A Review on Orthogonal Frequency Division Multiple Access (OFDMA) in Broadband Wireless Access

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Abstract: OFDMA is the basis of future broadband access, due to its many inherent advantages such as scalability and fine granularity for multi-user access. OFDMA is a multi-user version of the popular Orthogonal Frequency-Division Multiplexing (OFDM) digital modulation scheme. Multiple accesses are achieved in OFDMA by assigning subsets of subcarriers to individual users. The purpose of this paper is to review on Orthogonal Frequency Division Multiple Access (OFDMA) in broadband wireless access. The review analysis is purely based on OFDMA Uplink system, OFDMA Cognitive Radio Networks, OFDAM cellular networks and the OFDMA interference. Some of the challenges faced in a multi-carrier OFDM/OFDMA system are dynamic resource allocation which requires the exact knowledge of channel status that is not always easy to be obtained. This paper reviewed a wide range of challenges faced by OFDMA and their suggested solutions extensively. Apart from that a thorough comparison analysis between different techniques is studied and presented in this paper.

Keywords: OFDMA; Subcarriers; Networks; Modulation Scheme

I. INTRODUCTION

In communication systems, the increasing demand for high data rates over wired and wireless networks resulting the adoption of Orthogonal Frequency division Multiplexing (OFDM) technology which offer high rate transmission with low complexity for implementation over frequency-selective fading channels. The orthogonal frequency-division multiple access (OFDMA) scheme has been adopted by the IEEE 802.16 (WiMAX) standard [1] to provide efficient broadband wireless access to subscribers. One common property of OFDMA systems is the sensitivity to timing and frequency synchronization errors. In the uplink channel of OFDMA systems where multiple Subscriber Stations (SSs) with different timing and frequency offsets transmit simultaneously, synchronization can be achieved by a contention based random access process referred to as ranging in the IEEE 802.16 (WiMAX) standard [2 - 4]. A ranging process starts with the allocation of a set of subcarriers in specific time slots, which is known as a ranging opportunity. Multiple SSs can take this opportunity by modulating randomly selected ranging codes onto the allocated subcarriers.

In the same ranging opportunity, usually the number of possible ranging signals is much larger than the number of Ranging Subscriber Stations (RSSs), so the Base Station (BS) can distinguish each individual RSS and estimate its timing, frequency, and power [5]. In the event of multi-cell networks, inter-cell interference must be considered during scheduling. A few systems for reusing the frequencies are utilized as a part of request to farthest point the inter-cell interference. There are static reuse systems based upon the partial frequency reuse (FFR) [6]. The cell is isolated into an inner zone which is the same frequency is reused in all cells and external region where just the subset of frequencies is reused. Other than that, the dynamic frequency reuse methods is another illustration of the frequencies that are permitted to be utilized by all the cells and different strategies are utilized to evade interference or handle interference [7].

Cognitive Radio OFDMA Network can be planned on the premise of the existing explores on non-CR OFDMA networks [8]. There have been various studies on traditional OFDMA networks, particularly focusing on the subcarrier and force designation issue in a single-cell situation. An exhaustive study on these works can be found in [9]. The most critical issue in a multi-cell OFDMA network is the coordination among multiple cells to productively reuse the spectrum. In [8] and [10], the creators proposed force administration conspires under the condition that all cells have the same spectrum for example Frequency Reuse Element (FRF) of one. In any case, the trouble with FRF being one is that the versatile stations (MSs) situated in the edge of a cell can endure serious inter-cell interference [11-14].

In wireless cellular networks, deploying a set of relay stations between a base station and mobile stations is a cost-effective approach for improving performance, such as coverage extension, power saving and cell-edge throughput enhancement. These advantages are achieved as relay-assisted cooperative transmission exploits the inherent broadcast nature of wireless radio waves and hence provides cooperative diversity [15, 16]. OFDMA is an enabling physical layer technology for spectrally efficient transmission as well as user multiplexing in broadband wireless networks. An intrinsic feature of OFDMA is its capability of exploiting the frequency selectivity enabled multiuser diversity. On the other hand, real life applications are delay sensitive and it is critical to consider the delay performance in addition to the conventional physical layer performance in OFDMA cross-layer design [17, 18]. A combined framework taking into account of both queuing delay and physical layer performance is not trivial as it involves both the queuing theory (to model the queue dynamics) and information theory (to model the physical layer dynamics) [19, 20].

In the IEEE 802.16 (WiMAX) standard [8], the ranging channel is specified as a multi-carrier code-division multiple access (MC-CDMA) channel where multiple RSSs are expected to use different ranging codes and thus distinguishable at the BS. The performance of a MC-CDMA channel is limited by Multiple Access Interference (MAI) which increases with the number of RSSs. The conventional ranging detection methods [8–10], [21, 22] simply treat the MAI as noise, which results in the performance degradation as the number of RSSs increases.

The paper is organized as follows Related Work (Section 2), Comparison Analysis (Section 3), and Conclusion (Section 4).

