CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)
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Project Number
S1624

Project Title
Sharing Spectrum the Smart Way: Cognitive Radio for Relieving Overcrowding on the Airwaves

Abstract

Objectives/Goals
While the over-crowdedness of the radio frequency spectrum has become an increasingly noted problem, potential solutions lie in the fact that up to 70% of the licensed spectrum is actually idle at any given time. Cognitive radio is an emerging technology that enables primary and secondary users in a hierarchical access structure to interoperate and use radio spectrum efficiently. One of the most pressing issues in such systems, however, is the complex interaction between distributed secondary users: each user must rely solely on its own observations to optimize the tradeoff between selecting idle channels temporarily unoccupied by primary users and avoiding collisions with other secondary users. The objective of this research was to gain insights into the interaction between distributed secondary users and to use this information to design high performance networking policies with low complexity.

Methods/Materials
In this project, a class of distributed randomized policies was investigated. Using a Partially Observable Markov Decision Process (POMDP) to formulate the problem, MATLAB was employed to simulate a proposed multi-user policy in various network settings. Simulation data were then analyzed to draw conclusions about the policy, and subsequently to improve its performance.

Results
From analysis of simulation data, a theorem was derived in which the optimum percentage of channels to normalize in any given system could be determined given the ratio of users to channels and the packet arrival probability. In addition, the causes of the relationship between this optimum percentage of channels and the temporal correlation of spectrum opportunity # a system-determining property # were investigated.

Conclusions/Discussion
The policy developed in this project improves implementation efficiency by up to 90% while maintaining the optimal average throughput of the original policy. This is significant because it is necessary for users to be able to make good decisions quickly and efficiently in time slots that last only fractions of a second. The policy detailed in this research can have a wide range of applications including cell phone networks, portable devices, and wireless internet.

Summary Statement
My research focuses on developing high performance networking policies that will enable users to efficiently share radio frequency spectrum without interfering with one another.

Help Received
I did this research at the University of California at Davis under the supervision of Professor Qing Zhao.