Regulatory Framework(s) for Facilitating New Spectrum Sharing Schemes

Session IV: Validating and Regulating New Sharing Schemes

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Presentation Overview & Questions

- Survey of U.S. and International Regulatory Efforts to Promote “Shared” Access to Spectrum Resources
- Various Perspectives for “Regulatory” Frameworks
  - References, where available, listed on last slide.

Key questions to consider:

- What do we mean by “shared” access?
- Are long-term visions becoming clouded by short-term reality?
- What are the nearer-term opportunities and the regulatory challenges to them?
- Are regulators trying to fit DSA round pegs into square holes of legacy regulatory models?
- What is/are the missing ingredient(s) for effective co-existence model(s)?

Some Recent Regulatory Efforts to Promote "Shared" Access (overview)

- U.S. Efforts
  - FCC: SDR, Cog. Radio, 2ndary Markets & TVWS
  - FCC: Broadband Plan & DSA Notice of Inquiry
  - President Obama's Spectrum Memo & NTIA Implementation
  - NTIA: "Redbook" Authorization of SDR, CR and DSA*****
- International Efforts (primarily in Europe)
  - U.K. OFCOM cog. devices in TVWS/interleaved bands, secondary trading initiative
  - EU Radio Spectrum Policy Group (RSPG) Cog. Radio and Spectrum Sharing Initiatives*****
  - EU COST-TERRA Initiative
  - ITU-R/WRC-12 Agenda Item 1.19 on CRS and SDR
  - Industry Canada TVWS Consultation
  - Asia/Pacific Rim TVWS Trials (Singapore, Japan, Korea)

***** Slightly deeper dive next 2 slides

U.S. Efforts (for example)

NTIA: “Redbook” Authorization of CR and DSA

- September 2008 revisions added SDR and CR
- May 2011 changes added DSA

6.1.1 Special Terms (General)

Cognitive Radio System: A radiocommunication system that is aware of its environment and internal state and can make decisions about, and adjust, its operating characteristics based on information and predefined objectives.

* * * * *

Dynamic Spectrum Access: The real-time adjustment of spectrum utilization in response to changing circumstances and objectives.

8.4 Cognitive Radio System, Dynamic Spectrum Access, and Software Defined Radio

Radiocommunication systems using Cognitive Radio, Dynamic Spectrum Access, or Software Defined techniques in any radiocommunications service shall operate in accordance with the provisions of NTIA rules governing those services.

International Efforts (for example)

EU Radio Spectrum Policy Group (RSPG): Cog. Radio and Spectrum Sharing Initiatives (ongoing)

- November 2011: Report on collective use of spectrum and other sharing approaches
- May 2012: (Draft) Request for Opinion on increasing opportunities for shared use of spectrum
  - Defining shared spectrum access right (SSAR): authorization that allows individual user or application to access same range of frequencies as another user or application on basis of a defined sharing arrangement
  - Focus on Licensed Shared Access (LSA) concept as form of shared use
  - Seeking to: (1) identify best practices on LSA; (2) look into details/definitions of LSA concept; and (3) investigate how to promote LSA to reap benefits from European perspective.

Some Perspectives*

- EU-RSPG Proposed Regulatory Framework for CUS/CR
- Peha Spectrum Sharing Models
- Zhao et. al DSA Taxonomy and OSA approach
- FCC SPTF Interference Temperature Approach
- Tenhula's Interdisciplinary/Cross-Layer Regulatory Approach(es)
- DISA Spectrum Management/Access Transformation
- PCAST 3-Tier Hierarchy

* Not necessarily endorsed by presenter, except maybe one.

