Towards Effective and Secure Dynamic Spectrum Provisioning

Haitao Zheng
Department of Computer Science
University of California, Santa Barbara
Santa Barbara, CA 93117, USA
htzheng@cs.ucsb.edu

ABSTRACT

Dynamic spectrum access is the clear solution in a world where innovative wireless technologies are stifled by a shortage of available spectrum. Given a well-designed dynamic allocation scheme, cognitive radio devices can obtain spectrum that matches their demands and avoids interference to other devices using separation in physical distance or frequency.

Recent research has produced significant advances on a number of core problems, including robust spectrum auctions and model-based spectrum allocation. Despite these breakthroughs, two obstacles remain before cognitive radio devices can provide a true abstraction of "always-on" spectrum to its systems and applications.

First, we must bridge the gap between robust, model-based spectrum allocation algorithms, and the complex, unpredictable nature of wireless propagation in the physical world. Recent work shows that allocation schemes using abstract interference models perform poorly in practice, and accurate representations of interference can only be constructed through detailed measurements of a physical area. But since we do not know the positions of cognitive radio devices *a priori*, using per-link measurements to build conflict maps is intractable, especially for outdoor networks.

Second, even if we address the first challenge, and can allocate spectrum while taking local physical properties into account, such allocations are not *enforceable.* Given the flexibility of cognitive radio devices, it is easy for an application to transmit on frequencies outside of its allocated range, either accidentally due to software bugs or misconfiguration, or intentionally to avoid costs of licensing spectrum. Unchecked, the interference from these "spectrum misuse" events will disrupt legitimate transmissions, ultimately destabilizing the system and preventing its successful adoption.

In this talk, we present our recent proposal that addresses these problems of robustness and allocation enforcement. We propose, *Phoenix*, an architecture for robust dynamic spectrum allocation that provides both accurate interference models using small-scale physical measurements, and efficient mechanisms that enforce spectrum allocation by detecting spectrum misuse events.

The first component of Phoenix is a practical tool for building accurate interference maps in dynamic spectrum distribution [2]. Using a limited set of spectrum sensors, our solution scans transmissions of legitimate users, builds and calibrates *physical* conflict graphs that would normally require an intractable number of physical measurements. These physical conflict graphs are environment-specific and capture cumulative interference, enabling conflict-free spectrum allocation in real world settings.

Phoenix's second component enforces spectrum allocation using *spectrum permits* [1]. We explore embedding crytographically secure, externally readable spectrum permits into data transmissions as cyclostationary signatures at the PHY layers, allowing spectrum police nodes to identify unauthorized transmissions. The choice of our design came from an effective analogy between the spectrum misuse problem and the problems of enforcing vehicle speed limits and deterring illegal parking. Instead of a per-vehicle solution, highway patrols or meter maids provide a much lower-cost and more practical deterrent. Thus in Phoenix, authorized users display spectrum permits that are easily verified but cannot be duplicated/forged, and a number of trusted mobile devices patrol transmission areas to detect (and stop) unauthorized users.

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Categories and Subject Descriptors

C.2.3 [**Network Operations**]: Network Management, Network Monitoring

General Terms

Algorithms, Measurement, Security

Keywords

Dynamic spectrum allocation, cognitive radios, conflict graphs, interference, misuse detection

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Short Biography

Haitao (Heather) Zheng is currently a Professor of Computer Science Department, University of California, Santa Barbara. She received her B.S.degree (with highest honor) from Xian Jiaotong University, China, in 1995, and her Ph.D degree in Electrical and Computer Engineering from University of Maryland, College Park, USA, in 1999. She joined wireless research lab, Bell-Labs, Lucent Technologies as a member of technical staff in August 1999, and moved to Microsoft Research Asia as a project lead and researcher, in March 2004. Since September 2005, she has been a faculty member at University of California, Santa Barbara.

Dr. Zheng's research work has been widely cited by media outlets like the New York Times, MIT Technology Review, Boston Global, and Computer World, etc. She was one of the 2005 MIT Technology Review Top 35 Innovators under the age of 35 for her work on cognitive radios. Her work was selected by MIT Technology Review as one of the Top 10 Emerging Technologies in 2006. She also received the 2013 Sigmetrics Best Practical Paper Award, the 2007 DySPAN Best Student Paper Award, the 2002 Bell Laboratories President's Gold Award, and the 1998-1999 George Harhalakis Outstanding Graduate Student Award from University of Maryland, College Park. Dr. Zheng's recent research interests include wireless systems and networking, data centers, social networks and graph analysis.

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