Carnegie Mellon University

Competing Models for Spectrum Sharing

Jon M. Peha
Carnegie Mellon University

Professor and Associate Director,
Center for Wireless & Broadband Networking
www.ece.cmu.edu/~peha **peha@cmu.edu**

Feb. 28, 2006, National Academy of Sciences

This Session is on "unlicensed, short-term, dynamic, and shared-use" mechanisms

- Many specific proposals.
  - feasible
  - offering different opportunities.
- NTIA and FCC should give spectrum-users the ability and incentive to match the right spectrum-sharing model to the intended applications.

Different Spectrum-Sharing Models

- Sharing among equals
  - Devices coexist, perhaps avoid mutual interference, e.g. today's unlicensed bands
  - Devices cooperate, carry each other's traffic
    - Potential for cooperative gain, increased capacity.
    - Many technical and policy challenges, outside scope of this talk.
- Sharing between licensed primary and secondary. Secondary must not cause harmful interference to primary.
  - Secondary may or may not coordinate with primary.
  - Secondary may or may not be licensed.
- Each of the models above is good for different things.

 peha@cmu.edu

Unlicensed Bands

- Good for mobile wireless systems:
  - Mobile LANs, PBXs, etc.
  - Works anywhere, regardless of license-holders or incumbents.
- Good when many owners have many low-power devices.
  - No lengthy or expensive licensing process required.
- Hard to prevent interference. No QOS guarantees possible.
- Less incentive to conserve shared spectrum. We have analyzed scenarios where this is a problem.
- FCC or NTIA can
  - keep utilization low (power limits, fees, permits, etc.)
  - design rules to promote efficiency for intended applications
  - Different rules in different bands can provide opportunities and incentives for different applications.

 peha@cmu.edu

Primary and Secondary Coexist

- Secondary is invisible to primary
- All complexity in secondary devices.
  Good where legacy systems are not easily changed.
- Probably no QOS guarantee possible for secondary.
- Secondary transmits
  - at low power, or
  - *opportunistically* after sensing the environment
- Technology of opportunistic access is
  - challenging in some environments.
    An area of current research.
  - easier if primary transmitters are fixed,
    e.g. where broadcasters or fixed point-point are primary.

peha@cmu.edu

Primary and Secondary Coordinate

- Example: secondary requests permission to use spectrum before transmitting
  - an opportunity for primary to guarantee QOS
  - an opportunity to collect payment, if commercial
- Primary needs component that can act as gatekeeper.
  - e.g. more convenient for cellular than broadcaster
- We've analyzed scenarios where extensive communications among secondaries is possible with little impact on primary.
  - Use location technology to enhance frequency reuse, and secure payment system technology.

peha@cmu.edu

A Licensed Secondary

- A possibility not included in agenda for this session, but a viable alternative for *some* application types.
- A licensed secondary need not contend with other secondaries
- If/when primary can be avoided, QOS is guaranteed
- Two approaches
  - No coordination: Operates in spectrum unused by primary, e.g. white space or guard bands, and/or transmits opportunistically
  - Coordination: Operates as licensed system except when primary is active, e.g. interruptible service
- We've analyzed scenarios where extensive communications among secondaries is possible with little impact on primary
  - Sometimes the primary's need for spectrum is sporadic, e.g. public safety
  - Sometimes there is "white space" to exploit

peha@cmu.edu

Primary-Secondary Models

Research at CMU has considered the following models.

Primary: blue Secondary: red	Secondary is unlicensed	Secondary is licensed
No coordination between primary and secondary	**Unlicensed underlay**. e.g. Broadcasters with site licenses and opportunistic devices w.o. QOS guarantees	**Licensed secondary** with exclusive access **in white space**, guard bands, e.g. Broadcasters and microcellular or cellular
Coordination between primary and secondary	**Real-time secondary market**, e.g. Cellular and devices with temporary QOS guarantees	Secondary with exclusive access but **interruptible access**, e.g. Public safety and cellular

peha@cmu.edu

No Choosing the "Best" Model

- We must explore primary-secondary sharing.
  - Essential to increasing efficiency of spectrum use, thereby alleviating spectrum shortage.
  - Four models, each appropriate for a different set of primary and secondary applications
- Unlicensed bands are also needed
  - A proven and successful approach

Carnegie Mellon University

CENTER FOR Wireless & Broadband NETWORKING

Some of the papers referred to in these slides are available at www.ece.cmu.edu/~peha/wireless.html

Jon M. Peha
Professor and Associate Director,
Center for Wireless & Broadband Networking
Carnegie Mellon University