DEVELOPMENT OF WAVEFORM COMPONENT FOR SDR SYSTEM SUPPORTING MOBILE WIMAX

Mijin Baek (Division of Electrical and Computer Engineering, Hanyang University, Seoul, Korea; back0622@dsplab.hanyang.ac.kr); Seungheon Hyeon (Division of Electrical and Computer Engineering, Hanyang University, Seoul, Korea; hsheon@dsplab.hanyang.ac.kr); and Seungwon Choi (Division of Electrical and Computer Engineering, Hanyang University, Seoul, Korea; choi@dsplab.hanyang.ac.kr)

ABSTRACT

In this paper, we develop waveform components for software defined radio (SDR) based mobile WiMAX. Waveform components are developed in accordance with the "PIM and PSM for Software Radio components" specification that is promoted by Object Management Group (OMG). This specification defines standard components and application programming interfaces (API) for developing waveform components. A developing procedure of the waveform component is focused on composability and substitutability of components. Even though developed waveform components are to Mobile WiMAX, the proposed procedure can be adopted to any waveform.

1. INTRODUCTION

The market of mobile communication has grown quickly so far. Thus it is important that new technologies and services need to be provided at the right time. If the existing system can be upgraded only by installing software without changing hardware devices, it will efficient and cost-effective. Thus, a SDR technology is a keen interest in the 4G mobile communication. In the SDR system, it is possible to apply the multi-bode and multi-band technologies by adding a software module to the hardware platform [1].

There are various methods to develop the system based on SDR. In this paper, the method for modularizing the function of the communication waveform block is used. . If the component is divided with criterion of the function of waveform, If the component is divided into blocks with criterion of the function of waveform, each block can be shared in the system That is to say, if specified components for a new waveform are added to the system, the new waveform application is able on the same hardware platform. Thus, a resource efficiency of the system can be guaranteed by increasing the reusability of components and flexibility of waveform.

In this paper, the function block of Mobile WiMAX with the SDR components based on the “PIM and PSM for Software Radio components” specification [2] by OMG [3] is developed. Adding components specified for the Mobile WiMAX enable the Mobile WiMAX waveform to use when the Mobile WiMAX is loaded to the conventional SDR system.

The rest of the paper is organized as follows. In Chapter 2, the purpose of the Mobile WiMAX based on SDR and describe a basic structure of the Mobile WiMAX SDR system based on a Software Communication Architecture (SCA) is explained. In chapter 3, the method of developing the component of the each Mobile WiMAX block based on Software Radio components (SWRadio components) is described. The paper is concluded in Chapter 4.

2. SCA AND SWRADIO COMPONENTS IN THE SDR SYSTEM

In SDR system, the SCA is a software platform which defines a configuration, control and management of the system. It decides a reconfigurability of the system and takes a role of software bus which joined hardware platforms made by heterogeneously distributed systems. Also the SCA involves both the SDR system implementation and the design methodology. Hence the SCA is considered as the standard framework in the development of the SDR system and the standard of the SDR-software platform in fact [5]-[7].

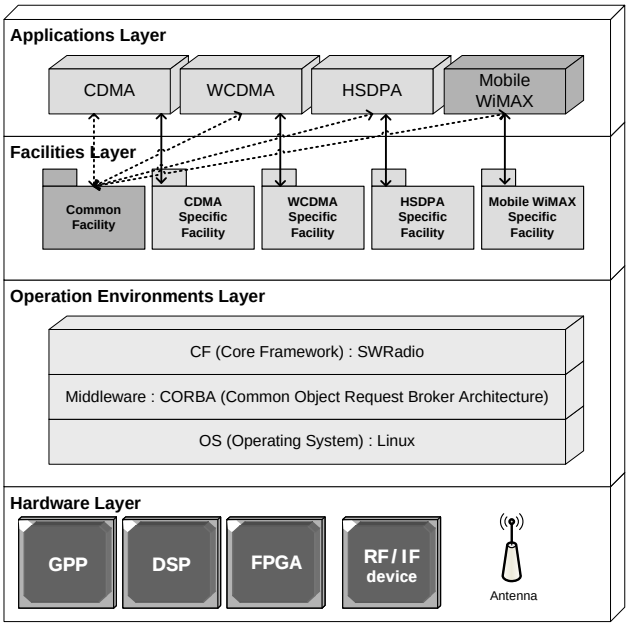

Figure 1 –SDR system based on SWRadio components

The SCA is considered the Operating Environment Layer and the Facility Layer among the four layers composed the Hardware Layer, the Operating Environment Layer, the Facility Layer and the Application Layer in the SDR system. It includes the Application Layer in general. The SCA defines the service and interface which is provided to the Operating Environment (OE) and waveform application and the OE is composed of a Core Framework (CF), a Common Object Request Broker Architecture (CORBA) middleware and operating system.