EU-RSPG Proposed Framework

Terminology

- “vertical sharing” – cognitive radios share spectrum with existing users
- “horizontal sharing” – cognitive radio technologies have same rights to access spectrum as existing users
- “collective use of spectrum” (CUS) – allows undetermined/unlimited number of independent users and/or devices to access spectrum in same range of frequencies at same time and place under “well-defined set of conditions”
- “Licensed Shared Access” (LSA) – individual licensed regime of limited number of licensees in a frequency band already allocated to incumbent users for which additional users allowed to use spectrum in accordance with sharing rules thereby allowing all licensees to provide a “certain level of QoS”

EU-RSPG Framework (2)

5.3 Summary of Regulatory Intervention

Regulatory Intervention	Vertical Sharing	Horizontal Sharing
Collective Use of Spectrum (CUS) Model (license-exempt use, light licensing and private commons)	• Designate the frequency band where cognitive radio could share spectrum with existing users on an opportunistic basis. • Define the appropriate technical conditions for the cognitive devices.	• Designate the frequency band to allow usage on a cognitive basis which does not interfere with existing users; • Define technical conditions for the block of spectrum where cognitive radio will operate within.
	• Cognitive Technology (CT) devices will need to be able to adapt to new sharing conditions in line with evolution of other radio systems; • Sharing between cognitive radios could be set between themselves through industry standardisation or negotiated access between the spectrum users; • Ensure equitable and non-discriminatory access to spectrum for all the cognitive users and to ensure competition.	

EU-RSPG Framework (3)

5.3 Summary of Regulatory Intervention (ctd.)

<table>
<tr><th>Regulatory Intervention</th><th>Vertical Sharing</th><th>Horizontal Sharing</th></tr>
<tr><td rowspan="2">Rights of spectrum usage could be tradable or leased</td><td>• Define the framework for trading or leasing of rights of spectrum usage (including, where needed, QoS requirements);
• Assess the results of negotiations between market parties and their effects on e.g., competition and approve them.</td><td>• Define the framework for trading and leasing of rights of spectrum usage;
• Provide defined mechanisms in case of disputes and interferences issues and in case of not fulfiling the conditions of use.</td></tr>
<tr><td colspan="2">• Ensure that the rights of spectrum usage are tradable or could be leased and are flexible

Identification of spectrum for cognitive access lies with the existing licensed holders and not with regulators.</td></tr>
</table>

Peha Spectrum Sharing Models

Figure 1: Examples of spectrum-sharing models of each type.

(References to Sections of Paper) [EU RSPG Terminology Match?]

