A review paper on Software Defined Radio

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***Abstract*—-In this paper, we summarize a flexible software defined Radio. Software Defined Radio is the reconfigurable Radio. The term reconfigure is nothing but use of the same hardware for different function for different time. The Software Defined Radio is the radio whose physical layer is significantly defined in software. The Hardware Defined Radios are fixed mode radios which consist of active filters, oscillators, mixer, and amplifiers. The Hardware Radio cannot be reconfigured easily at significant capacity (FM radio). In short SDR is the shift from the fixed mode Hardware Radios towards the Flexible, low cost Software Defined Radios.**

***Index Terms*— Trans- receiver, SDR layer, Adaptive modulation**

I. INTRODUCTION

A radio communication system yields a communication by radio. Various types of the radio communication are deployed depend on technology, regulations, service positing, radio spectrum allocation. Communication system involve a radio equipment's like transmitter with an antenna, as well as receiver with an antenna, terminal equipment such as microphone at the transmitter and the loudspeaker at the receiver in the case of voice communication system. An ancient radio communication system were using a frequency division multiplexing (FDM) to split and share available RF band width; now a days modern radio communication system uses time division multiplexing (TDM) and code division multiplexing (CDM) as alterative to the ancient FDM strategy. Moreover, there was a need to develop a radio which can tune any frequency spectrum by means of programmable hardware.

The term SDR was first defined by the Dr. Joseph Mitola in 1990s to refer a Radio that can be reconfigured and reprogrammed easily via software [1].The goal to design SDR was to get more quickly a reconfigurable and reprogrammable radio. SDR is flexible enough to avoid the limited spectrum. Flexible SDR can tune any frequency band and receive any modulation across a large frequency spectrum by means of programmable hardware [2]. Also, SDR gives a better platform to an intelligent Cognitive Radio (CR) which demands a high programmability and controllability for radio transmission and reception. Many an organization has defined the SDR by different way. Federal Communication Commission define SDR as a "generation of radio equipment that can be programmed quickly to transmit and receive on any frequency within a wide range of frequencies, using virtually any transmission format and any set of standards". The International Telecommunication Unit has proposed a definition of SDR as a "radio in which the operating parameters including frequency range, modulation type and/or output power limitations can be set or altered by software". The SDR Forum offers a broader definition: "SDR is a collection of hardware and software technologies that enable reconfigurable systems architectures for wireless networks and user terminals".

SDRs have been found lots of uses in industries, government, and military application. Software Radio is used for testing and evolution of multi-hop as well as mobile multimedia broadcast transmission, wireless network experimentation, and cross layer prototyping in communication laboratory.

II. TYPICAL MODEL OF SDR

Software Defined Radio (SDR) is an opening architecture based on the modern communication theory and digital signal processing, which consist of antenna, RF front end, Processor. Typical model of SDR as showed in Fig.1,