The CF is a core in the SDR system and it is a framework that is composed of interface and profile providing a deployment, management, interconnection and intercommunication of waveform component in the facility layer. Also it abstracts the hardware and the software platform of SDR system and provides an independent interface to the application platform. Hence the application has portability and compatibility. The CORBA middleware takes charge of interface among components in the heterogeneously opened-SDR hardware platforms. Hereby it is able to do the distributed processing of components existed in different spaces [8]. It is possible for the OS to do real-time scheduling of the system as providing the service and interface defined application environment profile (subset of the POSIX.13 Real-time Controller System Profile).

Figure 1 shows an open-SDR platform proposed by this paper and it is able to load various waveforms. SWRadio components and APIs defined in the "PIM and PSM for Software Radio components" specification by OMG provide a common service to a communication waveform application in the SDR system. If the existing system use the open platform based on the SDR with one waveform in the Application layer, system does not need to consider the other waveforms because it is similar to a commercial system. However, the SDR system will be adapted widely for various waveforms with the single platform in order to satisfy market trend that requires flexible and various waveforms to the system. Consequently, if the SWRadio Facility is configured to the system basically for general communication system and the waveform specific component that is used to the specific application waveform is added to the system, the system can be operated as a multi-mode system loading various waveforms with the single system.

When the waveform application is loaded to the Application Layer, the waveform specific components are loaded to Facility Layer. This system is ensured the interoperability where the SWRadio components and waveform specific components are loaded to the system. In this paper, it is considered that the Mobile WiMAX waveform is loaded to the Application Layer and Mobile WiMAX specific components are additionally loaded to Facility Layer.

Common components in the wireless communication waveform were implemented according to SWRadio components in the system, so that the system does not require same functional components in each part but shares one common component. Thus, we can compose very flexible system and use the memory in the system more efficiently. Besides, reusability of waveform component increases.

3. DEVELOPMENT MOBILE WIMAX COMPONENT

In this paper, we propose the development method of the Mobile WiMAX waveform component based on SWRadio components from functional blocks of Mobile WiMAX. Componentizing the Mobile WiMAX blocks, these components are loaded to the system as software module. Thus, common components such as modulation block can be shared with other waveforms.

Figure 2 is a system block diagram of Mobile WiMAX. The system is made up of the Base station (BS) and the Mobile station (MS) and each block of the MS and the BS has an inverse relationship. Hence the method that is to be developed the Mobile WiMAX waveform component based on SWRadio components, MS blocks-centered is presented in this paper.

SWRadio components in mobile communication system are defined as software module by OMG. SWRadio components do not contain components specified for the Permutation block or the Subcarrier-Emulation-per-Slot block in Mobile WiMAX because SWRadio components are defined only common components among various

waveforms. Thus, these blocks undefined SWRadio components are developed with a discretionary interface.