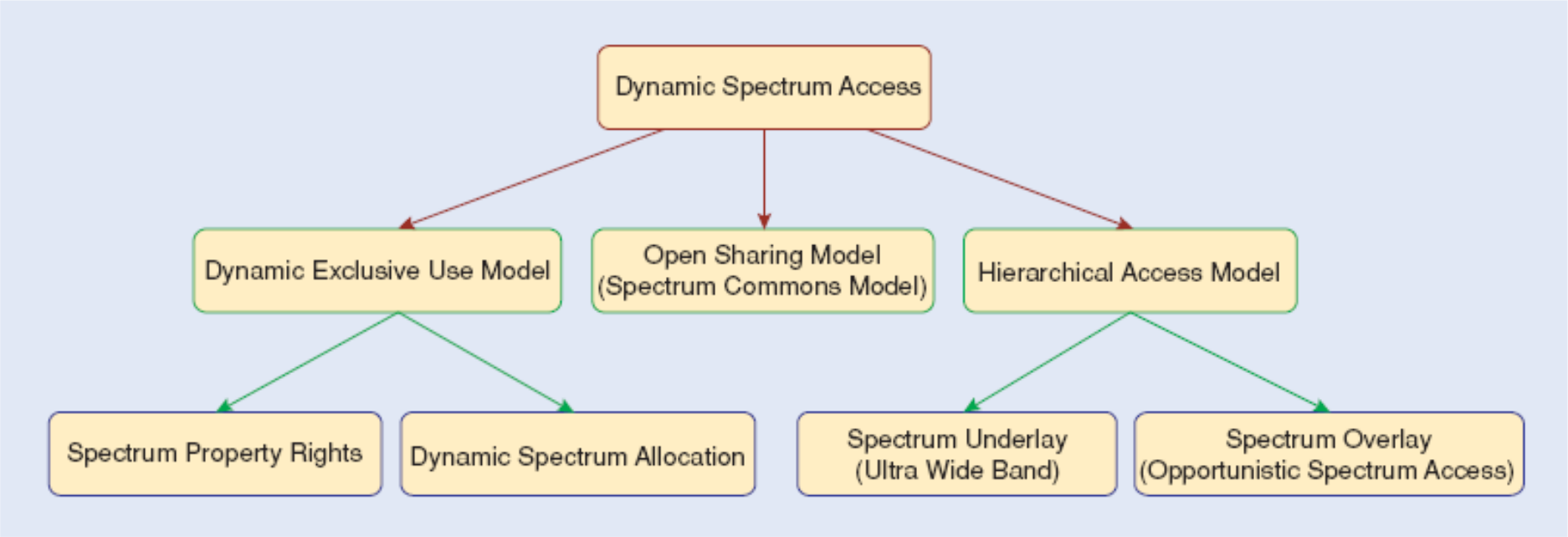
	Sharing Among Equals [Horizontal]	**Primary-Secondary Sharing [Vertical]**
Coexistence	- All devices share unlicensed bands. (3.1) - Unlicensed secondary devices share with each other when & where not used by primary users. (3.3) - LMR public safety systems share through distributed [decentralized] trunking. (3.4)	- Secondary devices use cognitive radio to opportunistically share with primary spectrum users. (3.2) - Secondary devices use GPS and a database of transmitter locations to access spectrum where primary uses do not operate. (3.2) - Secondary devices use ultrawideband technology to share spectrum with primary users. (3.2)
Cooperation	- Unlicensed devices all use prescribed common protocols and carry each other's traffic in a cooperative commons managed by a regulator or license-holder. (3.1) - Unlicensed secondary devices all communicate and cooperate to prevent interference to primary spectrum users and each other. (3.3) - LMR public safety communications systems share spectrum through centralized trunking (3.4)	- Secondary devices explicitly request permission from a license-holder whenever they wish to transmit in a real-time secondary market. (3.2) - An interruptible system has exclusive rights to spectrum until or unless a primary user (such as public safety) temporarily preempts this system. (3.2) - One cellular carrier experiencing excessive call volume coordinates with another to briefly use the latter's spectrum for a fee. (3.4)

Peha Models (2)

Figure 2: Examples of licensed and unlicensed secondary systems

	Secondary is unlicensed	**Secondary is licensed**
Coexistence between primary and secondary	Primary system: Licensed TV broadcasters. Secondary systems: Opportunistic devices with no quality of service guarantees	Primary System: Licensed TV broadcasters Secondary system: Microcellular or cellular network which defers to primary, but does not share with other secondaries.
Cooperation between primary and secondary	Primary system: Cellular Secondary systems: Devices that get temporary quality of service guarantees in a real-time secondary market	Primary system: Public safety Secondary system: Cellular network with exclusive but interruptible access to spectrum

Zhao et. al DSA Taxonomy



[FIG1] A taxonomy of dynamic spectrum access.

