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Signal Processing for an SDR Based Wireless Communication Gateway

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Abstract*—The conventional ways for implementing the wireless standards are dependent on their dedicated hardware chips, and thus in order to add a new standard or change an obsolete standard, a new dedicated hardware chip should be installed. This hardware dependency incurs extra costs to customers to deploy and maintain wireless services. Software defined radio (SDR) technology enables software components running on a generic hardware platform to perform signal processing instead of hardware chips. Thus, it is possible to support multi-standard, multi-band and multi-mode solutions and easy to enhance and reconfigure wireless communication. It reduces the hardware dependency and this approach allows the integration of multiple wireless devices into a single generic wireless gateway device and improves flexibility, adaptability, and connectivity of wireless vehicular communications. In terms of the communication requirements posed by the military, civil, and commercial applications, SDR offers inexpensive and efficient solutions to the constraints and economic viability present in current hardware-based systems. Here the implementation is to be done in Simulink and the entire results show the efficient transmission of an image signal.

***Index Terms*— Software Defined Radio(SDR), Wireless Communication Gateway, Run Time Performance.**

1.INTRODUCTION

ASoftware-Defined Radio (SDR) is a radio that ware provides software control of a variety of modulation and demodulation techniques, wide-band or narrow band operation, communications security functions (such as hopping), and waveform requirements of current and evolving standards over a broad frequency range. SDR technology facilitates the software development of the radio system functional modules, such as modulation/demodulation, signal generation, coding, and link-layer protocols. SDR technology can be used to implement military, commercial, and civilian radio applications. Designers can implement a wide variety of radio applications using SDR technology, such as Bluetooth, WLAN, GPS, radar, wideband code division multiple access (W-CDMA), general packet radio services (GPRS), etc. SDR has generated tremendous interest in the wireless communications industry because of the wide-ranging economic and deployment benefits it offers. This implementation helps designers to build reconfigurable software radio systems in which parameters are selected to dynamically. This hardware dependency incurs extra costs to customers to maintain wireless services in vehicles. To alleviate this problem, this paper proposes a wireless communication gateway, which is called as the Signal processing for an Software-Defined Radio (SDR)-based Wireless Communication Gateway (SWICOM). It exploits the SDR technology[1] that uses software running on a generic hardware platform to perform signal processing instead of dedicated hardware.SDR devices can be controlled using dynamic software programming[4] and thus can easily be reconfigured and updated. Using the dynamic reconfigurability capacity of SDR, the SWICOM can provide an effective means to reduce the maintenance costs associated with multiple wireless devices and can improve flexibility, adaptability, and connectivity of wireless vehicular communications.Software radio is being facilitated by the evolution and convergence of several different technologies. Extensive development of A/D capability in recent years by the semiconductor industry has been stimulated by the prospects of digital wireless applications. This has resulted in improvements in accuracy, linearity, sampling rates, and resolution; however, the trade-off between ND performance and sampling rate continues to be a limitation. While the use of multiple A/D channels may be a short-term solution, power consumption limits this approach to base station products.

The rest of the paper is organized as follows. Section 2 describes the operation of SDR with performance parameters and design considerations. Section 3 explains the results and discussions of this approach. Conclusions are presented in Section 4.

2.SDR BASED WIRELESS COMMUNICATION

2.1. SDR and its Operation

Signal processing components, such as modulators, demodulators, and filters, are typically implemented in dedicated hardware chips. Those hardware chips are customized for a particular and static use rather than intended for general-purpose use. This resulted in minimal flexibility in supporting wireless communications. However, SDR delegates much of its signal processing to software components (i.e., waveform software) running on a generic hardware platform that is equipped with one or more programmable processors, such as general-purpose processors (GPPs), DSPs, or field-programmable gate arrays (FPGAs).

SDR devices can be controlled through dynamic programming of its waveform software and can be reconfigured and updated to improve its features, such as performance, and services. The ultimate goal in radio receiver design is to implement all receiver functions in software.