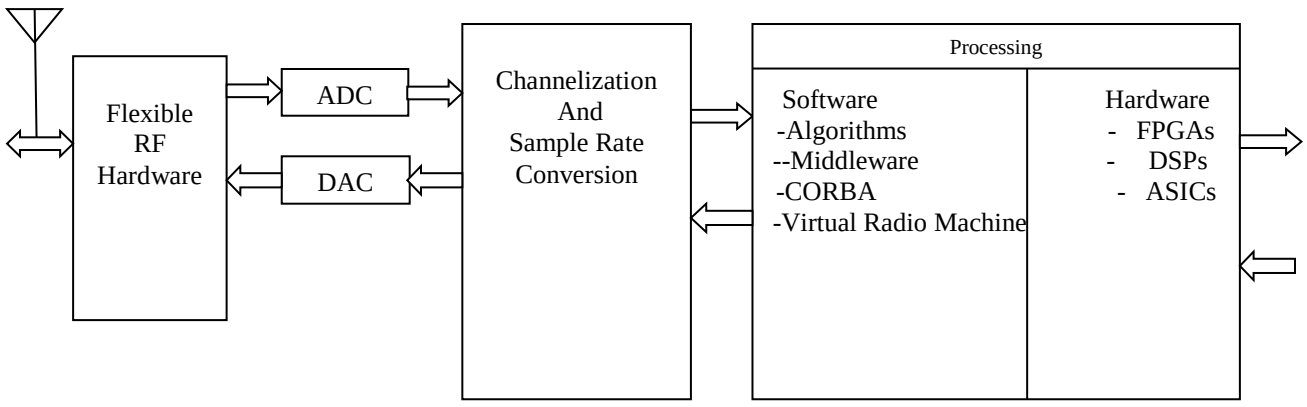

Figure 1 Typical model of Software Defined Multimode Radio [3].

As shown in the above Figure1 the trans receiver consists of smart RF antenna. The RF antenna provides a gain versus direction characteristic to minimize the interference, multipath and noise. The RF antenna gives similar benefits to the transmitter as well as receiver. At the receiver chain, most software radios digitizes signal as early as possible and convert to analog domain as late as possible using digital to analog converter (DAC). The received signal is digitized to the Intermediate frequency (IF) band. This IF is mixed exactly to the baseband. At the transmitter side, RF antenna catches analog signal and converts it to digital domain in the IF range using analog to digital converter (ADC) which eliminates the last stage in conventional model in which problem like carrier offset and imaging are encountered. To interface the output of ADC to the processing hardware digital filtering (channelization) and sample rate conversions are needed. Processing is performed in software using DSPs, field programmable gate arrays (FPGAs), or application specific integrated circuits (ASICs). The algorithm used to modulate and demodulate the signal may use variety of software methodologies, such as middleware, common object request broker architecture (CORBA), or virtual radio machines.

III. RECEIVER RF FRONT END

In SDR it is very difficult to create a Radio Frequency (RF) front end that is applicable to variety of signals with different parameters such as Bandwidth, and center frequency. A receiver consists of an Antenna, Filter, and ADC. The main purpose of the receiver is to isolate the desired signal from interference and noise for demodulation and further processing. It catches signal from an antenna filter it to remove an undesired signal and then convert the signal to the center frequency with amplitude compatible with the analog to digital conversion process. This process is depicted in Fig. 2.

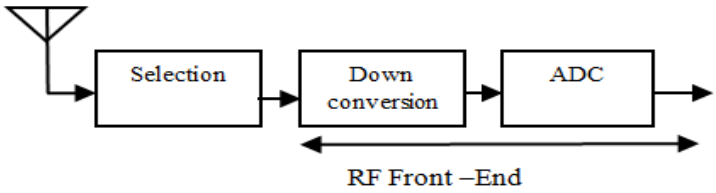

Figure 2 Processing Steps in the Receiver RF Front –End [3].

The objectives are summarized in the following list.

- Deny as many undesired signals as possible
- Convert the desired signal center frequency to a range compatible with the ADC with minimal distortion.
- Amplify the desired signal to the level required by ADC.
- Minimize Additive noise.
- Achieve a compatible range that is compatible with that of the ADC.

IV. TRANSMITTER RF FRONT END

The different processing steps in Transmitter RF front end are as shown in Fig. 3,

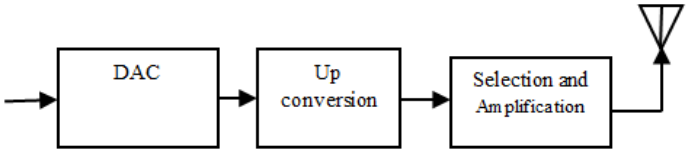

Figure 3 Processing steps in Transmitter RF Front – End [3].

Transmitter Section consists of an Antenna, amplifier and DAC. The purpose of the transmitter RF section is to convert the digital representation of the analog signal into radiated analog signal .This process at the transmitter end is nearly reverse that of receiver. The DAC is used to convert digital to analog signal. The converted analog signal is up- converted to the desired RF center frequency. The signal is further amplified to the appropriate power level, and limiting the signal's bandwidth before it is radiated. In practice, multiple stages of conversion and amplification may occur before the signal is radiated.

