Cognitive Radio Systems (CRS)

Definition, applications, benefits and use

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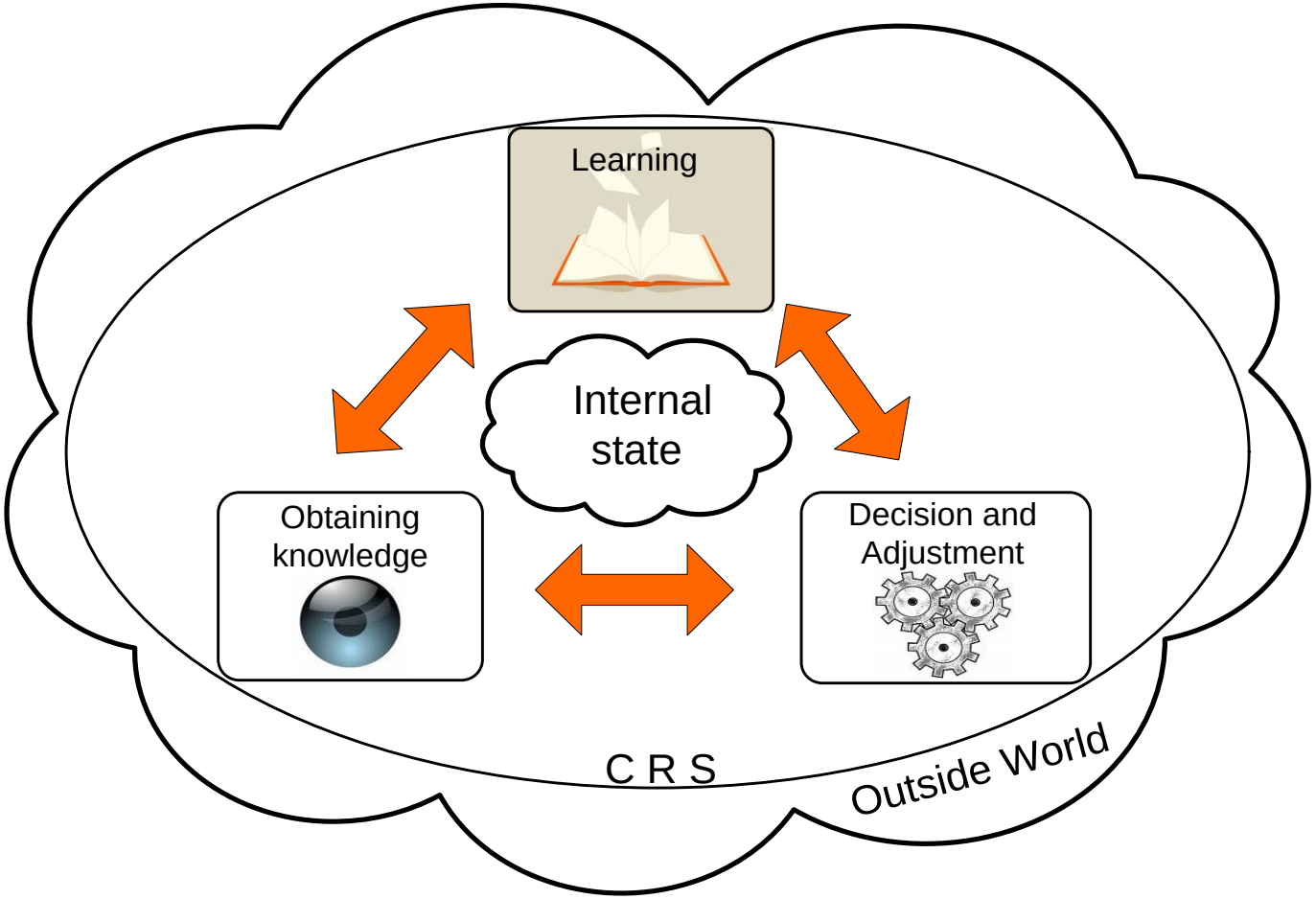
ITU-R Definition: Cognitive Radio System (CRS)

"A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained."

Reference: Report ITU-R SM.2152 "Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)"

Cognitive radio system concept



Reference: Report ITU-R M.2225 "Introduction to cognitive radio systems in the land mobile service"

Methods to obtain knowledge

- Radio link and network quality assessment
- Listening to a wireless control channel
- Spectrum sensing
- Geo-location
- Database usage
- Collaboration between CRS nodes and other different radio system nodes.

Decision and Adjustment

- The operational parameters that the CRS may modify include but are not limited to the following parameters:
  - Output power
  - Operating frequency
  - Modulation type
  - Radio access technology
- This may be implemented using software defined radio (SDR) technology.

Learning

- Enables performance improvement for the CRS by using stored information of its previous actions and their results.
- Each action is evaluated and the parameters are routinely optimized to further improve the performance (e.g., improve capacity).
- Gathers and maintains knowledge while operating in a changing radio environment and to potentially use this information in future transmissions.

Some potential benefits of CRS

- Additional flexibility
- Improving the efficiency of spectrum use
- Self-correction and fault tolerance
- Deploying new communication systems in disaster stricken areas or in emergency situations
- Additional power efficiency using CRS
- Potential new mobile communication applications.

CRS is an enabler

- WRC-12 agenda item 1.19 “to consider regulatory measures and their relevance, in order to enable the introduction of software-defined radio and cognitive radio systems, based on the results of ITU R studies, in accordance with Resolution 956 (WRC-07)”
- CRS is a set of functionalities of nonspecific radio technologies, and is not to be confused with a Radiocommunication Service.

