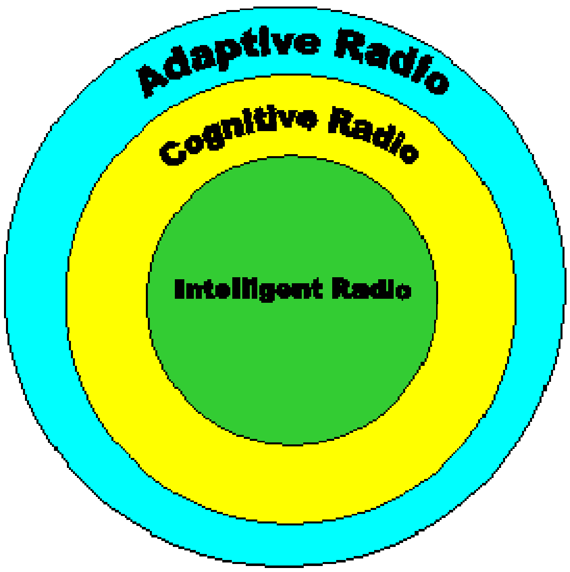
What are Cognitive Radio and Dynamic Spectrum Access

SDR can act as a key enabling technology for a variety of other reconfigurable radio equipments commonly discussed in the advanced wireless market[1]. While SDR is not required to implement any of these radio types, SDR technologies can provide these types of radio with the flexibility necessary for them to achieve their full potential, the benefits of which can help to reduce cost and increase system efficiencies:



Venn diagram illustrating relationship between associated advanced wireless technologies

Adaptive Radio

Adaptive radio is radio in which communications systems have a means of monitoring their own performance and modifying their operating parameters to improve this performance. The use of SDR technologies in an adaptive radio system enables greater degrees of freedom in adaptation, and thus higher levels of performance and better quality of service in a communications link.

Cognitive Radio

Cognitive radio is radio in which communication systems are aware of their internal state and environment, such as location and utilization on RF frequency spectrum at that location. They can make decisions about their radio operating behaviour by mapping that information against predefined objectives.

Cognitive radio is further defined by many to utilize Software Defined Radio, Adaptive Radio, and other technologies to automatically adjust its behaviour or operations to achieve desired objectives. The utilization of these elements is critical in allowing end-users to make optimal use of available frequency spectrum and wireless networks with a common set of radio hardware. This will reduce cost to the end-user while allowing him or her to communicate with whomever they need whenever they need to and in whatever manner is appropriate.

Intelligent Radio

Intelligent radio is cognitive radio that is capable of machine learning. This allows the cognitive radio to improve the ways in which it adapts to changes in performance and environment to better serve the needs of the end user.

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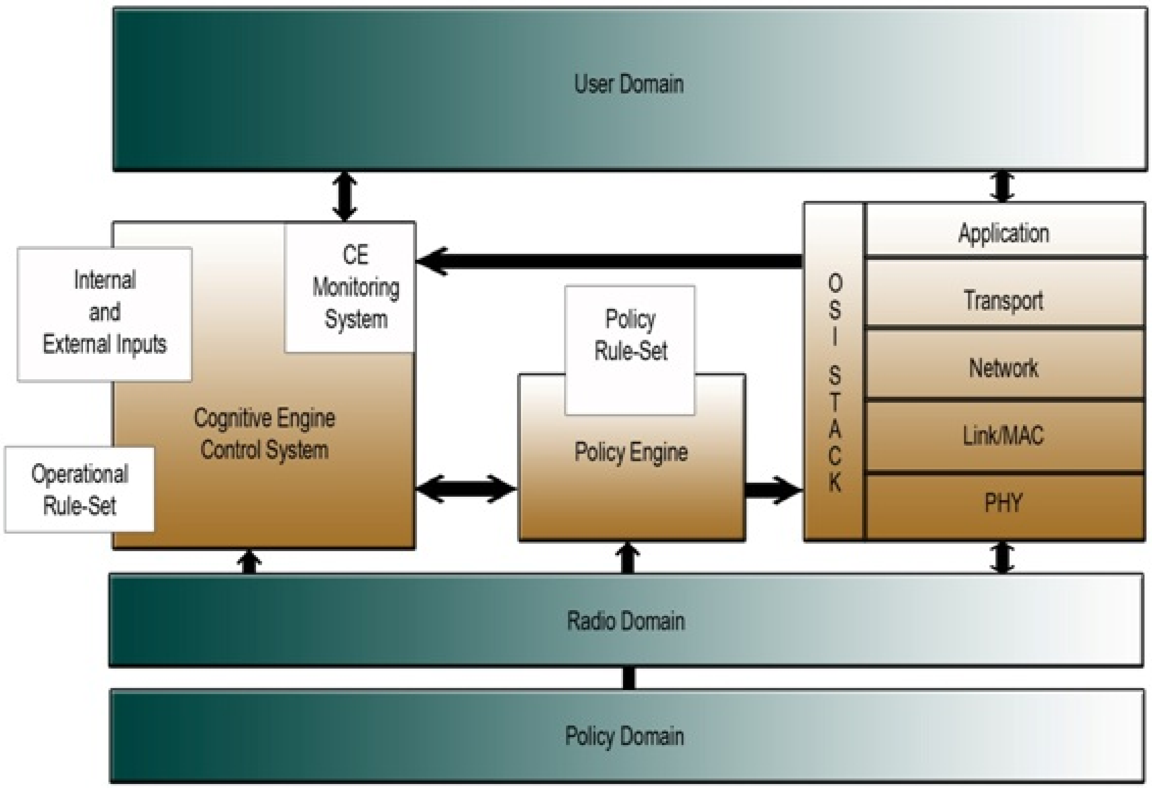
[1] http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-06-P-0009-V1_0_0_CRWG_Defs.pdf

In addition to utilizing SDR technologies, adaptive radio, intelligent radio and cognitive radio systems may all support dynamic spectrum access (DSA), allowing the systems to select the frequency spectrum in which they will operate at a given location and over a given period of time to optimize the use of available spectrum and avoid interference with other radios or other systems.

