Block Turbo Code and Its Application to OFDM System Design For Cognitive Radio

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Abstract

Abstract- Recently, Cognitive Radio has been proposed as a promising technology to improve spectrum utilization. A highly flexible OFDM system is considered to be a good candidate for the Cognitive Radio base band processing where individual carriers can be switched off for frequencies occupied by a licensed user. In order to support such an adaptive OFDM system, we propose a Multiprocessor System-on-Chip (MPSoC) architecture which can be dynamically reconfigured. However, the complexity and flexibility of the base band processing makes the MPSoC design a difficult task. This paper presents a design technology for mapping flexible OFDM base band for Cognitive Radio on a multiprocessor System-on-Chip (MPSoC).

Keywords: Keywords: OFDM, MPSoC, Multiprocessor, Cognitive Radio

INTRODUCTION

To overcome multi path fading and Inter symbol Interference (ISI), in convolution Single carrier systems equalizers are used. But it increases the system complexity. Another approach is to use a multi carrier modulation technique such as OFDM, where the data stream to be transmitted is divided into several lower rate data streams each being modulated on a sub carrier. To avoid ISI, a small interval, known as the guard time interval, is inserted into OFDM symbols. The length of the guard time interval is chosen to exceed the channel delay spread. Therefore, OFDM can combat the multi path fading and eliminate ISI almost completely. The other problem is the reduction of the error rate in transmitting digital data. For that we use error correcting Codes in the design of digital transmission systems. Turbo Codes have been widely considered to be the most powerful error control code of practical importance. Turbo codes can be achieved by serial or parallel concatenation of two (or more) codes called the constituent codes [16]. The constituent codes can be either block codes or convolution codes. Currently, most of the work on turbo codes have essentially focused on Convolution Turbo Code (CTC) and Block Turbo Code (BTC) have been partially neglected. Yet, the BTC solution is more attractive for a wide range of applications.

In this paper simple explanation of BTCOFDM theory is given. The BER performance is
evaluated for the Block Turbo coded BPSK and QPSK OFDM system, under both AWGN channel and Rayleigh fading channel. It also compares the BER performance of Block Turbo coded OFDM with the uncoded OFDM. In this paper the BTCOFDM system with 4 iterations is sufficient to provide a good BER performance. Additional number of iterations does not show noticeable difference. The simulation results show that the BTCOFDM system achieves large coding gain with lower BER performance and reduced decoding iterations, therefore offering higher data rate in wireless mobile.

The concept of using parallel data transmission by means of frequency division multiplexing (FDM) was published in mid 60’s [1]. Some early development with this can be traced back to the 50s [1]. A U.S. patent was filed and issued in January 1970 [2]. The idea was to use parallel data streams and FDM with overlapping sub channels to avoid the use of high speed equalization and to combat impulsive noise, and multipath distortion as well as to fully use the available bandwidth. The initial applications were in the military communications. Weinstein and Ebert [3] applied the discrete Fourier transform (DFT) to parallel data transmission system as part of the modulation and demodulation process. In the 1980s, OFDM has been studied for high speed modems [4], digital mobile communications [5] and high-density recording [6]. In 1990s, OFDM has found its applications in wideband data communications over mobile radio FM channels [9], wireless LAN [8], wireless multimedia communication [10], high-bit-rate digital subscriber lines (HDSL) [11], asymmetric digital subscriber lines (ADSL) [7], digital audio broadcasting (DAB) [12], digital video broadcasting (DVB) [17]. OFDM has been chosen as the modulation technique for the new 5 GHz IEEE802.11a [13] standard as well as High-Performance LAN (HIPERLAN) [14], [15]. 4 For the reduction of the error rate in transmitting digital data we use error correcting Codes in the design of digital transmission systems. Turbo Codes proposed by Berrou in 1993 [16] have been widely considered to be the most powerful error control code of practical importance. Turbo codes have error correcting capability very close to the theoretical performance limits.

2. Cognitive Radio

Due to the explosive growth of wireless communication, the demands for radio spectrum are rapidly increasing. It is very difficult to accommodate new wireless services under the current spectrum allocation scheme. On the other hand, the allocated spectrum is not efficiently utilized. [16]

Cognitive radio is a promising technology to improve today’s spectrum utilization. Cognitive Radio is proposed as a technology to solve the imbalance between spectrums Scarcity and spectrum under-utilization. Spectrum utilization can be improved by making it possible for a user who does not have the license for spectrum (secondary user) to access the spectrum which is not occupied by the licensed user (primary user). This secondary user has the awareness of the spectrum and adapts its transmission accordingly on a non-interference basis. This spectrum access and awareness scheme is referred to as Cognitive Radio. The idea is also known as Dynamic Spectrum Access (DSA) or Open Spectrum Access (OSA). Cognitive Radio is seen as the final point of software defined radio (SDR) platform evolution. A fully flexible and efficient software defined radio platform will be the enabling technology for Cognitive Radio. Cognitive Radio imposes a number of requirements on the processing platform such as flexibility, energy efficiency and guaranteed throughput/latency. The trend in the implementation of SDR is moving towards Multiprocessor System-on-Chip (MPSoC) platforms.

This paper mainly focuses on the design of the adaptive physical layer (base bandprocessing). The physical layer considered in this work mainly consists of two parts: transmission and spectrum sensing. A recognizable MPSoC
platform is used to support the adaptive baseband processing of Cognitive Radio. [18]

Although MPSoCs offer many advantages, it is a challenging task to map applications onto MPSoCs, especially highly dynamic applications such as Cognitive Radio. There is a gap between the application models used for the specification of such applications and an optimized implementation of the application on an MPSoC. To close the gap, we propose to use a task transaction level (TTL) interface approach both for developing the Cognitive Radio application at system level and for the platform interface between the application and the proposed MPSoC platform. The TTL approach is used throughout the work as the system-level design methodology and its advantages are elaborated by mapping adaptive physical layer algorithms for Cognitive Radio onto the MPSoC platform[16]. The TTL model allows verifying the system’s functional behavior and provides profile information for complexity analysis.

The transmission of Cognitive Radio strictly depends on the reliable detection of the primary user through spectrum sensing [19]. As a result, spectrum sensing is an essential part of Cognitive Radio. Spectrum sensing should also be considered as a part of the physical layer. The major task of the physical layer spectrum sensing is to detect the licensed signal by employing various signal processing techniques. This paper reviews different signal processing schemes for sensing and focuses on so-called energy detection. An energy based multi-resolution spectrum sensing scheme is proposed in this work. The sparse FFT proposed for OFDM based Cognitive Radio also suits this multi-resolution sensing scheme quite well. The filter bank spectrum sensing technique is also considered due to its easy integration with a filter bank multi carrier system.

REFERENCES


