Software Defined-Radio Emerging Technology for Next Generation Wireless Communication Systems

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1. EVOLUTION OF WIRELESS COMMUNICATION SYSTEMS

Mobile communication technology has grown rapidly in a relatively short period of last 25 years. Analog wireless communication systems were replaced by digital ones, voice services are complemented with data services, supported data transfer speeds have increased by more than a thousand-fold and many other remarkable achievements have taken place in a relatively short period.

First generation (1-G) mobile communication systems of 1980s such as (AMPS) (advanced mobile phone system) were analog systems with voice only capability. Second-generation (2-G) systems of 1990s such as GSM and IS-95 were digital systems which provided digital voice text messaging services with data rates 9.6-14.4 Kbps. Further, 2.5-G systems such as GPRS provided services like voice, SMS and MMS with data rates 56-114 Kbps. 2.75-G systems, such as EDGE further enhanced the data rates up to 384 Kbps. Third-generation (3-G) systems such as CDMA-2000 and UMTS provided services like video calls and broadband wireless data with data rate support up to 14.4 Mbps. Fourth generation (4-G) systems have promised to provide a comprehensive IP solution where voice, data, and streamed multimedia can be given to users on an “Anytime, Anywhere” basis, and at higher data rates, of the order of 100 Mbps-1Gbps.

2. USER NEEDS AND TRENDS

Until now, wireless communication systems were developed around a given technology and then appropriate services were developed for these systems. With this bottom-up approach, 2-G systems provided basic services of voice text messaging and level of user expectation was fulfilled. In 3-G, gap between services and user expectations was difficult to close since user ware exposed to sophisticate services through wired high-speed internet connections. In 4-G systems, development focus is on top-down approach, where technology follows services applications to meet user expectations.

3. NEED OF SOFTWARE-DEFINED RADIO

As 2-G was a total replacement of the 1-G networks and handsets; and 3-G was a total replacement of 2-G networks and handsets; so 4-G cannot be an incremental evolution of current 3-G technologies, but rather the total replacement of the 3-G networks and handsets. So, as one moves from 1-G to another one needs to replace existing networks and terminals as per the requirement of new generation standards. Another problem is coexistence of several air interfaces such as GSM, CDMA, Japanese PDC, IMT-2000 etc. Currently, if one wants to be globally connected, more than one terminal may be needed. One needs to have equipment universally usable.

‘Software-defined radio’ (SDR) is a flexible platform which can cope with the continuously evolving wireless standards and meet the broad range of user requirements. SDR provides features of re-configurability, upgradeability, portability, interoperability and universality to meet the above requirements. It is a radio whose personality can be changed by software.

SDR will allow mobile terminal manufacturers to design and manufacture products that are independent of any particular specifications or standard and can be configured to support any air interface by porting appropriate waveform software. Thus, SDR can replace many radios with one radio providing Following advantages –

- Upgradeable terminals
- New services added without having to change the terminal
- Bugs fixed without the need to recall the product
- Versatile software
- Reduced variety of hardware, since several standards can be implemented in a single terminal

SDR technology and open standards promise to do for the wireless communication industry what the PC and object-oriented software and operating systems have done for the computer industry.
4. WHAT SOFTWARE IS A DEFINED RADIO?

According to SDR forum, software-defined radio is used to describe radios that provide software control of a variety of modulation techniques, wide band or narrow-band operations, communications security functions, and waveform requirements of current and evolving standards over a broad frequency range.

SDR is different from conventional radios in many ways such as conventional radios support a fixed number of waveforms while SDR can dynamically supports multiple waveforms. Conventional Radios have traditional RF and base-band design while SDR have reconfigurable hardware architecture and are based on software architecture. Conventional radios are not upgradeable while SDR can be made future proof with provisions for easy upgrades.

In SDR, software replaces hardware as much as possible, this reduces costs and increases versatility. SDR represents a major challenge in the design paradigm for radios in which a large portion of the functionality is implemented through programmable signal processing devices, giving the radio ability to change its operating parameters to accommodate new features and capabilities.

SDR uses a base architecture with core set of modular hardware and software components. The hardware is required to be modular and to have sufficient processing resources and RF front-end capability to support intended waveform characteristics. To achieve the required flexibility, the boundary of digital processing is moved as close as possible to antenna and ASICs are replaced with programmable implementations.

The processing elements used in SDR for signal processing and protocol processing consist of general purpose processors (GPPs), digital signal processors (DSPs) and field programmable gate arrays (FPGAs). FPGA performs high speed DSP and control processing while DSP performs symbol rate or slower algorithms. FEC functions can be done in either DSP with dedicated hardware (less flexible) or within an FPGA, or a combination of both. GPP is used to implement control functionality, user interface and overall waveform management.

The SDR requires modular and high level design of embedded software to ensure portability across various hardware platforms. The software architecture in an SDR provides placement of waveforms/applications onto the SDR platform in a standard way. It describes system as collection of elements / objects, defines interfaces between elements and allows elements to communicate.

One such software architecture for SDR is (SCA) Software Communication Architecture. SCA has been specially designed to assist development of SDR. It is an open, non-proprietary specification i.e. it is a set of rules that constrain the design of Software Defined Radios. It is one of the elements of the SDR that will increase interoperability of radios i.e. the ability of radios to talk to each other. Use of SCA in SDR will ensure waveform portability, components reusability and upgradeability in terms of easy insertion of new technology. SCA accomplishes its goal by defining set of interfaces that isolates software application (waveform) from hardware and additionally providing common software infrastructure.