

Software Defined Radio & Cognitive Radio Systems

کارگاه آموزشی:

راديو نرم افزاری و سیستم های رادیویی شناختمند

انجمن مهندسين برق و الكترونيك - اصفهان
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Outline

- | Introduction
- | Cognitive Radio Techniques
- | Cognitive Radio Standards
- | References



Cognitive Radio

INTRODUCTION

... A radio that can be built by SDR techniques

Cognitive Radio

Definition

- I **Cognitive radio** is a paradigm for wireless communication in which either a network or a wireless node **changes its transmission or reception parameters** to **communicate efficiently without interfering with licensed users**.
- I This alteration of parameters is based on the **active monitoring** of several factors in the external and internal radio environment, such as radio frequency spectrum, user behavior and network state.
- I A CR is an autonomous unit in a communications environment. In order to use the spectral resource most efficiently, it has to
 - be aware of its location
 - be interference sensitive
 - comply with some communications etiquette
 - be fair against other users
 - keep its owner informed

Cognitive Radio

Definition

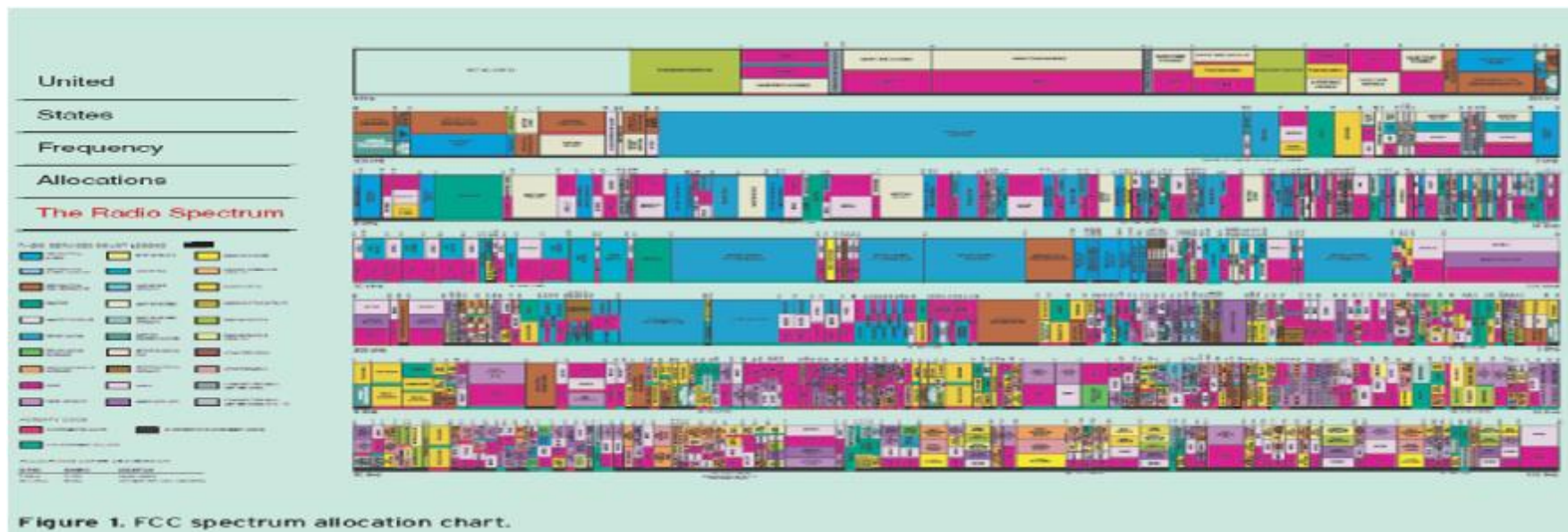
- | The FCC suggests that any radio having **adaptive spectrum awareness** should be referred to as “**Cognitive Radio**” (CR).
- | A **cognitive radio (CR)** is a radio that can **change its transmitter parameters** based on interaction with the environment in which it operates.
- | The majority of cognitive radios will probably be SDRs (Software Defined Radios), but neither having software nor being field programmable are requirements of a cognitive radio.”
- | A **Cognitive Radio (CR)** is usually an SDR that additionally **senses** its environment, **tracks** changes and **reacts** upon its findings.



Cognitive Radio

Spectrum Usage

- | Today “spectrum“ is **regulated by governmental agencies**.
- | “Spectrum“ is **assigned** to users or **licensed** to them on a **long term basis** normally for **huge regions** like whole countries.
- | Doing so, resources are **wasted !!**
- | **Vision:** Resources are assigned where and as long as they are needed.

