What is Software Defined Radio

With the exponential growth in the ways and means by which people need to communicate - data communications, voice communications, video communications, broadcast messaging, command and control communications, emergency response communications, etc. – modifying radio devices easily and cost-effectively has become business critical. Software defined radio (SDR) technology brings the flexibility, cost efficiency and power to drive communications forward, with wide-reaching benefits realized by service providers and product developers through to end users.

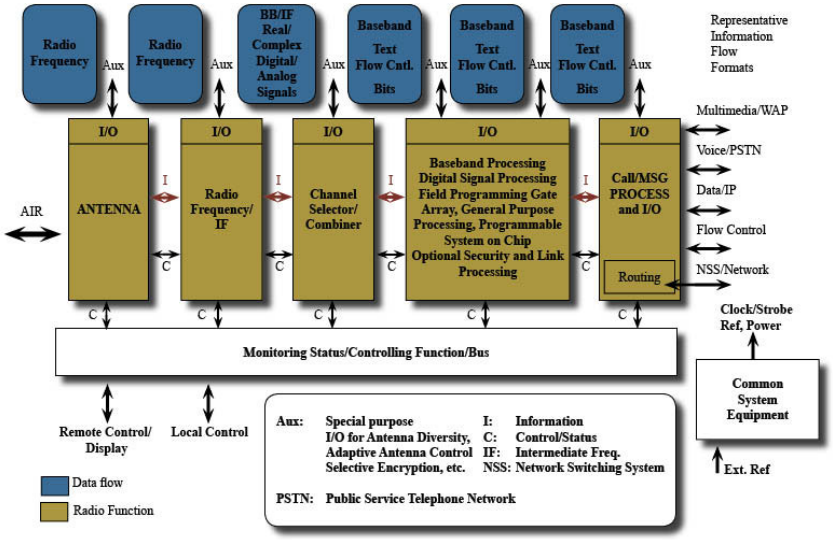
Software Defined Radio - Defined:

A number of definitions can be found to describe Software Defined Radio, also known as Software Radio or SDR. The SDR Forum, working in collaboration with the Institute of Electrical and Electronic Engineers (IEEE) P1900.1 group, has worked to establish a definition of SDR that provides consistency and a clear overview of the technology and its associated benefits. Simply put Software Defined Radio is defined as[1]:

"Radio in which some or all of the physical layer functions are software defined"

A radio is any kind of device that wirelessly transmits or receives signals in the radio frequency (RF) part of the electromagnetic spectrum to facilitate the transfer of information. In today's world, radios exist in a multitude of items such as cell phones, computers, car door openers, vehicles, and televisions.

Traditional hardware based radio devices limit cross-functionality and can only be modified through physical intervention. This results in higher production costs and minimal flexibility in supporting multiple waveform standards. By contrast, software defined radio technology provides an efficient and comparatively inexpensive solution to this problem, allowing multi-mode, multi-band and/or multi-functional wireless devices that can be enhanced using software upgrades.



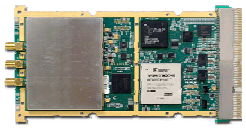
SDR Forum Generalized Functional Architecture – Commercial (source: http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-01-P-0006-V2_0_0_BaseStation_Systems.pdf)

[1] http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-06-R-0011-V1_0_0.pdf

SDR defines a collection of hardware and software technologies where some or all of the radio's operating functions (also referred to as physical layer processing) are implemented through modifiable software or firmware operating on programmable processing technologies. These devices include field programmable gate arrays (FPGA), digital signal processors (DSP), general purpose processors (GPP), programmable System on Chip (SoC) or other application specific programmable processors. The use of these technologies allows new wireless features and capabilities to be added to existing radio systems without requiring new hardware.

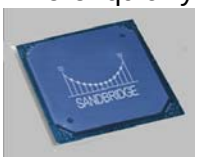
Software Defined Radio - Benefits:

The benefits of SDR are compelling.



For Radio Equipment Manufacturers and System Integrators, SDR Enables:

- A family of radio "products" to be implemented using a common platform architecture, allowing new products to be more quickly introduced into the market.
- Software to be reused across radio "products", reducing development costs dramatically.
- Over-the-air or other remote reprogramming, allowing "bug fixes" to occur while a radio is in service, thus reducing the time and costs associated with operation and maintenance.