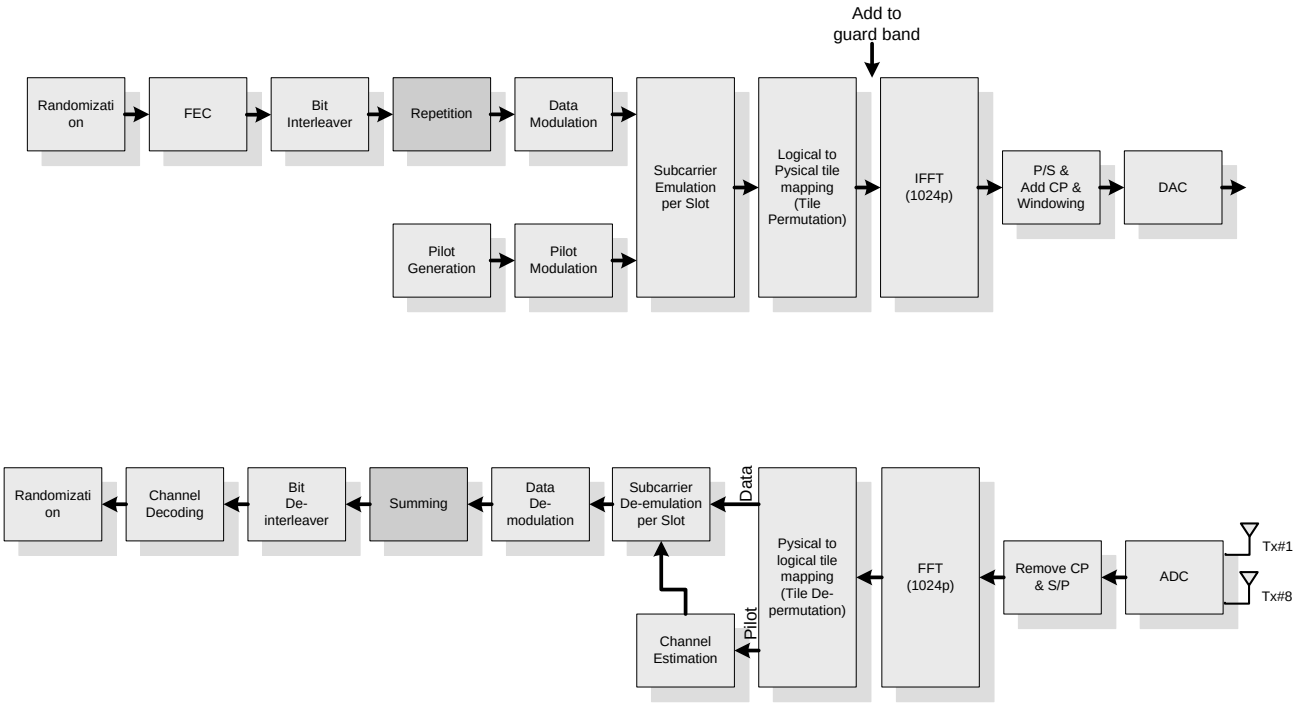

Figure 2 - Block diagram of Mobile WiMAX

Figure 3 shows a Modem component defined in SWRadio components. The components mapped to the Mobile WiMAX block as a specific component are the PNSequenceGenerator component, the ChannelCoding component, the ConvolutionalInterleaver component, the Mapper component, the BlockInterleaver component, the Transform component.

Table 1 - mapping components

SWRadio components	Mobile WiMAX block	Component Type *
PNSequenceGenerator	Randomization, Pilot Generation	C
ChannelCoding	FEC	S
ConvolutionalInterleaver	Bit Interleaver	S
Mapper	Data Modulation	C
BlockInterleaver	Tile Permutation,	S
Transform	IFFT	C
HelicalInterleaver	Not used	C
SourceCoding	Not used	C
-	Subcarrier Allocation, Add CP (defined optional)	S

*** C : Common / S : Specific**

Table 1 describes SWRadio components for in the Mobile WiMAX blocks. Eight components defined Modem components are divided into Common components and waveform Specific components. Waveform specific blocks defined as SWRadio components are used for selecting a component of similar function or defining an interface at disposition.

The process of Waveform blocks mapping to SWRadio components is called an inheritance. When waveform blocks inherit the SWRadio components, it also inherits the attribute and the character of SWRadio components.

The PNSequenceGenerator component among SWRadio components is a component generated PN sequence and can be used scrambler, spreader, and data source depend on the waveform to realize. In this paper, the PNSequenceGenerator component is applied to the Randomization block and the Pilot Generation block.

Randomization block inherited by PNSequenceGenerator component has four attributes. A `chipRate` among these attributes, not used in code but defined when implementing the component, is described as a output rate of PN sequence. The `chiprate` could be different given by the purpose of the implementation. If PNSequenceGenerator component is implemented to the scrambler, the value of the `chipRate` is represented the sum of the data rate and overhead rate. For the purpose of the data source, the `chipRate` describes data rate as

simply. The PNSequenceGenerator component is implemented to the data source. However, this component is tested on the PC-based simulation without the SDR-hardware platform. Therefore `chipRate` is not concerned in this paper.