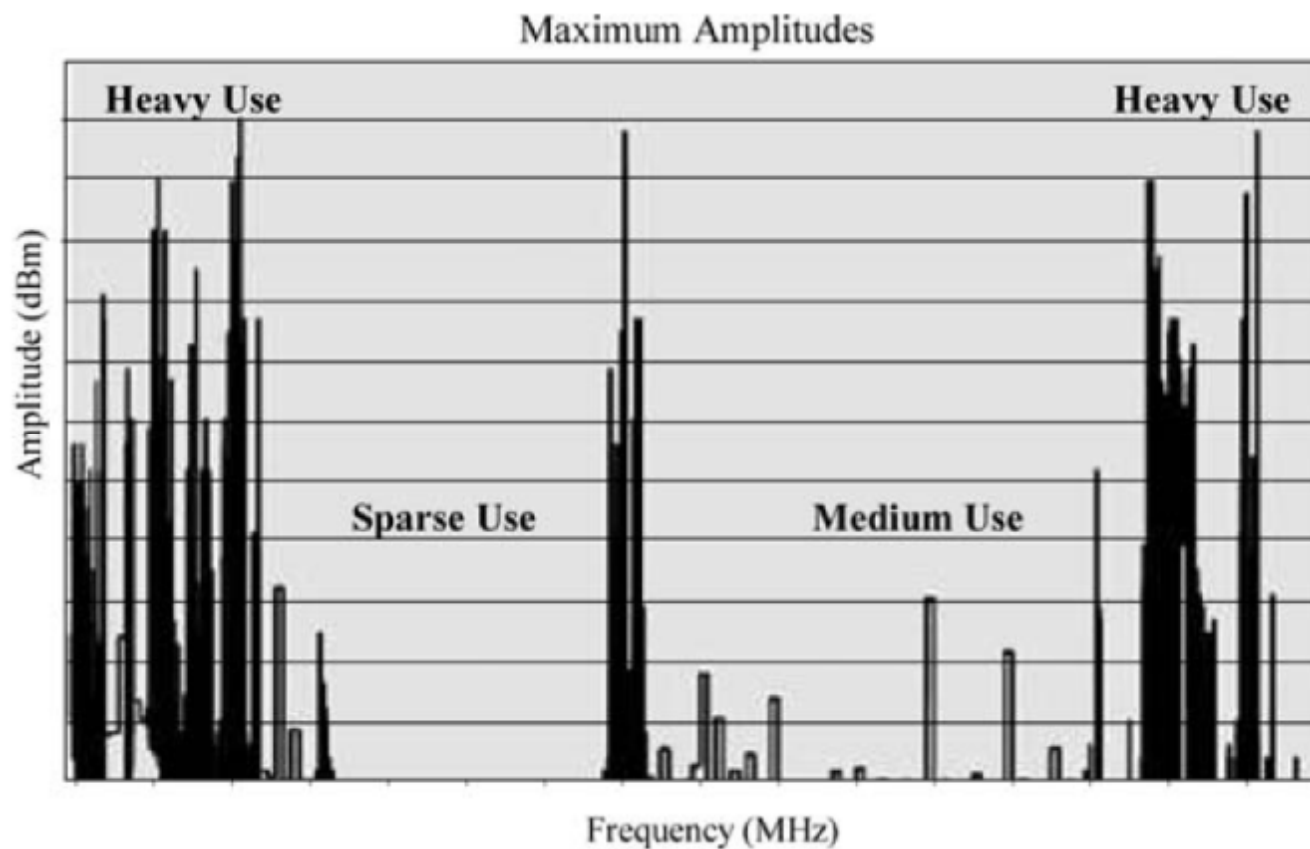




Cognitive Radio

Spectrum Usage

- Regulatory bodies in various countries (including the FCC in the United States) found that most of the Radio frequency spectrum was inefficiently utilized.



Cognitive Radio

Primary and Secondary Users

- | There are two different users:
 - | **Primary user (PU):** as an entity that has a high priority in a given frequency band (e.g. cell phone provider, TV station, emergency services, etc).
 - | **Secondary user (SU):** as users that use licensed bands of PU and have cognitive radio technique.

- | **PUs are not cognitive radio aware**, i.e. there are no means to exchange information between PU and SU
 - | PUs do not provide special signaling in order to access their frequency band.

