

Effect of Social Relations on Cooperative Sensing in Cognitive Radio Networks

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Agenda

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- Introduction
 - ▣ Cooperative Sensing
 - ▣ Social Network Analysis
- Key Contributions
- Social-Aware Cooperative Spectrum Sensing (SAC)
 - ▣ System Model
 - ▣ SAC
 - ▣ RAND (Social-Oblivious Scheme)
- Performance Analysis
- Conclusion and Future Directions

Cooperative Sensing

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- Cooperative vs. Local Sensing
 - Improvements
 - Combined decision accuracy
 - Spectrum capacity gain
 - Messaging overhead – Reporting delay
 - Common effecting factor: User selection
 - Independent, non-malicious users
 - Cooperation investment must have positive returns
 - Clever selection of cooperating CRs

Social Network Analysis

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- Social Network Analysis (SNA)
 - Relations, patterns between entities
 - Social Characteristics
 - Understanding the Implications

- Popularity of online social networks
 - Need to study social relationships and ties
 - SNA: Important tool
 - Creating a new design approach
 - New protocols, policies or applications



Social Network Analysis

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- Friendship and Community in SNA
 - ▣ Positive Social Characteristics
- Selfishness in SNA
 - ▣ Negative Social Characteristics (rationality)
- Long term characteristics, less volatile.



Social Network Analysis

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- Homophily
 - Similar interests – befriending, behavior, contact

- In our work
 - To assign friendship ties
 - Use friendship and community relations
 - Select cooperation set
 - Evaluating if a node should respond

Key Contributions

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- New CRN Model
 - CRs' operation mimic human societies
 - No assumption of altruistic cooperation
 - Social Aware Scheme
 - Clever choice of cooperation candidates
 - Exploit mutual sympathy
 - Select accepting and trustworthy CRs (RAND?)
- Bringing two emerging research domains together
 - Social Networks & Cognitive Radio Networks

System Model

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- CR in the system
 - ▣ C – Community
 - ▣ L_f – Friend list
 - ▣ L_s – Sympathy list
 - ▣ L_c – Cooperation score list
 - ▣ β – Cooperation tendency / selfishness

- Wireless device with a social context

System Model

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- Community Membership
 - ▣ Interests, education etc.

- Assigning of communities to users
 - ▣ Random

- Assignment of friends
 - ▣ Homophily

System Model

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- Friend list L_f
- Static vs. Dynamic

- Dynamic
- Sympathy list – changes in community perception
- Cooperation score list - L_c
 - Memory
 - Previous and most recent

System Model

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- Cooperation Tendency (Selfishness) – β
 - Dominant in a CR's response
 - Social tie – selfishness (can be altered by social ties)
 - Selfishness high – friends only
 - Average selfishness – same community may be enough

Social-Aware Cooperative Spectrum Sensing (SAC)

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- Operates in three steps:
 - **STEP 1: Cooperation set selection**
 - Friend score, community score, cooperation score
 - Cooperation receiving CRs respond (social ties and tendency)
 - **STEP 2: Cooperative sensing**
 - Majority Logic from accepting CRs
 - **STEP 3: Updating scores**
 - Community and cooperation scores

Social-Unaware Cooperative Spectrum Sensing (RAND)

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- RAND operates in two steps
 - Cooperation set selection:
 - Randomly select CRs from the grid
 - Cooperation receiving CRs respond according to tendency
 - Cooperative Sensing

- No contact memory or social-tie based knowledge.

Malicious Users

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- Realistic model
 - ▣ Exploit cooperative sensing
- Malicious user
 - ▣ Also a CR with social information
- Operation
 - ▣ Accept
 - ▣ No sensing
 - ▣ Return busy channel result