RECOMMENDATION 76 (WRC-12)

Deployment and use of cognitive radio systems

recognizes

a) that any radio system implementing CRS technology needs to operate in accordance with the provisions of the Radio Regulations;

b) that the use of CRS does not exempt administrations from their obligations with regard to the protection of stations of other administrations operating in accordance with the Radio Regulations;

c) that CRSs are expected to provide flexibility and improved efficiency to overall spectrum use.

Use of CRS in Radiocommunication

- "Any system of a radiocommunication service that uses CRS technology in a given frequency band will operate in accordance with the provisions of the Radio Regulations governing the use of that band"

  Reference: Report ITU-R M.2225 (2011) "Introduction to cognitive radio systems in the land mobile service"

- Radio Regulations (RR) Edition of 2012: http://www.itu.int/pub/R-REG-RR-2012

Radiocommunication in White Spaces in line with the RR

- **Within an allocated Radiocommunication Service** under the established regulations for the band in case, including international, regional and national regulations as required.

- **Under RR No. 4.4** "Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations."

TV white space

A portion of spectrum in a band allocated to the broadcasting service and used for television broadcasting that is identified by an administration as available for wireless communication at a given time in a given geographical area on a non-interfering and non-protected basis with regard to other services with a higher priority on a national basis.

Reference: Report ITU-R M.2225 "Introduction to cognitive radio systems in the land mobile service"

On-going work in ITU-R (1 of 3)

- ITU-R Working Party 5A: Wireless Access & Amateur
  - Report ITU-R M.2225 "Introduction to cognitive radio systems in the land mobile service"
  - Working towards a draft new Report ITU-R M. [LMS.CR2] on CRS in the land mobile service (Annex 20 to Document 5A/421)
  - Seminar on CRS and the use of white spaces (18 Nov 2013) Summary Record: Document 5A/INFO/8
- ITU-R Working Party 5C: Fixed Service
  - Working towards a draft new Report ITU R F.[FS-SDR] on the impact of SDR and CRS on the fixed service
- ITU-R Working Party 5D: IMT Systems
  - Report ITU-R M.2242: CRS specific for IMT systems
  - Additional studies of CRS implementation in IMT

On-going work in ITU-R (2 of 3)

- ITU-R Working Party 6A: Terrestrial Broadcasting
  - Working document towards a preliminary draft new Report ITU R BT.[CRS_BS_BANDS] on “Compatibility issues and national approaches related to introduction of cognitive radio systems within frequency bands used by terrestrial broadcasting services” (Annex 14 to Doc. 6A/360).
- ITU-R Working Party 1C: Spectrum Monitoring
  - Studies in response to Question ITU-R 235/1 on Spectrum Monitoring Evolution, including impact of CRS on spectrum monitoring
  - Working document towards a preliminary draft new Report ITU-R SM.[SPEC_MON_EVOLUTION] - Spectrum monitoring evolution SM.[SPEC_MON_EVOLUTION] (Annex 6 to Doc. 1C/74)

On-going work in ITU-R (3 of 3)

- ITU-R Working Party 1B: Spectrum Management
  - Report ITU-R SM.2152: Definition of SDR and CRS
  - Studies on WRC-12 Agenda item 1.19 (2008-2012)
  - Working document towards a PDN Report ITU R SM.[WHITE-SPACE] on spectrum management principles and spectrum engineering techniques for the use of white spaces by radio systems employing cognitive capabilities (Annex 8 to Doc. 1B/92)
  - Workshop on Spectrum Management related issues (20 January 2014). Possible topics:
    - Creation & responsibility/maintenance of spectrum/geolocation database for use by white space devices
    - White space network authorization/licensing regime
    - Protection of incumbent radiocommunication services
    - Coordination in border areas
    - Economic aspects.

References

Report ITU-R SM.2152 "Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)"

Report ITU-R M.2117-1 "Software defined radio in the land mobile, amateur and amateur satellite services"

Report ITU-R M.2225 "Introduction to cognitive radio systems in the land mobile service"

Report ITU-R M.2242 "Cognitive radio systems specific for IMT systems"

Question ITU-R 230-3/5 "Software defined radios"

Question ITU-R 241-2/5 "Cognitive radio systems in the mobile service"

Question ITU-R 235/1 "Spectrum monitoring evolution"

Resolution ITU-R 58 "Studies on the implementation and use of cognitive radio systems"

Recommendation 76 (WRC-12) "Deployment and use of cognitive radio systems"

Annex 20 to Document 5A/421: "Working document towards a preliminary draft new report ITU-R [LMS.CRS2]"
(Next WP 5A meeting is planned for May 2013 in Tunisia)

SDR and CRS Seminar held by ITU-R WP 5A on 4 February 2008: http://www.itu.int/oth/R0A06000047/en

Doc. 5A/INFO/4 (2008) Presentations, speaker biographies and audio feeds - Seminar on software defined radio and cognitive radio systems (Geneva, 4 February 2008)

Doc. 5A/INFO/3 (2008) Summary highlights of the Seminar on software defined radio and cognitive radio systems - Geneva, 4 February 2008

ITU-R WP 5A Seminar: Geneva, 18 November 2013 – WP 5A Seminar on Cognitive Radio Systems and the use of White Spaces - http://www.itu.int/en/ITU-R/seminars/rsg/RWP5A-2013 – Summary Record: Document 5A/INFO/8