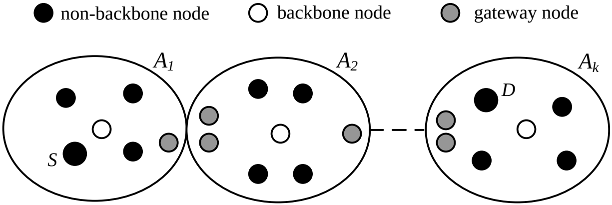

Thus, virtual backbones have very promising usages in CRNs.

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Q: How to exchange the extensive control information while constructing a virtual backbone?

- In CRNs, due to the dynamic availability of channels, it is impractical to use a static channel to exchange control information between nodes.
- Our goal is constructing a virtual backbone in a CRN without a common control channel (CCC).

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Initial Home Channel Selection.

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Let $\mathcal{Q} = M(c_k)$ {The channel segment for $c_k$}
repeat
    $k = Z(|\mathcal{Q}|)$ {Generate $k$ such that $1 \leq k \leq |\mathcal{Q}|$}
    $q = \mathcal{Q}(k)$ {$\mathcal{Q}(k)$ is $k$th channel in $\mathcal{Q}$}
    $\mathcal{Q} = \mathcal{Q} \backslash \{q\}$ {Remove $q$ from $\mathcal{Q}$}
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- The IHC of each node can be used for control information exchange.

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Information learning in one cell.

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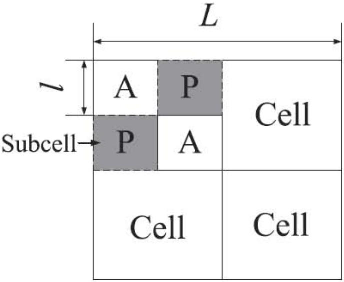
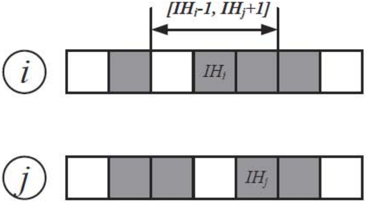


(a) cells and subcells



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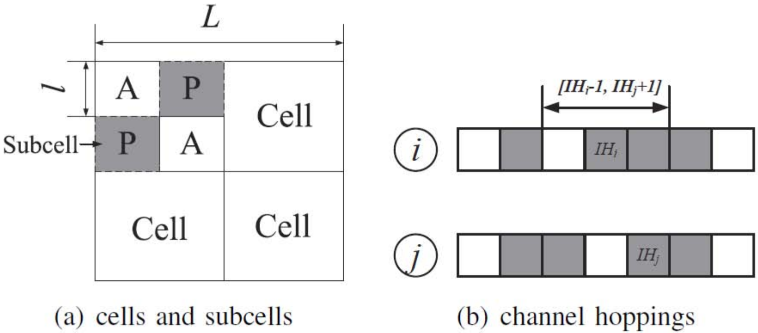

nodes in an active subcell: send only
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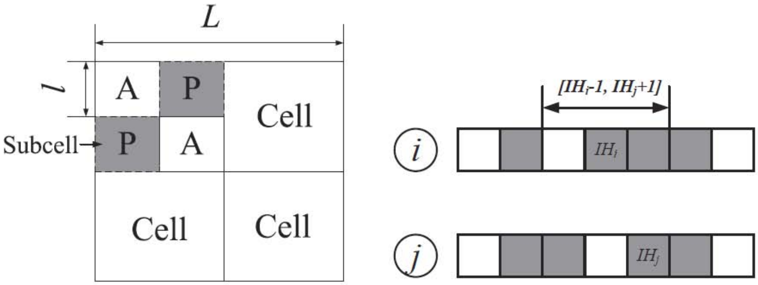

(a) cells and subcells

(b) channel hoppings

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Active nodes scan the channel hopping ranges and exchange information with passive nodes (only one round needed).

Self-Organization

Performance analysis.

- We give the lower bound of the self-organization success probability:
  Theorem: The P_s is lower bounded as follows,

$$P_s \geq 1 - (1 - m\beta p)^{\min(\tilde{N},\bar{N})}. \quad (1)$$

- p denote the probability that a channel among the m channels is available to a node; β is the probability of denote the event that passive node j selects the kth channel in the range; $\tilde{N}$ denote the number of passive nodes in the cell, and $\bar{N}$ denote the number of active nodes in the cell.

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  A: By using variable transmission ranges.

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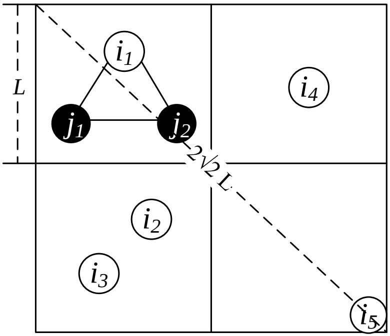

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- Passive nodes keep listening at their THCs.

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- Intra-area Data Transmission

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Inter-area Data Transmission:

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Multi hop transmission.

Intra-area Data Transmission:

- Scheduling within one area.

Inter-area Data Transmission:

- With the help of gateway nodes.
- Gateway nodes exchange information between two areas.

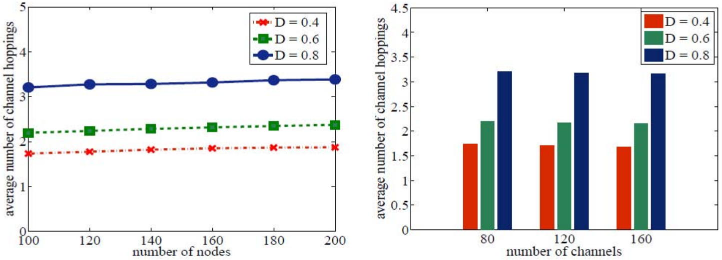
Simulation Settings

Main parameters:

- 200×200 unit square
- Cell size: 50×50
- Primary users: 40
- Number of nodes: 100 $\sim$ 200 with an increment of 20
- Number of channels: 80 $\sim$ 160 with an increment of 40

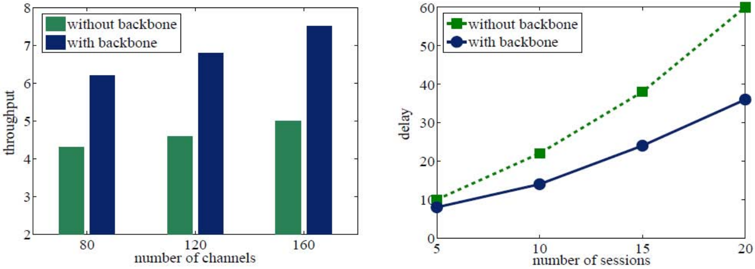
Simulation Results

Average number of channel hoppings.



Simulation Results

Performance comparisons between with and without backbones.



Conclusion

- We present a comprehensive approach to self-organization, virtual backbone construction, and end-to-end data transmission for CRNs, without relying on a common control channel (CCC).
- Each node makes use of the location information and adjustable transmission range for the virtual backbone construction.
- Each node chooses its own channel for data transmission and reduces the interference among different links.
- We propose an efficient scheme for end-to-end data transmission.
- The simulation results verify our theoretical analysis and show that the efficiency of our approach is significantly improved compared with the one without a virtual backbone.

Thank you!