ERPem
Edinburgh Research Partnership in Engineering and Mathematics
http://www.erp.ac.uk

Improving Cellular Access via Cognitive Radio Networks

Xuemin Hong, Cheng-Xiang Wang, and John S. Thompson

Problem and Motivation

- Problem: Existing cellular radio access networks cannot cope with future media-rich traffic demands:
  - Growing traffic vs. Limited network capacity
  - Random traffic vs. Stable network capacity
  - Multimedia traffic vs. Voice-oriented network
- Motivation
  - The above problems are essentially caused by a shortage of the cellular spectrum, i.e., the cellular spectrum is limited, fixed, and licensed.
  - We aim to solve the problems by introducing more flexible spectrum access schemes to the cellular networks using cognitive radio technologies.

Background and Research Gap

- Types of Dynamic spectrum access (DSA) schemes
  - Dynamic exclusive use model
  - Open sharing model
  - Hierarchical access model (e.g., cognitive radio)
- Related work on DSA for cellular networks
  - Based on the dynamic exclusive use model: European DRiVE/OverDRiVE projects.
  - Based on the open sharing model: Unlicensed mobile access (UMA) standardized in the 3rd Generation Partnership Project (3GPP).
  - Based on the hierarchical access model (cognitive radio): Research gap.

Cognitive Radio Based Direct Access Network

- System model (Fig. 1)
  - Cellular base stations (BSs) are able to directly communicate with mobile users via centralised cognitive radio networks.
  - The system model includes various factors such as user distributions, interference constraints, cell radius, and propagation effects.

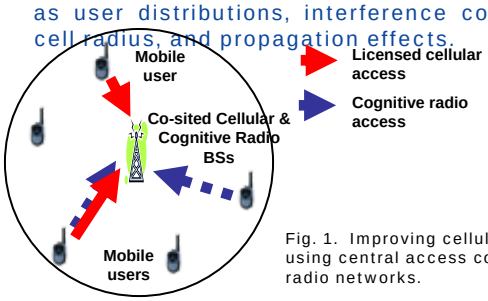

Fig. 1. Improving cellular access using central access cognitive radio networks.

- Main contributions
  - Two cognitive radio networks have been proposed.
  - We have provided analytical frameworks to quantify the network capacity. Such frameworks are useful for strategic planning.

Cognitive Radio Based Cooperative Access Network

- System model (Fig. 2)
  - Ad-hoc cognitive radio networks are used to organise multiple mobile users into cooperative groups to improve the licensed cellular access.
  - The system model includes various factors such as user distributions, size of cooperative groups, interference constraints, and propagation effects.

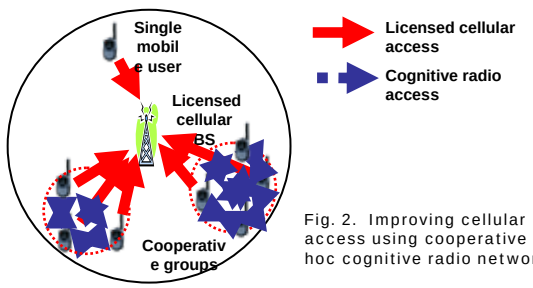

Fig. 2. Improving cellular access using cooperative ad-hoc cognitive radio networks.

- Main contributions
  - We have proposed a cooperative communication protocol based on virtual multiple-input multiple-output (MIMO) signalling.
  - We have provided analytical frameworks for link and system capacity evaluation.

Summary & Future Work

- We have proposed to use cognitive radio networks to improve the performance of cellular access and provided analytical frameworks for system capacity evaluation.
- Future work is to further investigate other means of using cognitive radios in cellular systems and develop practical spectrum access protocols and algorithms.

Related Publications

Book Chapters

[1] X. Hong, C.-X. Wang, J. S. Thompson, and H.-H Chen, "Capacity analysis of cognitive radio networks", in Cognitive Radio Networks: Architectures, Protocols and Standards, edited by Y. Zhang, J. Zheng, and H.-H. Chen, to be published by Auerbach Publications, CRC Press, 2009.

Journals

[1] X. Hong, Z. Chen, C.-X. Wang, S. A. Vorobyov, and J. S. Thompson "Interference cancellation for cognitive radio networks," *IEEE Vehi. Technol. Mag*, submitted for publication.

[2] X. Hong, C.-X. Wang, H.-H. Chen, and Y. Zhang, "Secondary spectrum access networks: spatial modelling and system design," *IEEE Vehi. Technol. Mag.*, accepted for publication, 2009.

[3] C.-X. Wang, X. Hong, H.-H. Chen, and J. S. Thompson, "On capacity of cognitive radio networks under average interference power constraints", *IEEE Trans. Wireless Commun.*, revised version submitted for publication.

[4] C.-X. Wang, H.-H. Chen, X. Hong, and M. Guizani, "Cognitive radio network management: tuning in to real time conditions", *IEEE Vehi. Technol. Mag.*, vol. 3, no. 1, pp. 28–35, March 2008.

Conferences (5 papers published in *IEEE ICC'08, VTC'08, and ICCCAS'08*)

SIP
Signal & Image Processing