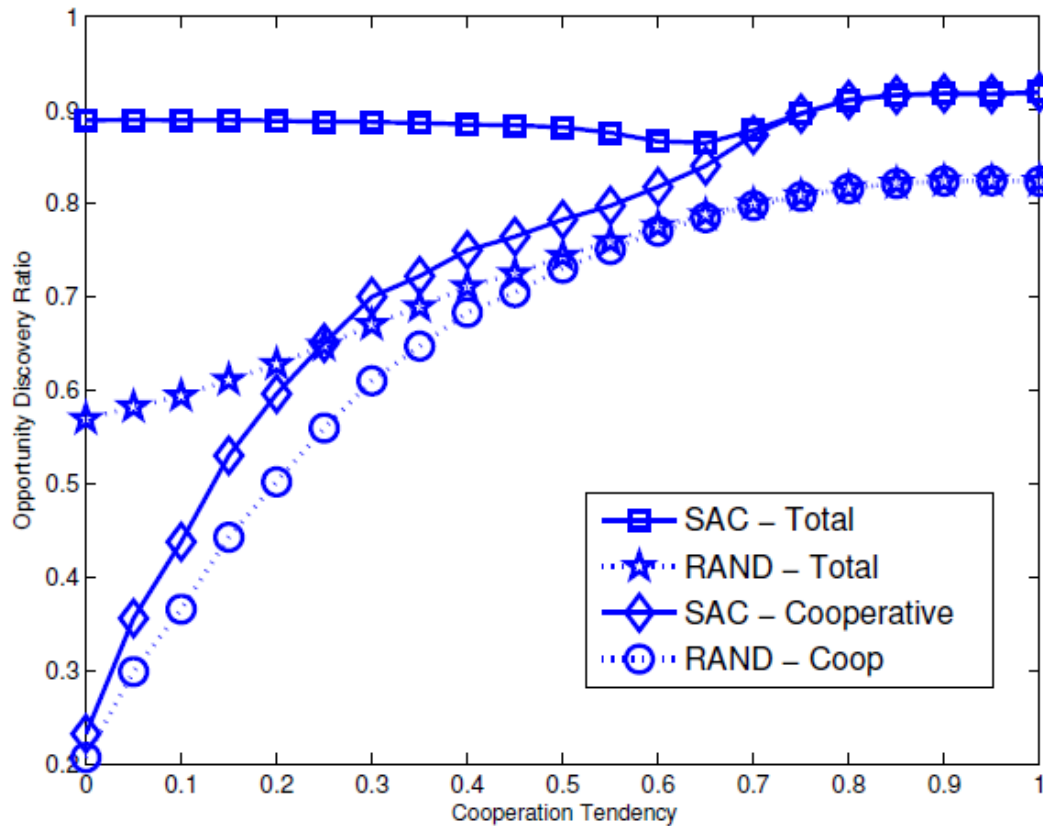
Performance Analysis

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- Simulation Scenarios
 - ▣ Effect of Cooperation Tendency β
 - ▣ Effect of Maliciousness d_m