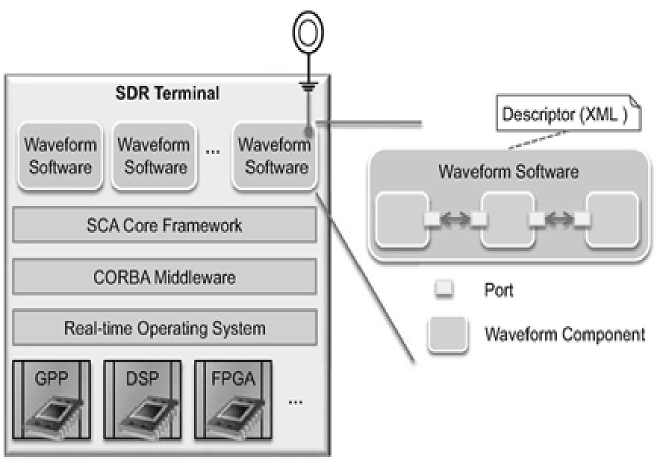

Fig.1 An SDR Terminal

A waveform software instance consists of one or more waveform components that perform signal processing tasks. Port interfaces are dynamically connected with the waveform components to pass data or send control information. Thus, the waveform software forms a series of signal processing tasks so that wireless communication protocols can be implemented on a generic software platform.

2.2. SDR Block Diagram

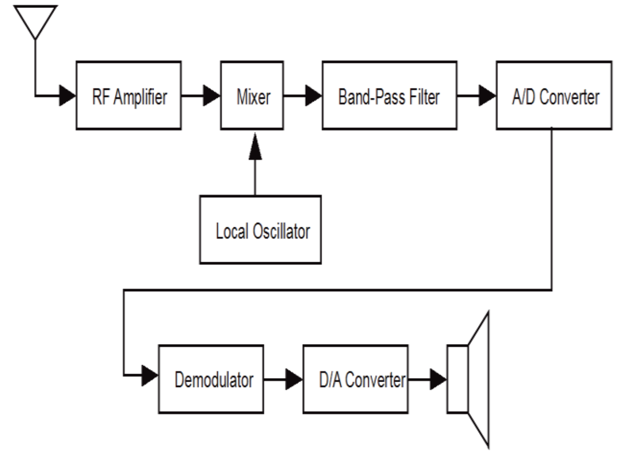

Fig.2 Block Diagram of an SDR

The SDR implementation involves frequency translation, analog-to-digital (A/D) conversion, and message recovery. In the frequency translation phase, the received signal frequency is translated to the intermediate frequency (IF) of 455 KHz. This part consists of an antenna, a radio frequency (RF) amplifier, a mixer, a local oscillator, a band-pass filter, and an A/D converter. We used the MATLAB and Simulink software to implement the blocks and obtain AM signal sample values. The demodulator circuit is based on a special sampling theorem, which makes using a mixer unnecessary. This signal then produces a demodulated output. The signal may be an image, or any multimedia type of signal.Here the proposed method is implemented in software with controlled parameters. The software used to implement the SDR is the Simulink and the parameters that control the SDR is tuned up in the MATLAB. That is the modulation techniques and other blocks are implemented in the Simulink and the control radio parameters are defined in a MATLAB file which controls the SDR Simulink file.

2.3. Modulation Used

The OFDM type of modulation has low sensitivity to time synchronization errors and high spectral efficiency as compared to conventional modulation schemes, spread spectrum, etc. The OFDM demodulator primarily performs an inverse discrete Fourier transform to construct 1000 subchannels. Unlike the WFM receiver, the OFDM receiver produces no application-level data but continues to demodulate the received signals into the bit stream, which can be referred to as a physical layer of the Open System

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Interconnection reference model. Hence, the OFDM type of transmitter and receiver can be considered as a simplified digital communication system without additional operations, such as cyclic prefix deletion and time and frequency synchronization.Orthogonal frequency-division multiplexing (OFDM), essentially identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT), a frequency -division multiplexing (FDM) scheme utilized as a digital multi- carrier modulation method. A large number of closely -spaced orthogonal sub- carriers are used to carry data. The data is divided into several parallel data streams or channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

