

SOFTWARE DEFINED RADIOS

Presentation to
National Spectrum Managers Association

May 21, 2003

Mitchell Lazarus
Fletcher, Heald & Hildreth, PLC
1300 North 17th St. 11th floor
Arlington VA 22209
703-812-0440
MLazarus@alum.MIT.edu

Topics

- Software defined radios, cognitive radios defined
- Spectrum shortage: myth, reality, causes
- SDRs can postpone the impact of spectrum limits
- Example 1: public safety and wireless phones
- Example 2: short-term secondary markets
- Example 3: unlicensed underlay
- Regulatory issues
- Frequency coordination issues

Software Defined Radios Defined

- *Software defined radio*: “A radio that includes a transmitter in which the operating parameters of frequency range, modulation type or maximum output power (either radiated or conducted) can be altered by making a change in software without making any changes to hardware components that affect the radio frequency emissions.” FCC Rules, 47 C.F.R. § 2.1.
 - Ability to download over the air is not part of the definition
 - But many SDR scenarios assume this capability.

Cognitive Radios Defined

- *Cognitive radio*: A radio that exploits the flexibility of software control in response to changing conditions in the operating environment.
 - Some definitions require that a cognitive radio be able to “learn.”

Spectrum Shortage: Myth

- Fact: Most of the spectrum is vacant most of the time
- A spectrum analyzer shows activity at local broadcast frequencies and cell/PCS allocations, but typically only sporadic use elsewhere
- The shortage is not of spectrum as such, but of *not-yet-licensed* spectrum.

Spectrum Shortage: Reality

- Some users who need spectrum don't have access to it (a recurring issue for innovators)
- Many licensed users do not make full use of their spectrum
 - . . . Although few will admit it.

Spectrum Shortage: Causes

1. Hardware-based radios lock each user into a particular band and modulation
2. FCC rules reflect hardware-based technology by limiting each licensed user to a particular band or frequency, modulation, power, etc.
 - Consequences:
 - a user experiencing congestion cannot move operations
 - . . . even if there is idle spectrum elsewhere.

SDRs Can Postpone the Impact of Spectrum Limits

- SDRs can change frequency, power, bandwidth, modulation on very short notice
- As a result, SDRs can . . .
 - distribute users more uniformly through the spectrum
 - allow users to move to where the vacant spectrum is
 - allocate available spectrum dynamically among users
 - shift to less interfering (or interference-resistant) modulations depending on the environment
 - implement priorities among users, and change these as needed.

Example 1: Public Safety and Cell Phones

- public safety users prefer empty spectrum -- available when needed
 - but public safety spectrum need not be empty -- just available
- SDR-equipped cell base station can simultaneously serve public safety and commercial wireless phones
 - public safety calls take priority; civilians share whatever is left
 - dynamic allocation: if a local emergency generates extra public safety traffic, system adjusts allocations automatically
- cost efficiencies:
 - can use existing handsets
 - public safety can share infrastructure with wireless phone.

Example 2: Short-Term Secondary Markets

- New FCC rules allow licensees to lease out spectrum
 - Licensees with excess spectrum can make it available to those who need it
- FCC contemplates spectrum leases lasting months or years
- Problem: how to modify embedded equipment to work on newly leased spectrum
 - Problem is especially acute for mobiles
- SDRs may be needed to fully implement secondary markets
 - Lessee can download software for new spectrum to end users
 - SDRs might enable spectrum leases by the minute, or even the second.

Example 3: Underlay Unlicensed Use (1)

- Spectrum usage can be measured along three axes: frequency, space, and time
- Cognitive radios can respond and adapt to all three
- FCC Docket No. 02-380 considers unlicensed operation on TV channels, in markets where particular TV channels are vacant
- TV industry opposes, fearing interference to viewers
 - . . . and cites DTV transition as worst possible time for proposal
- Cognitive radios can check for presence of TV carriers before every transmission
 - Can automatically adapt as TV stations are added, deleted, moved, and changed
 - Can automatically accommodate DTV roll-out.

Example 3: Underlay Unlicensed Use (2)

- Same FCC docket (ET 03-280) proposes unlicensed operation at 3650-3700 MHz
- Satellite operators fear interference to a limited number of earth stations
- Satellite position: exclusion zones cannot be implemented for mobile units -- therefore unlicensed mobile use must be barred
- Two manufacturers respond:
 - Install a low-power, narrowband beacon transmitter at each earth station
 - Unlicensed mobiles can detect the beacon, measure its strength, and turn down power as needed to protect the earth station.

Regulatory Issues

- The FCC certifies mobile radios for compliance with the technical rules
- Elaborate rules govern changes to certified radios
- The FCC adopted rules allowing changes to certified parameters via software downloads (September 2001)
- Security concerns remain an open issue.

Frequency Coordination Concerns

- SDRs raise novel issues of frequency coordination
- Traditional coordination occurs before the equipment is deployed, takes anywhere from hours to weeks
- But SDRs can shift to a new frequency, power, or modulation in milliseconds
 - And cognitive radios can do the same on their own initiative
- SDRs may call for changes to the frequency coordination process
 - The Further Notice phase of the secondary markets proceeding (WT Docket No. 00-230) may also have implications for frequency coordination.

Thank You!