For Radio Service Providers, SDR Enables:

- New features and capabilities to be added to existing infrastructure without requiring major new capital expenditures, allowing service providers to quasi-future proof their networks.
- The use of a common radio platform for multiple markets, significantly reducing logistical support and operating expenditures.
- Remote software downloads, through which capacity can be increased, capability upgrades can be activated and new revenue generating features can be inserted.

For End Users - from business travelers to soldiers on the battlefield, SDR technology aims to:

- Reduce costs in providing end-users with access to ubiquitous wireless communications – enabling them to communicate with whomever they need, whenever they need to and in whatever manner is appropriate.

Software Defined Radio - Rate of Adoption:

The SDR Forum commissioned a number of research reports in 2006 to evaluate the adoption of SDR technologies in various markets. The results of these studies demonstrated that, in

certain markets, SDR is moving beyond the innovators and early adopters as defined by Geoffrey Moore in "Crossing the Chasm" into the early majority phase defining the mainstream market[2]. In this phase, adopters select a technology not because it is innovative or visionary but because it has been shown to successfully solve a problem within their specific market.

Examples of SDR adoption illustrating the transition to the mainstream are abundant:

- Thousands of software defined radios have been successfully deployed in defense applications
- Cellular infrastructure systems are increasingly using programmable processing devices to create "common platform" or "multiband-multiprotocol" base stations supporting multiple cellular infrastructure standards
- Cellular handsets are increasingly utilizing System on Chip (SoC) devices that incorporate programmable "DSP Cores" to support the baseband signal/modem processing

- Satellite "modems" in the commercial and defense markets make pervasive use of programmable processing devices for intermediate frequency and baseband signal processing

While these types of systems are often not marketed as "SDR's", they utilize and benefit from SDR technologies to solve market specific problems such as; cost of development, cost of production, cost of upgrades and maintenance, time to market in supporting new and evolving air interface standards, or problems associated with network interoperability.

In addition, the SDR Forum's market and technology studies have shown that cost effective radio frequency technologies supporting the operation of software defined radios over a broad spectral range have begun to mature, allowing for the first time the use of software defined radio as an enabling technology for dynamic spectrum access systems with cognitive or smart radio functionality. This trend is expected to continue over the next several years, allowing SDR to finally achieve the defined vision of reducing costs in providing end-users with access to ubiquitous wireless communications – enabling them to communicate with whomever they need, whenever they need to and in whatever manner is appropriate





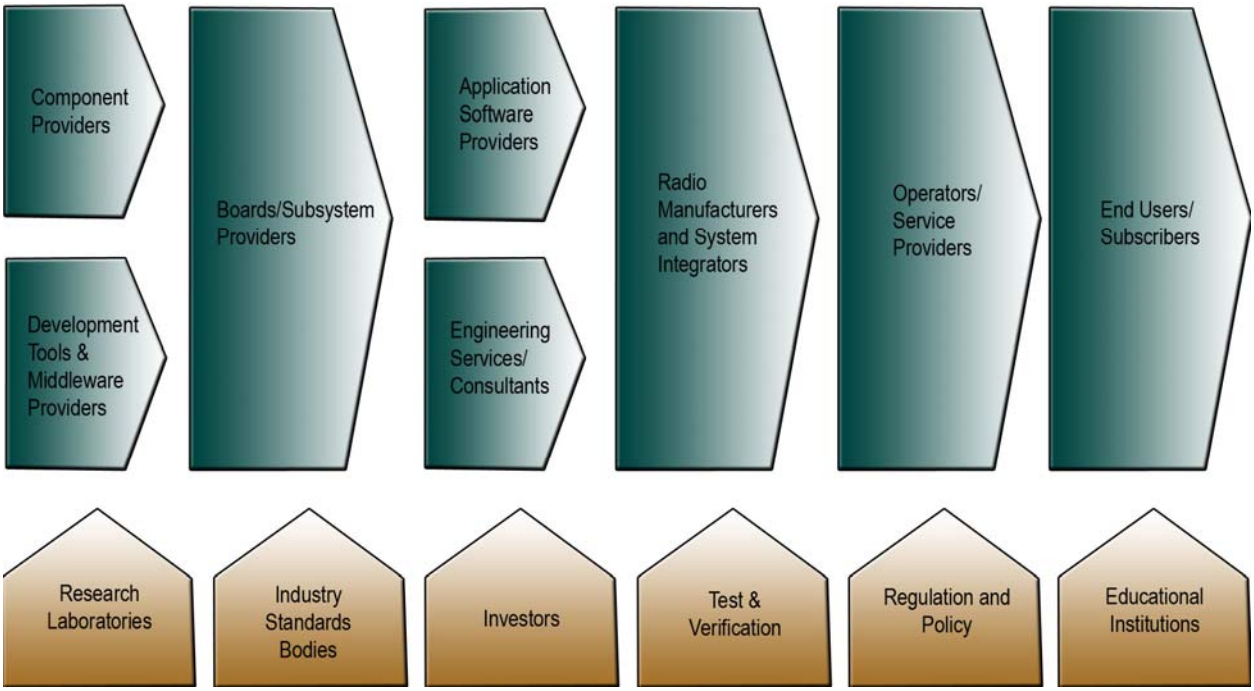
[2] Geoffrey A. Moore, *Crossing the Chasm (Revised Addition)*, Harper Collins Publishers, 2002