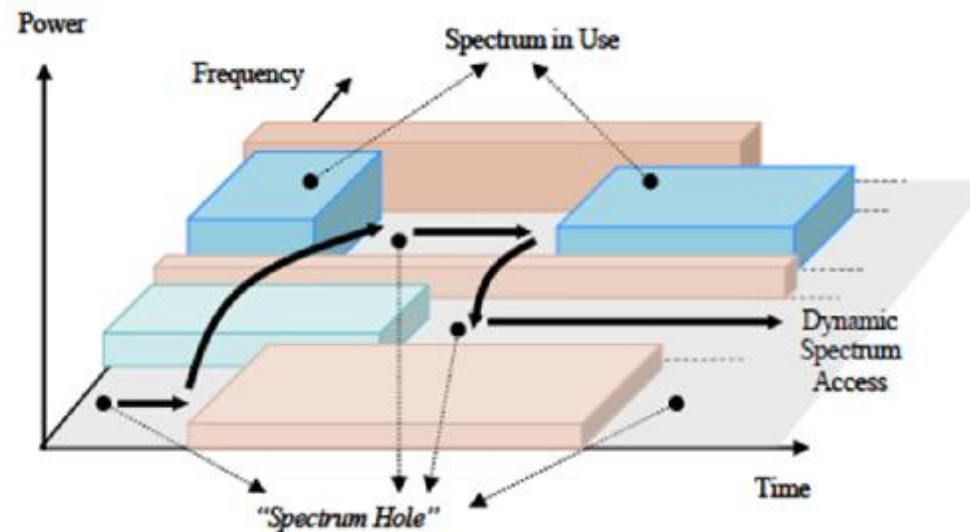
- | **All SUs having cognitive radio capability**, i.e. the system only consists of Primary Users and Cognitive Radio capable SUs. **Secondary Users are treated as noise by PU system.**



Cognitive Radio

Dynamic Spectrum Access (DSA)

- | Dynamic Spectrum Access (DSA) to exploit the existing wireless spectrum opportunistically
- | Uses white space
- | Vacates spectrum To avoid interference





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COGNITIVE RADIO TECHNIQUES

... Let's Share the Spectrum

Cognitive Radio Techniques

I **Spectrum Sensing**

Determine which portions of the spectrum are available and detect the presence of licensed users when a user operates in a licensed band.

I **Spectrum Management**

Select the best available channel.

I **Spectrum Mobility**

Vacate the channel when a licensed user is detected.

I **Spectrum Sharing**

Coordinate *access to this channel with other users.*



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Spectrum Sensing

- | There are two main Spectrum Sensing categories :
 - | Primary transmitter detection
 - | Energy Detection
 - | Wave-form Based Sensing
 - | Radio Identification Based Sensing
 - | Matched Filtering
 - | Other
 - | Interference Temperature Concept
 - | Cooperative Sensing
 - | Centralized Sensing
 - | Distributed Sensing
 - | External Sensing



Cognitive Radio

Spectrum Management

- | Capturing the best available spectrum to meet user communication requirements while not creating undue interference to other (primary) users.

- | The management functions to meet the QoS requirements can be classified as:
 - | spectrum analysis
 - | spectrum decision



Cognitive Radio

Spectrum Mobility – Spectrum Sharing

- I **Spectrum Mobility:** is defined as the process when a cognitive radio user exchanges its frequency of operation. Cognitive radio networks target to **use the spectrum in a dynamic manner** by allowing the radio terminals to operate in the best available frequency band, maintaining seamless communication requirements during the transition to better spectrum.
- I **Spectrum Sharing:** providing the **fair spectrum scheduling method**. One of the major challenges in open spectrum usage is the spectrum sharing. It can be regarded to be similar to generic media access control MAC problems in existing systems



Cognitive Radio

COGNITIVE RADIO STANDARDS

... It is just a beginning

Cognitive Radio

Standards IEEE 802.22

- I **IEEE 802.22** Working Group on Wireless Regional Area Networks. Enabling Rural Broadband Wireless Access Using Cognitive Radio Technology in TV Whitespaces.
- I **IEEE 802.22** is a standard for Wireless Regional Area Network (WRAN) using **white spaces** in the TV frequency spectrum. The development of the IEEE 802.22 WRAN standard is aimed at using **cognitive radio** (CR) techniques to allow sharing of geographically unused spectrum allocated to the Television Broadcast Service, on a **non-interfering basis**, to bring broadband access to **hard-to-reach, low population density areas**, typical of rural environments, and is therefore timely and has the potential for a wide applicability worldwide.
- I It is the first worldwide effort to define a standardized air interface base

TV White Space

- I 'White spaces' are channels within the licensed TV spectrum that are not used for TV services at a given location
- I The white spaces are used for wireless microphones.
- I It is proposed to use the white spaces for cognitive radio.
- I Wireless Internet: among the current WSD applications under consideration.
- I *Once cognitive radios become available they can be used for a range of broadcaster applications.*

TV White Space

- | The white spaces might be available everywhere, *however, the amount of white spaces available at any given location will differ.*
- | Regulatory and technical conditions for white space devices are in the process of being established.
- | WSD are already authorized in the USA.
- | There are no cognitive radio devices on the market yet.
- | ITU is starting work on WSD. *The ITU-R World Radio communication Conference to be held in 2012*



Cognitive Radio

Standards IEEE 1900.4

- | The **IEEE 1900.4** Working Group is on "Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks".
- | Use cases (cases in which the protocols described by this standard will be used) include:
 - | Dynamic spectrum assignment
 - | Dynamic spectrum sharing
 - | Distributed radio resource usage optimization



Software Defined Radio and Cognitive Radio Systems

REFERENCES

... To start your own journey



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Thank you for your attention!



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Any Questions?