V. DIGITAL HARDWARE

To design the digital hardware composition of a software radio is key design step in its creation. Basically, four Conflicting issues define the digital hardware composition: Flexibility, modularity, scalability, performance.

- Modularity of radio subsystem allows easy replacement or upgrading of subsystem to take advantage of new technology.
- Flexibility is the ability to handle a variety of air interfaces and protocols, even if they have yet to be defined. This means that the software radio must handle different data rates, which implies that the overall system clock rate must be adjustable.

- Scalability allows the radio to be enhanced to improve capability such as increasing number of channels that a base station could handle.
- Performance may be quantified by a power consumption, relative cost, and computational capability metrics.

Three main issues of foundational digital hardware are available: ASICs, FPGA, and DSPs. Each has a certain level of reprogram ability, that is, an ability to use device hardware or software for different function at different time. DSPs uses a microprocessor – based architectures and support programming in high level languages like C, both of which offer the most flexibility. FPGAs provide much hardware level reconfigure ability, allowing much more flexibility than an ASIC but less Flexibility than DSP [4].

VI. SDR LAYER

A. Intercorrelation of SDR, SDN layer

With the increasing demand of software implementation, it can be said that future network would be programmable network where programmable devices run application- and/or service-specific code. Programmable networks will have configurable data and control-planes, thanks to SDR, SDN and virtualization. The current programmable network and OSI model is as shown below in Fig. 4,

Figure 4 Current programmable network paradigm and the OSI model [5].

SDR and programmable data planes typically act on the physical and data link layers; software-defined networking (SDN) at the upper layers; and virtualization on multiple layers. This work gives this innovative perspective of programmable networks. Since the literature focuses on a single isolated technique (SDN, SDR, virtualization), we advocate convergence of those technologies, since they can work simultaneously and thus complement each other in order to support new applications and network services. We endorse convergence of these technologies can expand the amount of programmability on the network and support different innovative applications.

B. Typical radio layer with multimode radio

The layers of typical radio are as shown in Fig. 5.

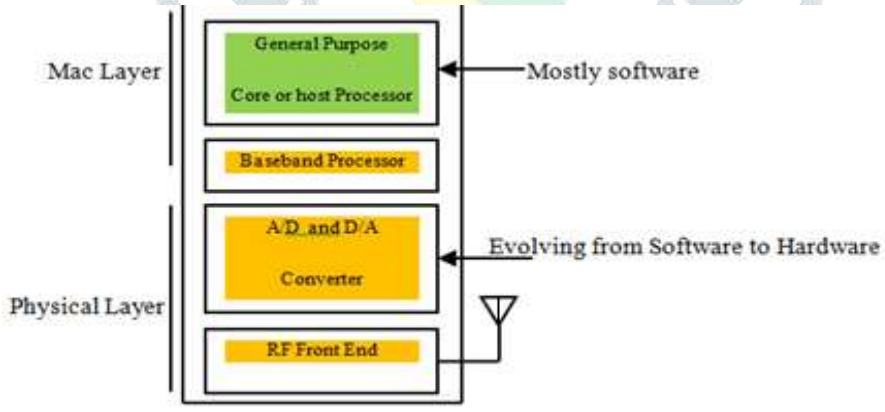

Figure 5 Typical Radio with MMR capabilities.

The typical radio has basic two layers as physical layer and Message Authentication Code layer (MAC). MAC layer is totally software based. It has general purpose processor or host processor. The original signal is controlled and set up through MAC layer. The user can handle or use the signal through this MAC layer. Next is the Physical layer, it works from modulation to transmission. It has baseband processor, Analog to Digital converter (ADC) and Digital to Analog converter (DAC) with Radio Frequency antenna. When the signal comes through the MAC layer to baseband processor, The baseband processor decides modulation scheme and modulates the signal at this baseband layer .The modulated signal has been converted from analog to digital signal with the help of ADC at the transmitter end. This digitized signal is then transmitted through the RF antenna. Nearly reverse action takes place during reception of signal. RF antenna receives the signal, then DAC converts digital signal to analog signal. At baseband processor demodulates and finally MAC provides signal to user.