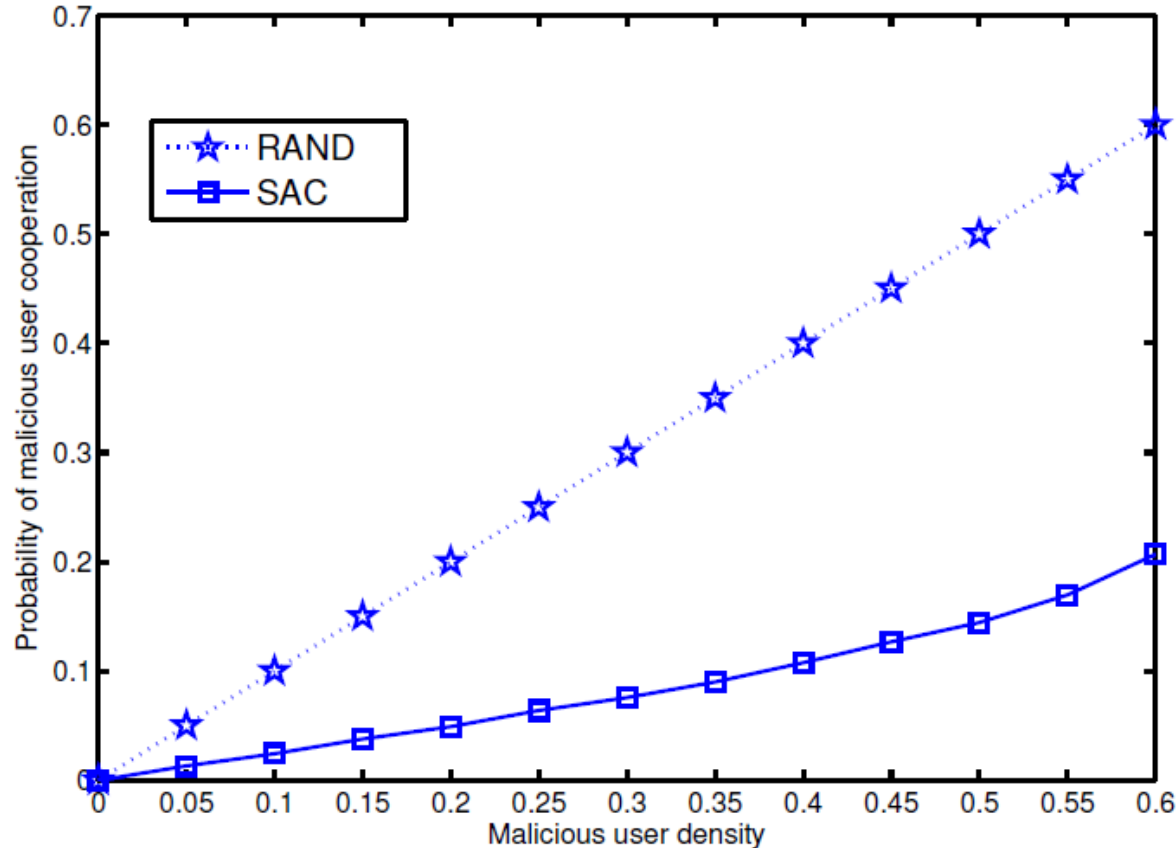
Performance Analysis

□ β vs. Opportunity discovery ratio



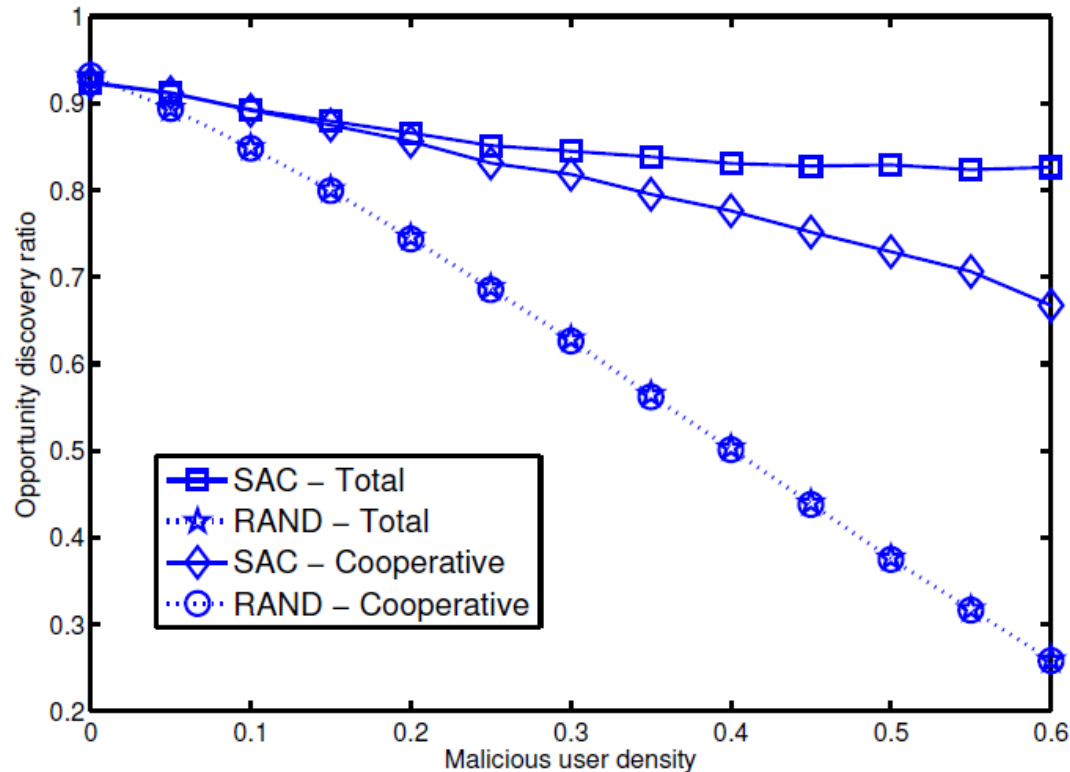
Performance Analysis

- d_m vs. probability of malicious user cooperation



Performance Analysis

□ d_m vs. opportunity discovery ratio



Conclusion

- We have presented a cooperative sensing scheme
 - Makes use of social relations (homophily)
 - Selecting cooperators
 - Eliminates the altruistic cooperative behavior assumption
 - Modeling cooperation tendency according to social ties
 - Makes use of previous cooperations
 - Sensing performance memory

- Trust mechanism between users
 - Experience, recommendation and knowledge

Conclusion

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- Strengths
 - Distinguish malicious and selfish users
 - Prefer eager-to-cooperate CRs
 - Local > cooperative sensing if cooperative sensing isn't beneficial
- Weakness
 - Prejudice and sympathy for communities
- SAC outperforms RAND overall.
 - Benefits of social-aware models over social-oblivious models.

Future Directions

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- Extending the model to various network models
 - e.g. Erdős–Rényi (ER), Barabási–Albert model

- Currently: Individual prevention mechanisms
 - Network-wide methods of encouraging cooperation
 - And discouraging selfishness/malicious activity
 - Quicker discovery of malicious nodes

- Random mobility → Homophily

Thank you.

Any questions?

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