Trends and Precedents Favoring a Regulatory Embrace of Smart Radio Technologies

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Peter A. Tenhula
Shared Spectrum Company

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Acknowledgements

Paper #1: “Trends and Precedents Favoring a Regulatory Embrace of Smart Radio Technologies," *DySPAN 2007 -- 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks,* pp.633-648, 17-20 April 2007 (Dublin, Ireland).

Co-Authors from Univ. of Colorado, Interdisciplinary Telecom Program :

- J. Brad Bernthal
- Timothy X Brown
- Dale N. Hatfield
- Douglas C. Sicker
- Philip J. Weiser

Paper #2: "The Potential Value of Decentralized Trunking as Regulatory Precedent for the Introduction of Dynamic Spectrum Access Technology,“*DySPAN 2007 -- 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks,* pp. 597-605, 17-20 April 2007 (Dublin, Ireland).

Co-Author from Univ. of Colorado, Interdisciplinary Telecom Program :

- Dale N. Hatfield

Perceived Regulatory Environment

"The major obstacle to the deployment of [DSA] technology is acceptance by the regulatory community." Shared Spectrum Co., XG Phase II Final Report (p. 110), Oct. 2005.

"[DSA] technologies are being developed in advance of spectrum-sharing regulations and policies, so the mechanisms must be adaptable to a wide range of future policies." BAA-05-05 PIP, neXt Generation (XG) Communications Program Phase III (p. 6), Oct. 2004.

Other Perceptions

- "Dynamic spectrum access represents a significant shift in how spectrum is managed and regulated, such that ***most current regulatory regimes are far from being capable of implementing dynamic spectrum access on a widespread basis***."

  -- Commission for Communications Regulation (Ireland), *Briefing Note: Dynamic Spectrum Access*, Document No. 07/22 (April 13, 2007)

- "CR has the potential to bring significant improvements to wireless communication, but ***its success will depend upon regulatory changes to promote its development and utilization***."

  -- *Cognitive Radio Technology, A Study for Ofcom* (UK), Volume 1, QINETIQ/06/00420 Issue 1.1, February 12, 2007

Objectives

- One important way of obtaining necessary support and regulatory permissions from U.S. and international regulators: show policy and legal precedents
  - or otherwise determine how implementation consistent with existing rules
- Relevant and recent precedent:
  - “U-NII” devices in 5.25-5.35 GHz and 5.47-5.725 GHz bands sharing with radar operations using DFS and TPC
- Older precedents:
  - FCC policies and rules promoting spectral efficiency through utilization of “decentralized trunking” in the VHF and UHF Private Land Mobile Radio bands.
  - Automatic Link Establishment (ALE) in HF Bands – enables automatic frequency agility in fluctuating interference environments, leading to efficient use of pooled frequencies.
- Analyzed potential value of these precedents in advocating for broader regulatory acquiescence and near-term deployment of DSA technology.