Software Defined Radio – Value Chain:

The time is now to engage SDR at all levels of the chain

The benefits and anticipated opportunities for SDR technology are having a significant impact on the wireless industry's value chain. This chain consists of product-based and service-based providers, with value added at each stage, ultimately resulting in SDR end products and services that meet the needs of the end users and subscribers.

Throughout the chain, the providers may be supported by external organizations such as educational institutions, research laboratories, industry standards bodies, investors, tests & verification and government. These supporting organizations provide critical input as development progresses through the chain, ultimately reaching the end user. The detail of the chain and the relationship within the context of the SDR Forum membership is outlined below.



SDR Value Chain: Product and Service Based Providers and Supporting Organizations (Source: SDR Forum 2005 Year Book)

Please note: *companies may represent more than one category in the value chain.* For instance, some defense contractors develop their own SDR subsystems and application software. Equally most component providers also provide development tools.

SDR has far reaching implications within the chain impacting a variety of organizations and industry sectors through the radio frequency (RF) chain (front end components, software developers, chips makers, etc) and throughout business modes (service providers, OEMs, IP holders, etc.). In order to provide viable products and services to meet the future development potential of SDR technology, organizations must look to structure SDR into all levels of the value chain. With successful applications seen in a number of markets, the opportunity to fully engage SDR at all levels of the chain is now.

The SDR Forum engages world class technical, business and government leaders from EMEA, Asia and the Americas, at all levels of the wireless industry's value chain. These members are committed to solving their customers' communications problems through families of radio devices that support a broad range of disparate wireless networks, evolving standards, and the addition of value added services. The dedication to promoting the success of next generation radio technologies that will inherently support software defined and cognitive radio (CR) capabilities is at the foundation of the Forum. Through its collective industry strength the Forum can support the adoption of SDR technologies through the value chain through advocacy, opportunity development, commercialization and education.

Software Defined Radio - Related Technologies

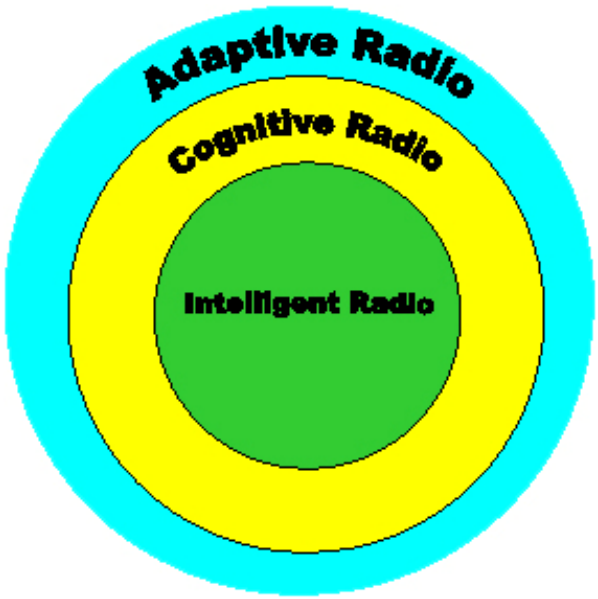
SDR can act as a key enabling technology for a variety of other reconfigurable radio equipments commonly discussed in the advanced wireless market.[3] While SDR is not required to implement any of these radio types, SDR technologies can provide these types of radio with the flexibility necessary for them to achieve their full potential, the benefits of which can help to reduce cost and increase system efficiencies:

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.



Venn diagram illustrating relationship between associated advanced wireless technologies

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

[3] http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-06-R-0011-V1_0_0.pdf

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. As noted earlier, 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.

These types of radio – adaptive radio, cognitive radio and intelligent radio – do not necessarily define a single piece of equipment, but may instead incorporate components that are spread across an entire network.