Cognitive Radio Concept Architecture

There are two major subsystems in a cognitive radio; a cognitive unit that makes decisions based on various inputs and a flexible SDR unit whose operating software provides a range of possible operating modes. A separate spectrum sensing subsystem is also often included in the architectural a cognitive radio to measure the signal environment to determine the presence of other services or users. It is important to note that these subsystems do not necessarily define a single piece of equipment, but may instead incorporate components that are spread across an entire network. As a result, cognitive radio is often referred to as a cognitive radio system or a cognitive network.

The cognitive unit is further separated into two parts as shown in the block diagram below. The first labeled the “cognitive engine” tries to find a solution or optimize a performance goal based on inputs received defining the radio’s current internal state and operating environment. The second engine is the “policy engine” and is used to ensure that the solution provided by the “cognitive engine” is in compliance with regulatory rules and other policies external to the radio.



Cognitive Radio Concept Architecture

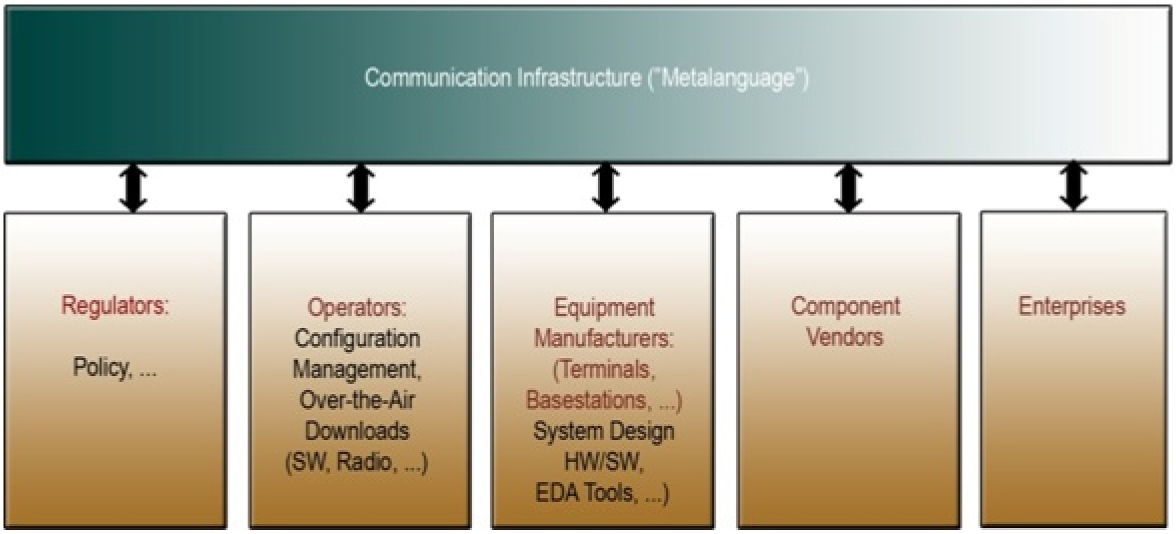
Next → Enabling Technologies Supporting Cognitive Radio

Enabling Architectures Supporting Cognitive Radio and Dynamic Spectrum Access

Support for cognitive radio and dynamic spectrum access requires a number of enabling technologies that are under development by the members of the Wireless Innovation Forum:

- Information Process Architecture: Understanding the current state of complex information systems and their associated communications subsystems to determine how to enhance them from a process perspective, and analyze them for opportunities to interact with other systems is a key problem. An information process architecture solves this problem by providing a top-down model and a series of tools for depicting the structure of complex systems to aid in defining, designing and selecting relevant cognitive radio processes and to facilitate an improved understanding of the structure and relationships between systems that span user domains.
- Modeling Language: Flexible and efficient communication protocols are required between advanced radio systems and subsystems to support next generation features such as vertical and horizontal mobility, spectrum awareness, dynamic spectrum adaption, waveform optimization, feature exchanges, and advanced applications. A modeling language built on detailed use cases, and defining the signalling plan, requirements and

technical analysis of the information exchanges provides the basis for developing specifications and standards supporting these capabilities.



A modeling language, or meta-language, expressed in a formal declarative language that is machine readable defines the communications infrastructure of the cognitive radio[2]

- Radio Environment Map: Operation of a cognitive engine requires data and meta-data defining the spectral environment that a terminal is operating in at a given moment in time. Referred to as the radio environment map, this data can include information on spectrum economic transactions, dropouts, handovers, available networks, and services. Data contained within the map is derived, in part, by capturing and synthesizing measurements from many radios, and may be stored in a database that can be accessed remotely by the cognitive engine. Requirements for a database structure enabling this access including standardized database structures, data formats and functionality must be defined to support the flexibility necessary to accommodate current and future cognitive radio spectrum applications, such as mobility, spectrum economic transactions, dropouts, handovers, available networks, and services.
- Test and Measurement: Cognitive radios pose unique test challenges in quantifying the performance of critical functions such as spectrum sensing, interference avoidance, database performance, and adherence to policy. Test methodologies supporting these challenges must be developed must consider a range of hardware platforms, protocols, algorithms, use cases, and spectrum stakeholder requirements. Test equipment functionality and performance, test interfaces and test modes must also be taken into account.

[2] http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-08-P-0009-V1_0_0_MLM_Use_Cases.pdf

Information on these and other projects can be found at:
http://www.sdrforum.org/pages/aboutTheForum/currentProjects.asp