Paper #1

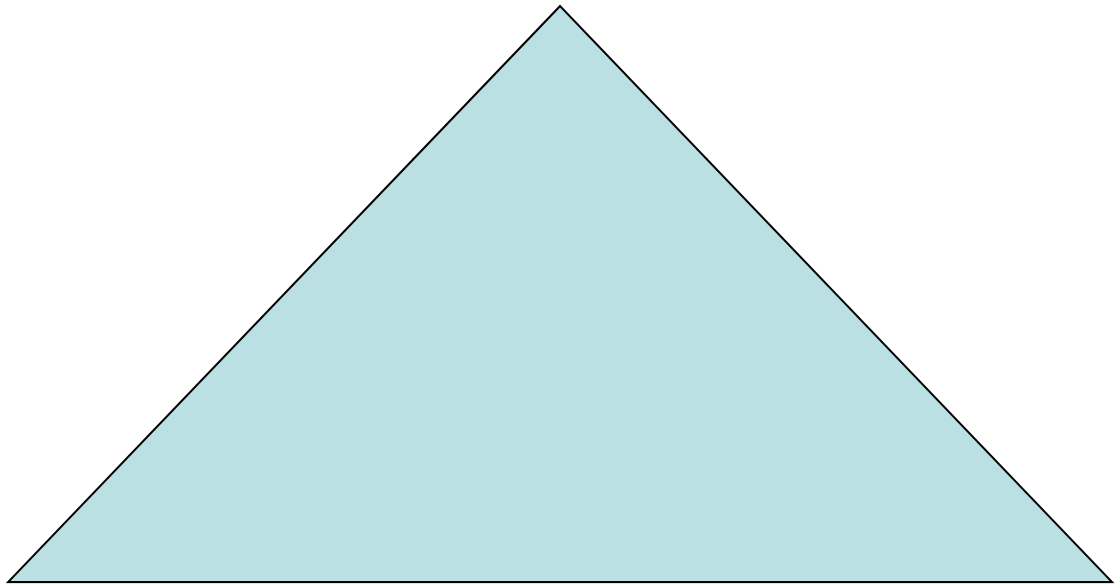
- DySPAN 2007 Plenary Paper: "Trends and Precedents favoring Regulatory Embrace of Smart Radio Technologies", Bernthal, et. al (University of Colorado).
  - **Key finding:** regulatory acceptance of smart radios (*i.e.*, software defined radio, cognitive radio and dynamic spectrum access technology) is a near term likelihood – not a long term crusade
    - Logical extension of policies and precedents already in motion.
    - Regulatory momentum in the U.S. supporting "smart" radio technology, secondary markets and other initiatives is positive sign.
- Early commercial or non-military deployment in U.S. likely to require staff-level actions by FCC and NTIA.
  - Equipment or system approval
  - Secondary frequency assignments or leases
  - Minor waivers to existing regulations
- Over the longer term, incremental implementation will eventually require additional rule changes.
- Did not address TV White Space proceeding since still pending.

Paper #2

- DySPAN 2007 Paper: "The Potential Value of Decentralized Trunking as Regulatory Precedent for the Introduction of Dynamic Spectrum Access Technology", Hatfield and Tenhula.
  - **Key findings:** Significant value inherent in strong policy and regulatory precedent for facilitating – indeed for promoting – introduction of advanced DSA technology in order to permit more efficient use of valuable radio spectrum resources.
  - In U.S., compelling argument can be made that DSA radio system using automated LBT technology to achieve decentralized trunking capabilities could be introduced onto shared channels in the PLMR bands without any major changes in existing rules or policies.
- Further research, development, testing and evaluation of DSA radios in the VHF/UHF bands, including actual field testing (e.g., NTIA Test-Bed), will provide technical support to appease skeptical, but bandwidth constrained incumbents as well as domestic and international regulators.

Paper #1

Smart radio functionalities



Regulatory objectives

Precedent technologies and sharing methods

Smart radios as regulatory enabler

1. Reduce artificial spectrum scarcity
2. Facilitate efficient and flexible regulatory functions
3. Leverage distributed intelligence

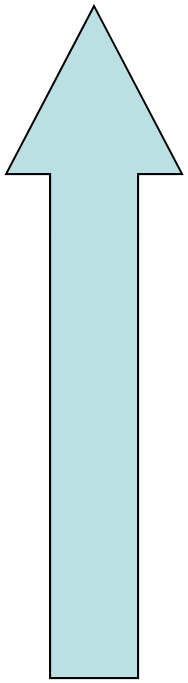
Administrative (Artificial) Scarcity

- **Empirical measurements**
  - McHenry, McCloskey (2006)
  - Ofcom (UK) (2006)
  - SSC/ University of Kansas (2004-05)
  - FCC (2002)
  - Lichtenau, Germany (2001)
- **Opportunity:** utilize intermittently available spectrum holes without harmful interference