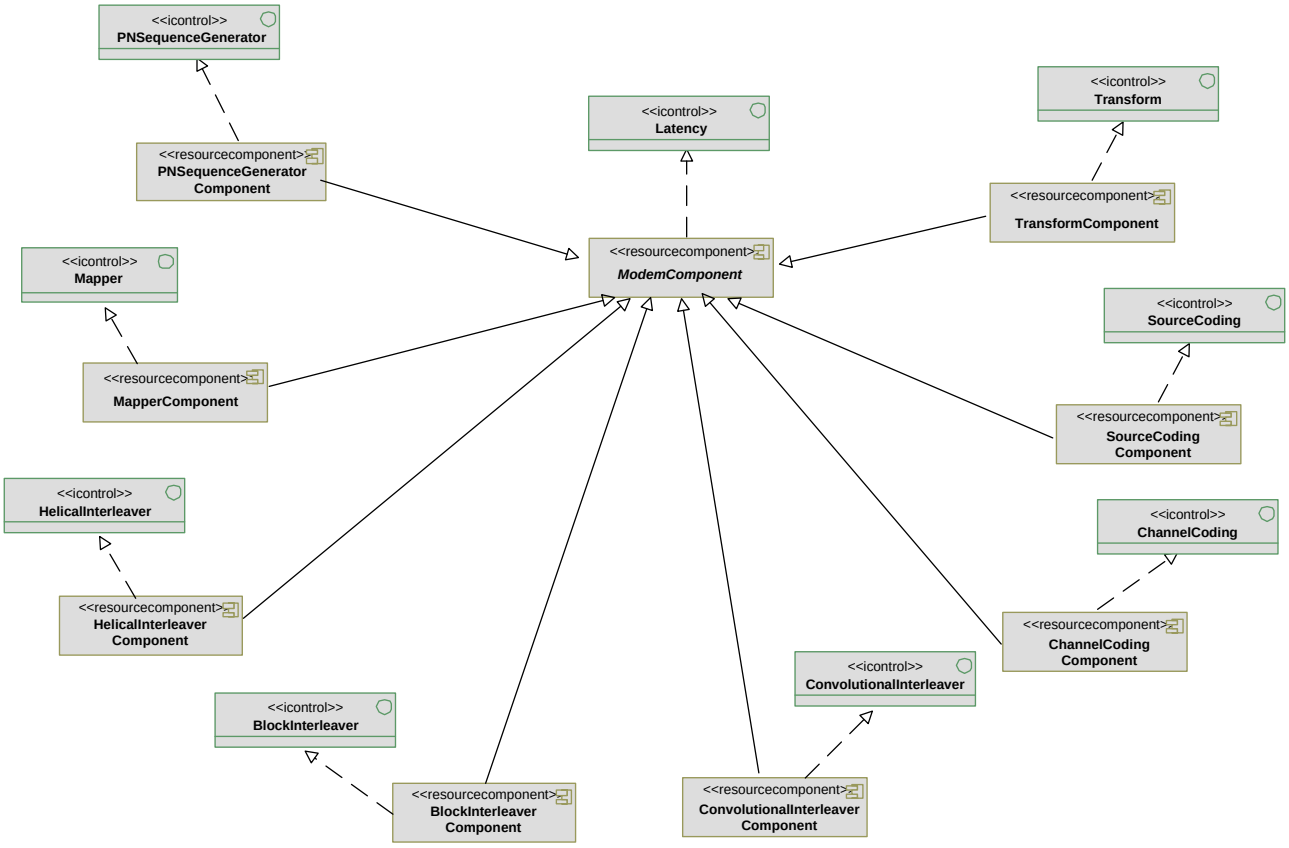

Figure 3 - Modem Facilities Overview

The Pilot Generation component can also use the PNSequenceGenerator component among Mobile WiMAX blocks. This is generated pilot inserted between symbols for effectively channel estimation when data received. The block generates pilot signal between data symbols to estimate channel effectively. It also inherits the attribute of the PNSequenceGenerator in the same with the developed Randomization component. Although there are the Pilot Generation block and the Pilot Modulation block in figure 2, these blocks are implemented to the one component in this paper. In substance, if there is no contents to realize in the component, additional implementation component would be inefficient. For this reason, not only the reusability but performances of system need to be considered when implementing component.

The data stream generated in the Randomization block is encoded in the FEC block. The encoding in used to demodulate protect data sent over it for retrieval even in the presence of noise and interference through channel. In this paper, components are implemented with the Convolutional Coding (CC) and the Convolutional Turbo Coding (CTC) encoding method of Mobile WiMAX specification. Compared to the CC, the CTC shows better performance due to supporting high data rate and it also contains the Interleaver component while the CC needs the Bit Interleaver component. So that additional interleaver component is replaced with the ConvolutionalInterleaver component of SWRadio Components.

