Capacity analysis of FBMC over OFDM in Cognitive Radio Systems

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Abstract – We present a performance analysis between two different multi-carrier transmission techniques: the OFDM, with cyclic prefix (CP) addition; and the FBMC (Filter-Bank Multicarrier), which is based on a filter-bank architecture. For both schemes, we propose a comparative analysis to be applied in a Cognitive Radio system (CR). The paper addresses the need for an adaptive, intelligent and reconfigurable communication system, capable of intuitively studying the requirements of an end user as well as the band spectrum and thereby assigning the requisite resources. We comparatively studied the channel capacity for a CR. The resource allocation algorithm uses subcarrier assignment. Power allocation was carried out sequentially. We formulated the rate of the total information under an uplink scenario with Rayleigh fading and path loss, subject to the mutual interference constraint existing between the primary user (PU) and the secondary user (SU) as well as the power constraint.

Keywords –Cyclic Prefix (CP); Polyphase Network (PPN); Cognitive Radio Network/System (CRN/S); multicarrier (MC)

I. INTRODUCTION

The need to effectively satisfy billions of wireless network users has brought about a revolution to the wireless industry, as well as tremendous debate and progressive research in Dynamic Spectrum Access (DSA) and CRN [1]. DSA and CR are a key component of fifth Generation of wireless technology. Much anticipation has been placed on the overall improved capacity in the existing wireless network to meet the requirements for 5G wireless network and beyond. The ongoing research in 5G Radio Access technology is targeted to be available by 2020, and it is expected to handle a very wide range of efficient network requirements. The fifth generation of wireless communication also known as 5G radio access will also address the exponential increasing traffic, this will allow people and machines to enjoy gigabits data rates with relatively zero latency. Unlike the existing 4G wireless access, such as LTE-Advanced, 5G will improve the throughput with sub-milli seconds latency and utilization of higher carrier frequencies and wider bandwidth in the band spectrum, thereby reducing energy consumption and cost [2]. Since the inception of OFDM, it has been the most popular radio access technology of choice for many standard of wireless communication, these include: 802.16 (WiMax), 802.11a/b/g under WiFi alliance and as well as Long Term Evolution (LTE). Some advantages of OFDM [3] include: simple equalization in frequency domain, most rewarding for multiple-input multiple-output (MIMO) systems as well as efficient usage of band spectrum through frequency overlapping, however, through fast Fourier transformation (FFT) less complex implementations has been achieved [4]. It is also possible for OFDM to exploit multi-user diversity and frequency diversity making it an appealing technology for many wireless systems [4]. However, other new waveforms which were designed for the next-generation wireless access systems carry enormous importance due to various critical limitations in OFDM, such as: susceptibility to carrier frequency offset, high side-lobes, cyclic prefix (CP) overhead, and very high peak-to-average-power ratio (PAPR) [5].

FBMC may use any prototype filter design [6] as captured through the Polyphase network. This paper will also aim at investigating how FBMC provides a way to mitigate both inter-symbol interference and inter-channel interference in CR system. In some literatures, multicarrier (MC) modulation has been presented as a contender for CR system due to its ability to access and utilize free spectrum holes [7]. However, OFDM has been proposed as a preferred candidate for CR systems [7]. OFDM appears to be very sensitive because of imperfect synchronization, to random fast time variations of the timing offset as well as to the radio channel. In addition, because of the insertion of Cyclic Prefix (CP), there is a sacrifice in the data transmission rate.

FBMC modulation [8][9], presents a system with the absence of the cyclic prefix guard band and shows better ability to handle the presence any residual frequency offsets. FBMC has however been recommended as a promising modulation scheme for cognitive radio systems [9]. Study has also shown that filter banks can be applied as a critical tool for spectrum analysis and sensing [10]. In [11], due to high performance at a very low cost, filter banks application to spectrum sensing has proven to be more efficient than various methods such as: Thomson's Multitaper (MT) method and the FFT components, however, the problem of optimal resource allocation in MC cognitive radio context with mutual interference as well as power constraints is still an area of research. Reference [12] carried out a downlink capacity maximization of the CR system with focus on the power and interference constraint, a power loading scheme was proposed. According to this scheme, the system throughput of the CR system was evaluated based on OFDM and FBMC [13]. The scheme however proposed an iterative PI-algorithm, but the mutual interference between the PU and the SU were assumed negligible. Channel pathloss was also not considered.

Our focus here is on the comparative analysis of FBMC and OFDM based CRN in terms of average channel capacity, which solely depends on the secondary system's approach to resource allocation. We thereby propose a resource allocation approach as initially envisaged in [1], however, only the uplink scenario is considered through Rayleigh channel with pathloss, and we also formulated the sum-rate maximization with inter-cell interference (ICI) and power constraint [14]. The procedure for our resource allocation was split into two steps to minimize

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