More Efficient and Flexible Spectrum Management

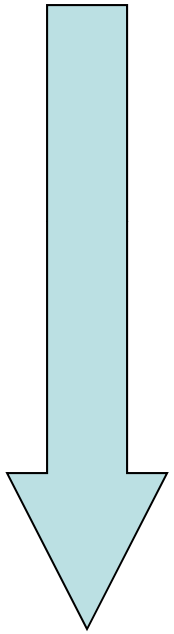
- Advance four traditional steps
  1. Allocation
  2. Service /Technical Rules: Channel/Block Allotments; Unlicensed Protocols
  3. Assignment of Licenses/Unlicensed Device Certification
  4. Monitoring And Enforcement
- Policy and transmission reconfigurabilty: move irrevocable ***product launch*** to modifiable ***introduction process***
- Automate certain spectrum management functions

Leverage Distributed Intelligence



Cost of vacant spectrum

Cost of intelligence at edges



Analysis (1)

Regulatory objective	Illustrative Precedent	Notable smart radio characteristic
Local decision-making (vs. Federal C&C); decisions based on improved information collection	• Alaska Land Mobile Radio • PMLR decentralized trunking • ALE techniques • Secondary markets • DFS/5GHz band	• Intelligence at edges— ability to monitor, analyze and adapt based on real-time spectrum environment

Analysis (2)

Regulatory objective	Illustrative Precedent	Notable smart radio characteristic
Provide greater access; increase spectrum utilization	• Spread spectrum • UWB •Liberalized unlicensed rules •DFS/5GHz band • PLMR Decentralized trunking	• Opportunistic/ dynamic •Decentralized safeguards • Adaptive

Paper #2

- Advantages of Trunking in PLMR
  - Conventional Repeater Systems
  - Trunking Concept
  - Centralized Trunking
  - Decentralized Trunking
- Policy and Regulatory History (FCC)
  - 800-900 MHz PLMR (1970s)
  - Refarming Proceeding (1990s)
  - 1998 Biennial Review

Analysis (1)

- Notwithstanding complex regulatory history, FCC has always supported non-exclusive, shared, multi-channel PLMR spectrum access through monitoring.
- Strong precedent for use of LBT as means of avoiding interference to existing users of the spectrum.
- Instructive for more advanced forms of dynamic spectrum sharing.
- FCC's reliance on industry to establish and implement appropriate monitoring requirements suggests that it will continue to look to industry and standards bodies, such as IEEE, to establish effective spectrum sharing requirements and standards using cognitive radio/DSA techniques.

Analysis (2)

Potential Technical/Economic Advantages related to Dynamically Accessing VHF/UHF Bands:

- Advanced LBT functionality facilitates dynamic spectrum access (DSA) and provides needed flexibility to establish more robust voice and data links in 150-174 MHz band, where current licensees often forced to employ non-standard channel pairs or un-paired (simplex) channels.
- Better propagation characteristics in these bands increase link range and reduce infrastructure costs, without displacing or interrupting incumbent users, which is often the case with new technology.
- In lower UHF band, characterized by heavy crowding (based on licensing data, not usage) especially in metropolitan areas, monitoring approach opens door for LBT-based frequency agile equipment to improve spectrum efficiency by accessing unused spectrum and to more effectively avoid interference through automatic deconfliction.
- Emerging signal detection technology capable of quickly and accurately identifying weaker signals.
- Similarly, the devices' detection threshold can be dynamically adjusted over a wide range through software policy controls.
- Such features that enhance the "listening" capabilities of radio transceivers make it easier to demonstrate and, consequently, to convince existing users that objectionable interference is not a problem.