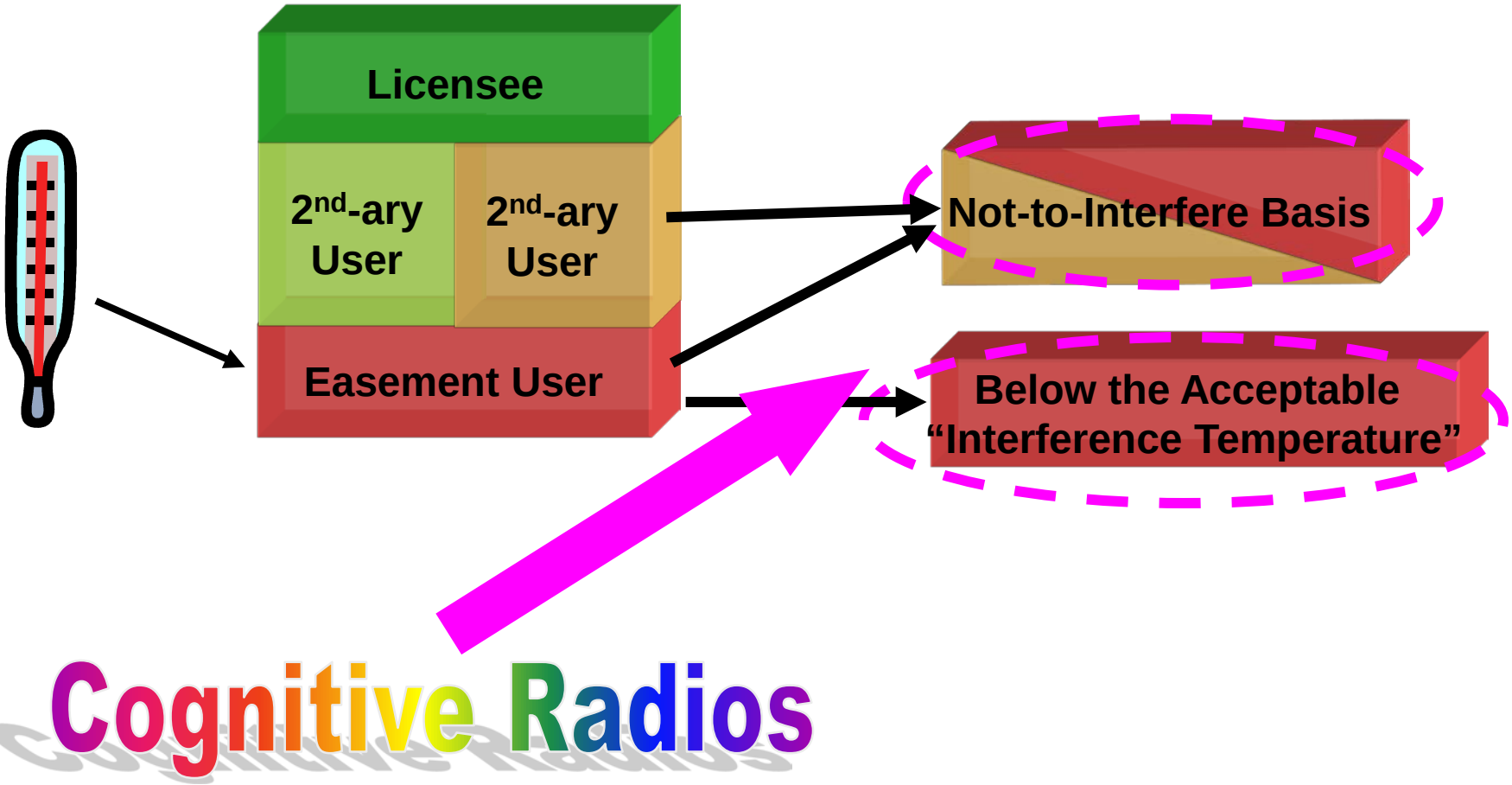
cross-layer approach that integrates signal processing and networking with regulatory policy making

Zhao et. al Opportunistic Spectrum Access (OSA)