VII. SOFTWARE DEFINED RADIO WITH ADAPTIVE MODULATION

Determining the appropriate radio parameters such as bit error rate, signal to noise ratio, latency, and symbol bit rate and given a dynamic wireless channel environment is the primary feature of software radios for wireless communication systems. However, the existing SDR technology does not satisfies the seamless mode switching according to channel noise. The novel idea is the mode switching software defined radio or radio with adaptive modulation. The concept of adaptive modulation is depicted in Fig. 6.

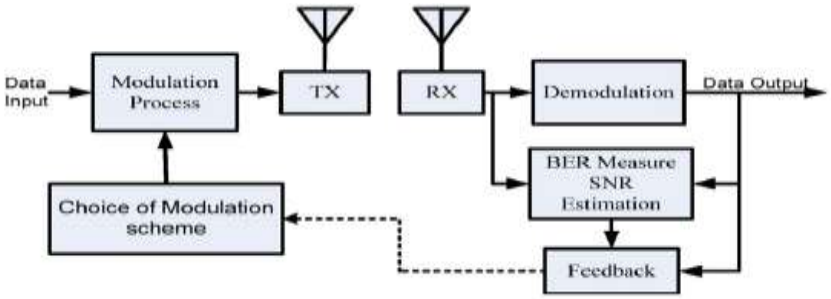

Figure 6 SDR with adaptive modulation [6].

The receiver terminal senses noise in radio channel and passes channel-state information back to the transmitter. The transmitter decides an appropriate modulation technique for the transmitting signal to minimize the transmission error in real time. If channel noise identifies it sends pilot information to the beginning of a data frame to inform the receiver for the modulation scheme being used. The receiver has a reconfigurable demodulator. A reconfigurable demodulator selects the demodulator indicated by the pilot and recovers the signal. This adaptive procedure maintains the bit error ratio (BER) below a certain threshold to ensure the quality of service [6]. In this process eliminating the pilot which contains no message is popular research topic recently. This requires the recognition of unknown modulation scheme from a noisy signal automatically in very short interval of the time. The SDR with reconfigurable demodulator is depicted in Fig.7.

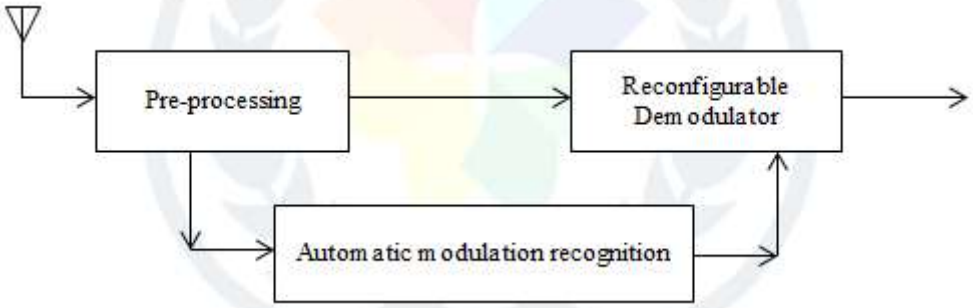

Figure 7 SDR with Reconfigurable Demodulator.

According to the channel condition modulation scheme is selected which is unknown to the receiver side and a frame of the symbol is transmitted through RF antenna. If it is noisy channel, it needs to recognize and to change the modulation scheme. Once a modulator scheme is recognized software configured demodulator is instructed to change the demodulation scheme accordingly. If Modulation Recognition processing is sufficiently fast, the software-configured demodulator can adapt itself to the scheme change and demodulate the continuous data frames in real time with no packet loss.

VIII. CONCLUSION

The analysis of several papers has reached to the conclusion that software radio is the step towards the fixed mode Radio. The complexity of the design in the hardware radios is eliminated in SDR. We can say that, SDRs are more flexible than the HDRs. The adaptive modulation in the SDR is the solution to the fixed mode radios. By sensing the channel condition we can switch the modulation technique according to the channel noise. However latency of the MMR may be increase as compared to the fixed mode HDRs.

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