Analysis (3)

Challenges for near-term deployment of DSA systems in the PLMR bands below 512 MHz:

- **Potential Regulatory Hurdles:**
  - DSA equipment must meet existing Part 90 rules (*e.g.*, out-of-band emission restrictions) and be approved through equipment authorization process (which now accommodates SDR and CR technologies).
  - Operator of equipment must obtain station license and be eligible as public safety or industrial/business entity.
  - DSA systems deployed in these bands must meet spectral efficiency requirements established by refarming rules (4800 bits per second per 6.25 kHz= .768 bps/Hz)
  - Contiguous channels and relief from 10-channel limit (10 x 12.5 kHz = .125 MHz) required for true broadband capability.
  - Secondary markets/leasing policy not extended to shared or exclusive PLMR channels.
  - Existing licensees may not have clearly defined rights to take immediate action in the event that a problem arises: co-primary vs. co-primary; primary vs. secondary.
  - “Involuntary” or “non-cooperative” sharing under new rules established by FCC (More risky and time-consuming)

Analysis (4)

Challenges for near-term deployment of DSA systems in the PLMR bands below 512 MHz: (ctd.)

- **Potential Economic/Technical Hurdles:**
  - Transaction costs negotiating with incumbent licensees
  - Existing users would have to be convinced that the potential interference, if any, produced by the new operation would be acceptable, even under worse-case situations.
  - Use of specialized intermediaries such as spectrum brokers to facilitate spectrum aggregation.
  - Economic incentives to “share” access with others lacking or not apparent (*e.g.*, through adequate remuneration, cost reductions or added functionality or capacity).

Update: US Regulatory Support

- **Obama Administration**
  - Presidential Memo on "Unleashing the Wireless Broadband Revolution"
    - "We can also unlock the value of otherwise underutilized spectrum and open new avenues for spectrum users to derive value through the development of advanced, situation-aware spectrum-sharing technologies."
    - Key Objective: enable spectrum to be put to its highest value uses by facilitating research, development, experimentation, and testing by researchers to explore innovative spectrum-sharing technologies.
    - Intra-governmental Steering Group (PPSG) established a Spectrum-Sharing Technologies Working Group
- **U.S. Congress**
  - Snowe/Kerry Bill – "Spectrum Measurement and Policy Reform Act" would
    - Require spectrum occupancy measurements
    - Promote spectrum sharing, including "temporary dynamic short-term use," through identification of spectrum for sharing, pilot and permanent programs

Regulatory Support (ctd.)

- **U.S. Department of Commerce/NTIA**
  - Modifications to NTIA Manual (New § 8.4, Sept. 2008): "Radiocommunication systems using Cognitive Radio or Software Defined techniques in any radiocommunications service shall operate in accordance with the provisions of NTIA rules governing those services."
  - DSA Spectrum Sharing Innovation Test-Bed Initiative (410-420 MHz/470-512 MHz)
  - Commerce Spectrum Management Advisory Committee (CSMAC)
    - New Spectrum Sharing Working Group formed
- **Federal Communications Commission (FCC)**
  - Implementing Broadband Plan to encourage innovative ways of using of spectrum, including "opportunistic" sharing.
    - Planning to finalize TV White Space rules
    - Enhance secondary market access
    - Improve transparency (spectrum "dashboard")
    - Conduct measurements
    - Work with NTIA to identify Federal spectrum for opportunistic access.

Regulatory Support (ctd.)

- **International Telecommunications Union (ITU-R)**
  - World Radio Conference agenda items on cognitive radio/SDR & technical neutrality/flexibility looking positive (no or light regulation).
- **IEEE and others**
  - Developing industry standards for TV White Spaces, DSA Policy Architectures, DSA Detector Interfaces, etc.

Thank You

Contact Information:

Peter A. Tenhula
Vice President, General Counsel
Regulatory Affairs and Business Development
Shared Spectrum Company
1595 Spring Hill Road
Suite 110
Vienna, VA 22182
Main Tel: +1 703-761-2818
Direct Dial: +1 703-462-6949
Fax: +1 703-761-2817
Email: ptenhula@ieee.org
or ptenhula@sharedspectrum.com