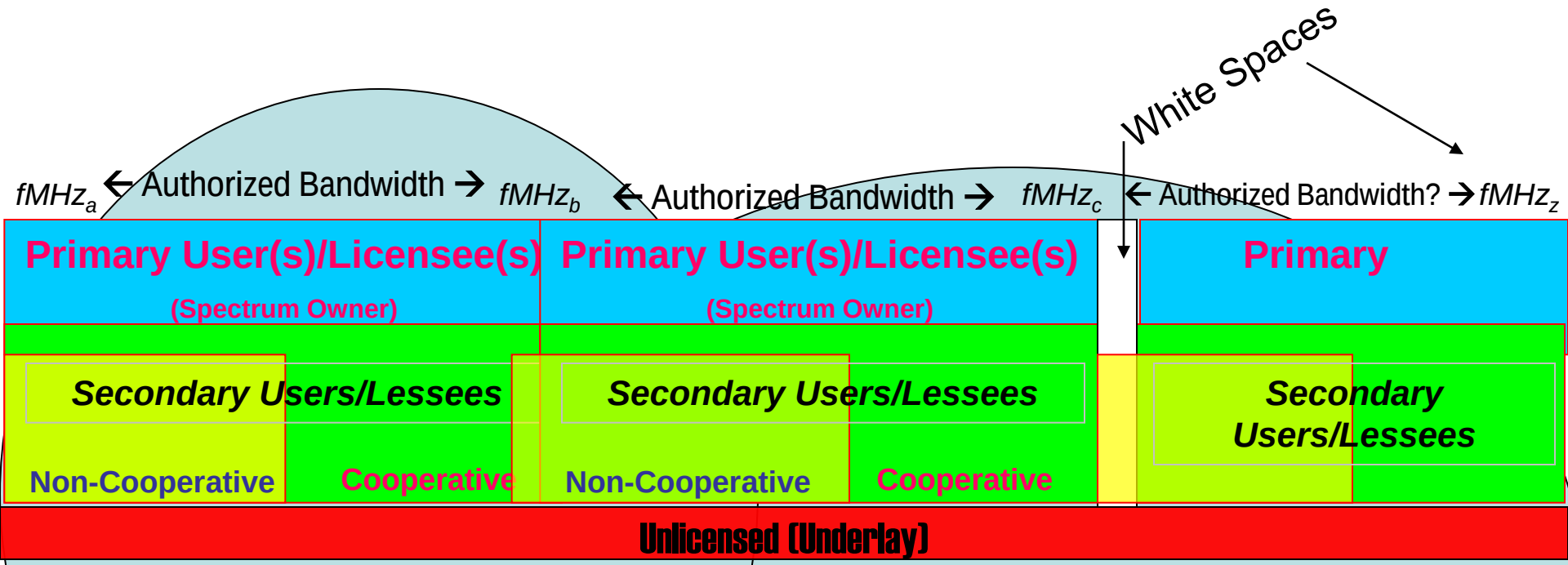
Basic Components of OSA Overlay Approach

- spectrum opportunity identification
  - module responsible for accurately identifying and intelligently tracking idle frequency bands that are dynamic in both time and space
- spectrum opportunity exploitation
  - module takes input from the opportunity identification module and decides whether and how a transmission should take place
- regulatory policy
  - defines the basic etiquette for secondary users to ensure compatibility with legacy systems
    - Fixed vs. Dynamic/Open
    - Centralized vs. Decentralized
    - Implemented on radio devices

FCC SPTF Interference Temperature Model



Tenhula's Multi-Faceted Approach

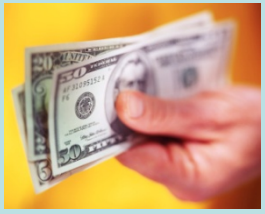


Access rights governed by new "sharing" rules, private agreement & ex post remedies.