2.3.1. Operation Execution Time

The data transfer rate and the packet delays in the data sessions were measured between the SWICOM[1] and the application host. For measurement, a simple test waveform was made using a file reader and a stream binder. It continues to read sample data from the specified file and send the data through data sessions. To measure the maximum possible throughput of the data sessions, it was conducted while the data packets were transferred as fast as possible without being affected by the signal processing overhead. These results demonstrate that signal processing on the SWICOM, if efficient signal processing algorithms are used and real-time scheduling is supported, can meet the time constraints required by many wireless communication protocols. Each procedure consists of several of the aforementioned primitive operations. The average execution times of the individual operations are presented with their 95% confidence intervals. The figure indicates that it takes most of the execution time for each procedure to perform the I/O operations associated with it.

The demodulation schemes take longer than their corresponding modulation schemes. This is because modulation schemes can efficiently be implemented by table mapping from bits to symbols, whereas demodulation schemes require several arithmetic operations. This is also true for the channel-coding schemes. Nevertheless, the processing delay for one block is far less than 700μs.

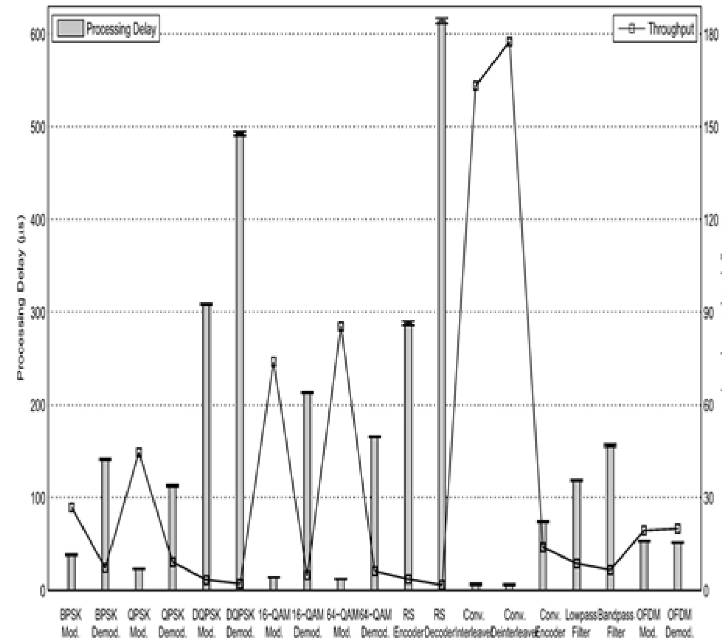

Fig.3 Run-time performance of signal processing

2.4. SDR Design Considerations

A good definition of software radio is difficult to generate. This is largely due to the flexibility that software-defined radios offer, allowing them to take on many different forms that can be changed to suit the need at hand. However, software-defined radios, or SDRs, do have characteristics[5] that make them unique in comparison to other types of radios. As the name implies, an SDR is a radio that has the ability to be transformed through the use of software or redefinable logic. Quite often this is done with general-purpose digital signal processors (DSPs) or field programmable gate arrays (FPGAs), as discussed later in the chapter.In order to take advantage of such digital processing, traditional analog signals must be converted to and from the digital domain. This is accomplished using analog-to-digital (ADC) and digital-to-analog (DAC) converters. To take full advantage of digital processing, SDRs keep the signal in the digital domain for as much of the signal chain as possible, digitizing and reconstructing as close to the antenna as possible, which allows digital techniques to perform functions traditionally done by analog components as well as others not possible in the analog domain. There are limits to this, however. A fundamental challenge with SDR is how to achieve sufficient computational capacity, in particular for processing wide-band high bit rate waveforms, within acceptable size and weight factors, within acceptable unit costs, and with acceptable

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power consumption.The evolution towards SDR systems has been driven in part by the evolution of the enabling technologies, first and foremost the D/A and A/D converters and the Digital Signal Processors (DSPs), but also that of the General Purpose Processors (GPPs) and the Field Programmable Gate Arrays (FPGAs). A fundamental challenge of SDR is to provide an ideal platform to application separation, such that waveform applications can be moved from one SDR platform to be rebuilt on another one without having to change or rewrite the application. Such waveform portability is highly desirable, particularly in the military sector, for example in order to achieve interoperability in coalitions by exchanging waveforms.

