Software-Defined . . . Radio?

By Stephanie Chiao

Over the past few years, Software-Defined Radios (SDRs) have taken huge strides that have significantly impacted many industries. Whether it's for wireless networks in the military, public safety, or commercial markets, SDR is steadily growing in importance in these segments. These industries have been revitalized mainly because communications devices are now more (re)configurable, interoperable, cost-effective, and flexible.

Most software-defined radios share a similar architecture: an antenna connects to a radio front end that interfaces to a Digital Signal Processing (DSP) system. The digital system may consist of a single fixed-purpose component, or a generalized system that includes discreet converters (ADCs and DACs) interfacing to an FPGA or other processing silicon.

SDR technology is compatible with diverse networking standards, making it easy to bridge various radio protocols and maintain cross-channel connectivity. SDRs are wireless communications devices where the receiver and transmitter functionality is changed/modified by the software alone without making any physical changes or modifications to the hardware. The aim is to completely (re)configure the functions of the radio with software rather than make changes to the hardware.

SDR's Impact on Wireless Networks

Modern SDR devices on the market are light-weight, compact, and offer a single platform, eliminating the need to have multiple radio devices and multiple platforms: Electronic Warfare (EW), communications (COMMs), and Signals Intelligence (SIGINT). Furthermore, SDR technology is being introduced to expand existing network infrastructure without the need for expensive networking equipment. Designed to support many end users, some SDR platforms can be configured to run more efficiently to support fewer clients.

Today, RF designers are able to design and build 1 system for a wide range of waveforms in order to gain economies of scale. The main challenge is to design wide band, linear RF front ends, DSP competencies for Field Programmable Gate Arrays (FPGAs), and firmware. FPGAs are ideal as they are integrated circuits that can be (re)programmed long after they are manufactured. With regards to cognitive SDRs, RF or DSP can no longer be developed separately because they need a high level of integration between both systems. As a result, SDR provides more benefits when compared to DSP based solutions and FPGAs.

As technology rapidly evolves, SDR is an ideal solution to incorporate into wireless networks as there is little to no need to change the hardware. SDR stations are highly adaptable, portable, and re-usable. This enables one to keep up with the evolution of wireless technology while keeping future costs down.

SDR capabilities will continue to evolve and expand for commercial and defense applications including electronic warfare, telecommunications, and radar applications.

Future of SDR in Wireless Networks

All of the market segments in the SDR industry are expected to keep growing as the need continues to grow for flexible wireless solutions and products. It will also gain importance with academic SDR users who will continue to further their research efforts, including research involving new protocols.

With the emergence of the Internet of Things (IoT) and Big Data, the need to communicate large volumes of data will intensify. So the race will continue to achieve these goals beginning with 5G wireless communication.

However, there are a growing number of technical challenges that are faced by the industry at the present time. These present and future challenges will be focused on COBRA (middleware) and SCA (framework), which are designed to support SDRs. However, both middleware and firmware require a significant investment, which goes against the ethos of the communication

The SDR marketplace is becoming highly segmented because of the availability and benefits associated with a diverse set of components. This includes:

- Amplifiers
- Filters
- Mixers
- Analog-to-digital converters/ Digital-to-analog converters (ADC/DAC)
- FPGAs

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DEFINITIONS

Electronic Warfare (EW): The military use of electronics to prevent or reduce an enemy's effective use, and to protect friendly use of electromagnetic radiation equipment.

Communication (COMMs): Military communications involve all aspects of communications, or conveyance of information, by armed forces.

Signals Intelligence (SIGNINT): Information gathered by the collection and analysis of the electronic signals and communications of a given target.

RF front end: In a radio receiver circuit, the RF front end is a generic term for all the circuitry between the antenna up to the analog to digital converter (reverse for transmit).

Digital Signal Processing (DSP): The numerical manipulation of signals, usually with the intention to measure, filter, produce, or compress continuous analog signals.

Field Programmable Gate Array (FPGA): An integrated circuit designed to be configured to desired application or functionality requirements after manufacturing.

Firmware: Software that has been written to the read-only memory (ROM) of a computing device. Firmware, which is added at the time of manufacturing, is used to run user programs on the device.

Cognitive Radio (CR): An adaptive, intelligent radio and network technology that can automatically detect available channels in a wireless spectrum and change transmission parameters enabling more communications to run concurrently and also improve radio operating behavior.

Cognitive Networks (CN): A new type of data network that makes use of cutting-edge technology from several research areas (i.e., machine learning, knowledge representation, computer network, network management) to solve some problems current networks are faced with.

industry. So it is expected that the focus of the industry will keep shifting to develop less resource-intensive middleware and framework to get the most of SDR devices.

Mobile operators are currently setting up heterogeneous networks to increase network capacity and coverage. In order to attain improved spectral efficiency, reconfigurable technologies such as SDR, Cognitive Radio (CR), and Cognitive Networks (CN) have been tested.

Communication today has risen from just voice to all types of data. This has created a massive strain on the network infrastructure, as voice is very compressible but other forms of data are not. As a result, providers have been working to make considerable enhancements to wireless access techniques. Some of these efforts have included investigation into the use of 5G technology along with new spectrum management techniques. SDR becomes an important aspect in this investigation as it offers the flexibility to support both 4G and 5G without the need to change hardware. It can also be used to survey the available spectrum to help determine other approaches related towards spectrum management.

The current focus is rapidly shifting to how one successfully applies SDR spectral efficiency technologies on new network architecture. Further research is being conducted to investigate how to achieve seamless migration from 4G to 5G wireless communication.

The Per Vices Crimson SDR has 4 independent receive chains and 4 independent transmit chains, each capable of as much as 322 MHz of RF bandwidth up to 6 GHz.

Some of the questions that must be answered in the wireless communication world include:

- What are the SDR and CR technologies that are needed for 5G?
- What are the standardization practices for reconfigurable SDR for 5G?
- What are the SDR and CR technologies required for radio access technologies in 5G?
- How does spectral and energy efficiency work for 5G with SDR and CR?
- What are the suitable multiple access technologies for 5G with SDR and CR?
- What are the new characteristics of reconfigurable SDR for 5G?
- What is the suitable protocol design of cognitive networks for 5G?

There are opportunities now to develop new features and applications using infrastructure that is already available. However, there is still a learning curve that will require time to attain seamless integration.

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