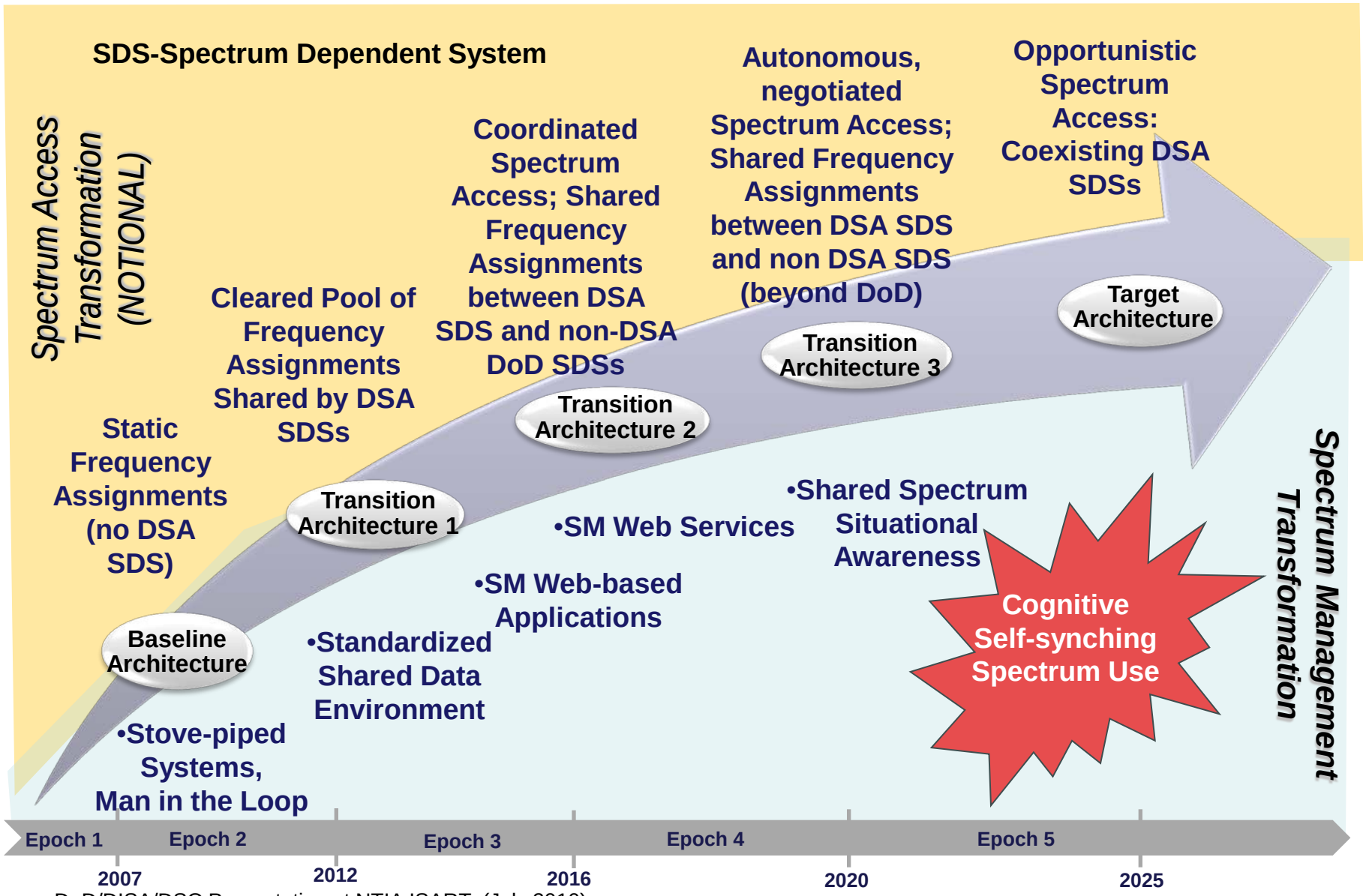
Externalities – OOB/Transaction Costs

OOB Interference/NIB Access Industry Technical Standards

Network control/monitoring & diversity

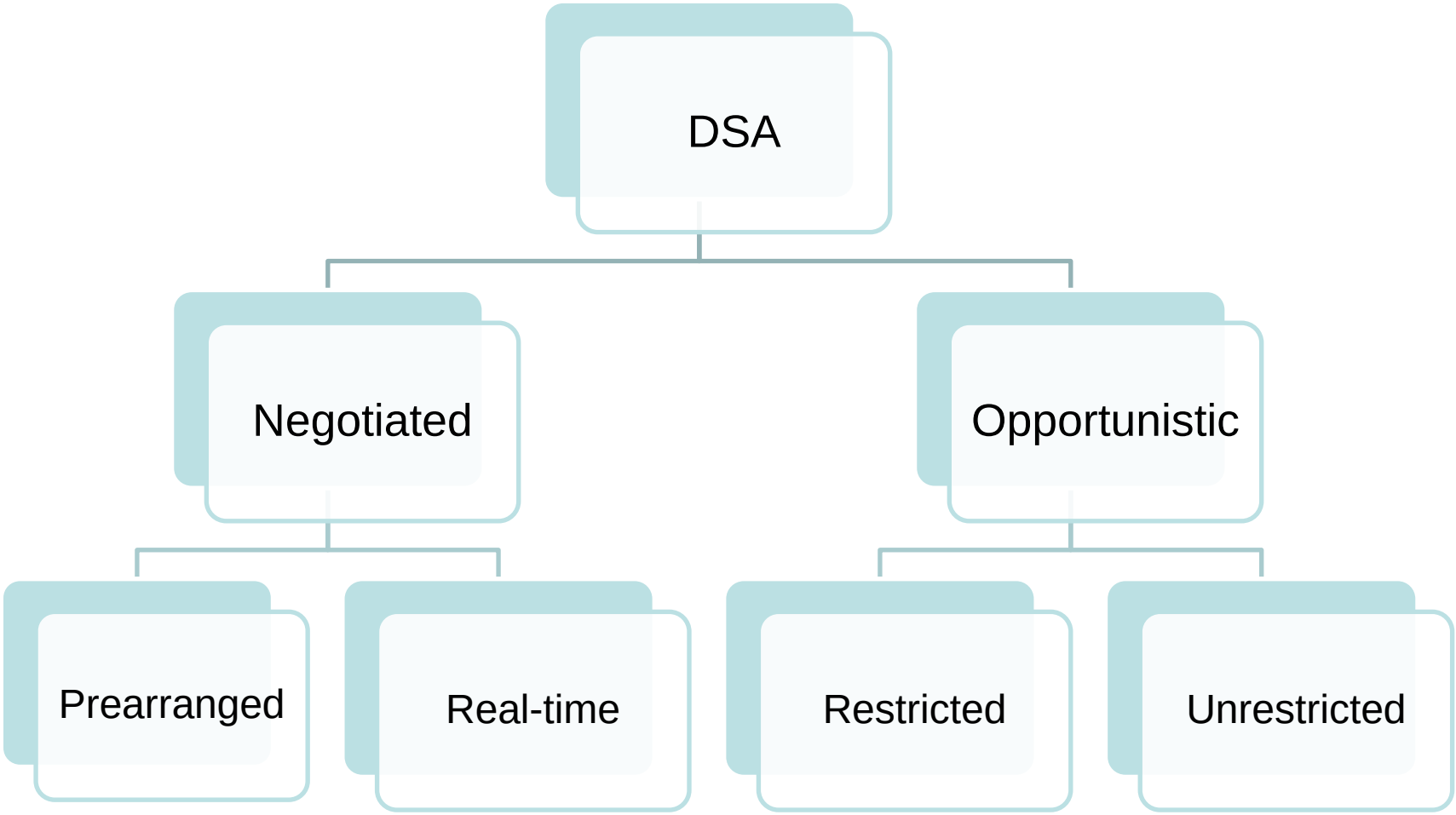


DoD Spectrum Mgt/Access Transformation



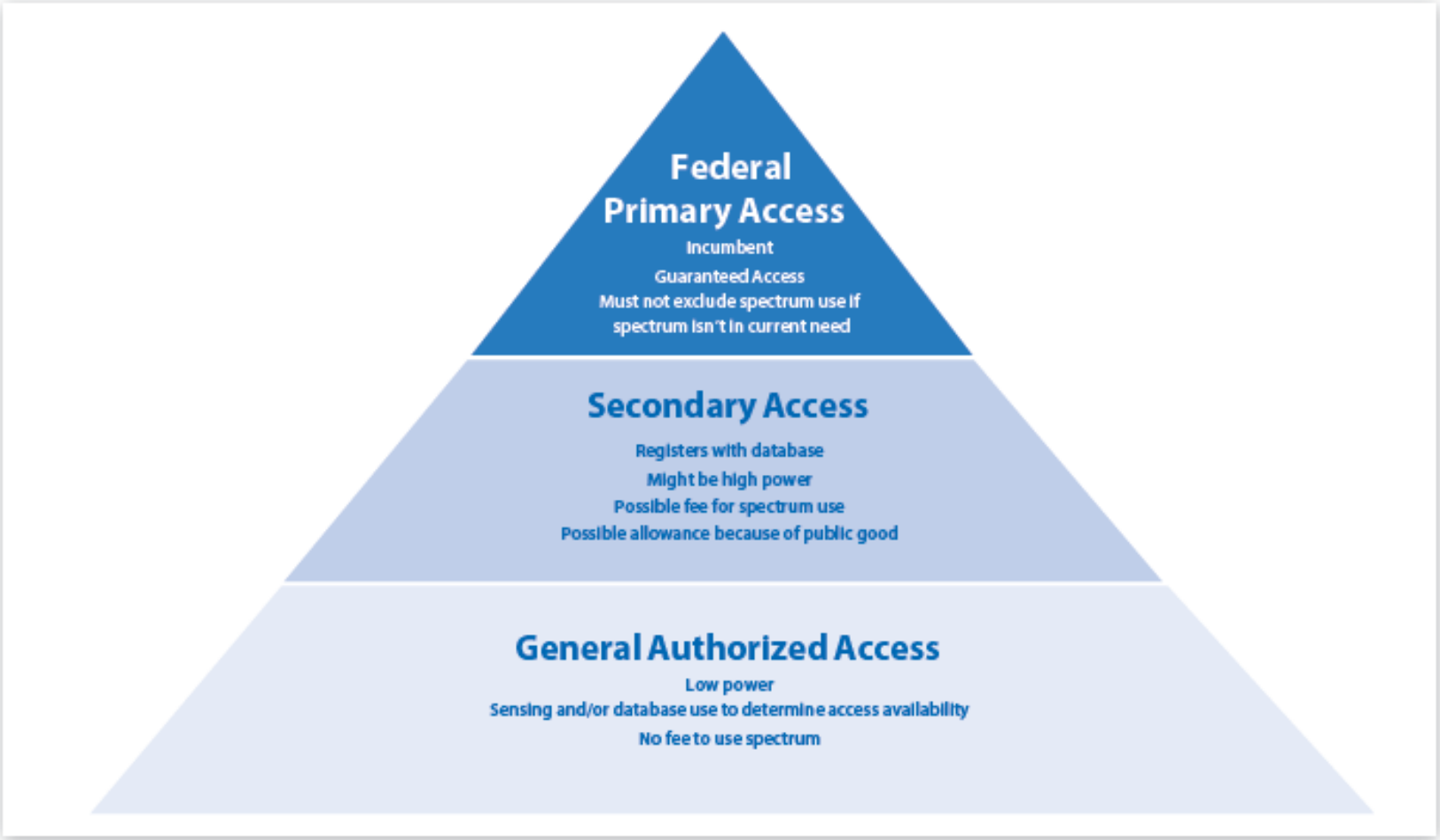
Source: DoD/DISA/DSO Presentation at NTIA ISART (July 2010)

Yet Another DSA Taxonomy



Source: unknown

PCAST 3-Tier Hierarchy



Source: PCAST Report Figure 2.4 (July 2012)

PCAST 3-Tier Hierarchy (ctd.)

- For Accessing Federal Spectrum
- Legacy Federal users have highest priority
- Secondary Access is lower in priority
  - secondary users register with database
  - may or may not pay for access
  - can transmit with high power and have some QoS provisions
- General Authorized Access Users
  - lowest prioritization
  - may access spectrum by sensing or registering with database, depending on policy
  - only low power transmission, but does not require a fee for use

Key Questions (revisited)

- What do we mean by “shared” access?
- Are long-term visions becoming clouded by short-term reality?
- What are the nearer-term opportunities and the regulatory challenges to them?
- Are regulators trying to fit DSA round pegs into square holes of legacy regulatory models?
- What is/are the missing ingredient(s) for effective co-existence model(s)?

References (embedded Word doc)

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