TABLE I

COMPUTATIONAL COMPLEXITY FOR SOME KEY ALGORITHM

Signal processing operation At 24 mbps	Gigacycles per second
FFT	15.6
FIR	6.08
Viterbi decoder	35.0

3.RESULTS AND DISCUSSIONS

The Symbol error rate and the Gain of the Modulated signal can be calculated in the Simulink and it is displayed in the diagram itself, upon execution of the process.

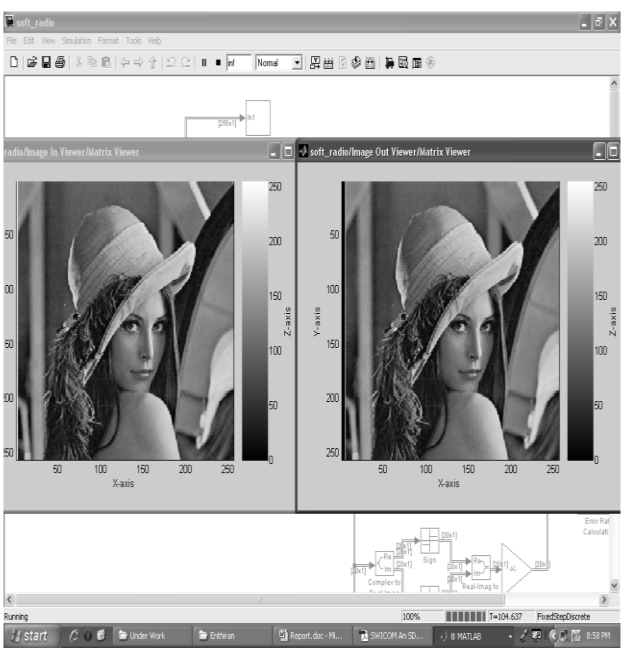

Fig.4 Simulation output (fully transmitted image)

In the above figure we can observe the fully (100%) transmitted and received image that the transmitted image (in the window-Image In Viewer) is exactly received at the other end (in the window-Image Out Viewer), which clearly results in an effective transmission. The main advantage is the combination of MATLAB and Simulink is possible and thus the radio parameters that control the process can be given in the MATLAB. Process can be reconfigured, updated, and also can control the simulation manually.

TABLE 2

VALUES GIVES AS INPUT

PARAMETERS	VALUES GIVEN
Symbol Rate	2.5Msymbol/Second
Interpolation Factor	16
Channel Model	AWGN
Receiver Sampling Rate	40 MHz
IF	70 MHz
Modulation Type	OFDM
FFT Size	64

4.CONCLUSION

This approach allows the integration of multiple wireless devices into a single generic wireless gateway device and improves flexibility, adaptability, and connectivity of wireless vehicular communications. To verify its viability, a prototype implementation was built, and measurements to quantify its run-time performance were obtained. The results clearly indicate that the method is efficient and suitable for practical application in the control of software-implemented wireless devices.Also from our simulation results it can be infer that the OFDM type of modulation gives better results when compared to higher order fixed modulation scheme. Its role in robust image transmission for multimedia application had also been verified. Hence it can be stated that image can be efficiently sent using OFDM modem for HDR (high data-rate) service.A fundamental challenge with SDR is how to achieve sufficient computational capacity, in particular for processing wide-band high bit rate waveforms, within acceptable size and weight factors, within acceptable unit costs, and with acceptable power consumption.SDR will have continued focus as a highly flexible platform to meet the

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demands from military organizations facing the requirements from network centric and coalitional operations. SDR will also have continued focus as a convenient platform for future cognitive radio networks, enabling more information capacity for a given amount of spectrum and have the ability to adapt on-demand to waveform standards.

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