The ChannelCoding component of SWRadio components is used in FEC block. It can be used in both encoder and decoder. There is an only one attribute that is `codeRate` from among attributes, because the every encoder and decoder has a different mathematical formula. Thus, attributes are defined by initial values of mathematical formula depends on the encoding.

The data which is encoded into block unit at a CC component is interleaved in a Bit Interleaver component. The encoded data with block unit at the CC component is interleaved in the Bit Interleaver component. Then the

interleaved data undergoes a permutation process through two stages. Mathematical formula of this block is defined in the Mobile WiMAX specification.

Data ended encoding is mapped to the symbol. Mapper component of SWRadio component is used this component. After encoding, the data is mapped to the symbol using the Mapper component of the SWRadio component. The Mapper component can be applied to data modulation block. Then, the Data Modulation component enables the data of bit stream to convert into the symbol. There are QPSK, 16-QAM, 64-QAM modulation methods defined by the Mobile WiMAX specification. Among them, the QPSK modulation is considered in this paper. Modulated data have real and imaginary parts, therefore this component need a port for I/Q data. According to the result, output port of data modulation component is selected as a complexFloat type.

Modulated data is allocated to subcarrier in the Subcarrier-Emulation-per-Slot block. The block is not indicated in SWRadio components specification but defined discretionary as an interface.

The tile Permutation block reduces errors to mix tiles when data is received. There is no certain component in the SWRadio components specification, however, the block is inherited by the BlockInterleaver component where a data is calculated with block unit.

IFFT block inherits a Transform component of SWRadio components. The Transform component can be used as both IFFT and FFT in SWRadio components specification. It is possible because IFFT and FFT code are same. The modulated symbols are organized into a one block of which size is fixed as 1024. Data port uses a realFloat type because input and output of IFFT component operate with a frame unit. a transform among attributes of Transform component decides one thing whether IFFT component is used IFFT block or FFT block in system initialize. The transform is inherited by property of an enumeration type. The IFFT component becomes the FFT with value 1 and IFFT component becomes the IFFT with value 2 defined in xml file.

Once variables that needed to be set are defined at xml files initially, it becomes much easier to change mode in the code and to apply new system. Thus, it does not need to change code because variables are already defined in xml files.

Also the Subcarrier-Emulation-per-Slot block or the Add CP block in communication system based on OFDM is specified for the Mobile WiMAX. These blocks are not enough to be defined with SWRadio components. Thus, waveform specific components need to be standardized in the future.

4. CONCLUSION

In this paper, the method for developing the Mobile WiMAX waveform component, in Figure 2, based on SDR with SWRadio components is proposed.

The development methodology of waveform components introduces the Oriented Object (OO) model in this paper. The proposed method is greatly different from the bottom-up type designed to implement existing hardware. The SDR system supposes to be a top-down process approach whether the OO model is decided with the software or the hardware to embody the system, that is, the system can be compatible with the hardware having a certain interface. This allows the system to support "Plug & Play" of the component. The proposed method has an advantage with that the Mobile WiMAX System is useable for Mobile WiMAX waveform application with adding only software modules system requires.

The point for development of communication software based on SDR is the application waveform component. There are various Waveform components according to the developing vendor. It is same to the condition described in this paper. The undefined part in SWRadio components is defined as the concept of the waveform specific component in order to implement the Mobile WiMAX waveform component. Therefore it is easier to add the waveform application to the system with standardizing the various waveform applications like as the standardization of SWRadio components.

5. REFERENCES

[1] SDR Forum – Software Defined Radio Forum, http://www.sdrforum.org

[2] OMG Software-Based Communication Domain Task Force, “PIM and PSM for Software Radio Components, v1.0, formal/07-03-01”

[3] OMG Software-Based Communication Domain Task Force, http://sbc.omg.org

[4] Part 16: Air Interface for Broadband Wireless Access Systems, IEEE Std 802.16Rev2/D2, December 2007

[5] Software Communication Architecture, http://sca.jpeojtrs.mil/home.asp

[6] Software Communications Architecture (SCA) Specification, v.2.2, Joint Tactical Radio Systems, November 17, 2001, http://www.jtrs.saalt.army.mil/SCA/SCA.html.

[7] John Bard, Vincent J., and Kovarik Jr., Software Defined Radio : The Software Communication Architecture, WILEY, 2007.

[8] The Common Object Request Broker: Architecture and Specification, V 3.0, Object Management Group, June 2002

[9] http://dsplab.hanyang.ac.kr/research_sa_api_new.php