II. RELATED WORK

In recent years, a couple of studies have been done on resource designation in single-cell CR-OFDMA networks. A power stacking count for subjective radios was proposed that uses the frequency groups close-by the PU's groups. In this paper the inventors explained a joint power and sub channel task issue under interference prerequisite for each sub channel by strategy for the twofold decay technique [8]. The power and sub channel segment count was proposed for supporting non-continuous administrations in an OFDM-based CR framework. Regarding the multi-cell CR-OFDMA networks, simply couple of works have been done so far resource task count for a multi- cell OFDMA framework was introduced in the association of CR, where the OFDMA framework was considered as the PU framework that tries to purge spectrum groups for a CR framework. a frequency channel and power task figuring was recommended that grows the amount of endorsers in a multi-cell CR system [23]. In any case, this work considers a frequency-division multiple passageway (FDMA) frameworks rather than an OFDMA framework.

A few works have been done on OFDM based on pilot plan. To lessen the computational multifaceted nature of chose mapping (SLM) plan for double branch Multiple-Input Single-Yield (MISO) OFDM frameworks with Space-Frequency Piece Coding (SFBC), [24] introduced the Polyphone Interleaving and Inversion (PII) plan and the low-many-sided quality SLM plan. In the meantime, [25] said that radio asset designation has a critical part to empower productive interchanges over element remote situations in OFDM [26]-[28]. Then again, because of the cross administration interference in the sharing spectrum situations of radio asset designation, transmission of the auxiliary administration may debase the essential administration execution. Subsequently, two distinctive methodologies are typically utilized as a part of the spectrum sharing which are agreeable spectrum sharing and coexisting spectrum sharing [29, 30]. In Orthogonal frequency division multiple access (OFDMA), [31] reported that vitality productivity (EE)- ghostly effectiveness (SE) trade off with the thought of circuit force has been considered for vitality constrained remote multi-bounce networks with a single source-destination pair.

According to Lau [1], the BS assignment problem in cellular systems deserved significant research efforts. Irrespective of the radio access technology, one of the most common BS assignment approaches is the Minimum Path Loss (MPL) that assigns each user to the BS that provides the highest radio link gain [32-36]. This approach alone constitutes the core of many BS assignment algorithms used in current 2G/3G cellular systems (where absolute and/or relative received signal level thresholds are used to decide upon the serving BS) and also forms part of more sophisticated approaches aimed to exploit, e.g., multiuser detection and multiple antennas [37]. Another common approach consists of taking into account the Signal to Interference and Noise Ratio (SINR) in the assignment process, which is particularly important when targeting an aggressive reuse of frequencies throughout the network [38, 39]. The problem of the paper allocation in Code-Division Multiple Access (CDMA) networks is addressed in many papers. More recently, an extensive literature addresses resource allocation in OFDMA networks. In general it is difficult to evaluate the QoS offered by the network with these methods implemented [24, 25, 40, 41]. Some studies consider the case of a single cell. Different frequency reuse schemes are compared. The present work adopts the approach proposed in [42] that is implemented in the dimensioning tool. It consists in proposing some network control mechanism that is simple enough and can be studied by the classical tools of queue theory. Moreover, the paper follows the ideas presented in and in for queue models suitable for streaming and elastic traffics respectively. Besides presenting in more detail the results there, the paper study the performance of a network serving elastic traffic, as a network serving simultaneously streaming and elastic traffic [5, 17, 18, 43-45]. Moreover, the paper illustrates the proposed approach by solving the dimensioning problem.

As reviewed by G. Na and W. Xin based on OFDM uplink system in network scheme reveal that there is numerous algorithm or system developed. A two Maximum Likelihood (ML) channel estimation for OFDM uplinks operate in dispersive time varying fading channels which is allows the Channel Impulse Response (CIR) model to vary within one OFDM symbol. A low complexity PAPR reduction scheme for OFDMA which is allows a single implementation to be configured in a multiple path during transmission of data either in high data rate [46]-[48]. The issue of balancing being solved based on where the optimal number of chunk and subcarrier are responsible to maximize a general utility function. Meanwhile, a resource allocation algorithm for downlink are using two-dimension (2-D) OFDMA system which is it can be implement without control [1, 9, 21, 22]. Power allocation algorithms for OFDM are based on cognitive radio where it gives an optional of using a low complexity power allocation. From a past studies based on OFDM uplink framework is network plan, there a various calculation or framework create.

A two most extreme probability (ML) channel estimation for OFDM uplinks work in dispersive time-varying fading channels which is permits the channel drive reaction (CIR) model to shift within one OFDM image [49]. In [21], a low intricacy PAPR decrease plan for OFDMA which is permits a single execution to be designed in a multiple way during transmission of information either in high information rate. The issue of balancing being fathomed based on [50] where the ideal number of lump and subcarrier are mindful to boost a general utility capacity. In the meantime, an asset distribution calculation for downlink are using two-measurement (2-D) OFDMA framework which is it can be actualize without control [37]. Power portion calculation for OFDM is based on psychological radio where it gives a discretionary of using a low intricacy power assignment [51]. So as to conquer the profoundly dynamic in portable radio channel, embrace a differential regulation procedure instead of lucid balance. Instead of that, a framework likewise ordinarily bolsters lower information rates and can a 3-4dB punishment in sign proportion (SNR) [50]. As notice some time recently, OFDM framework obliged high information rate for information transmission and ghastly. For this situation, lucid adjustment is more compelling to utilize, subsequently the channel estimation are needed as an integral piece of the beneficiary configuration. A ML based channel based channel estimation calculation was proposed for OFDM uplink handle in dispersive time-varying fading channels. These proposed calculations are helpful for OFDM uplink framework where it has effectively repaid the frequency counterbalance because of neighborhood oscillator crisscross [52].

The computational intricacy can be diminished by combined a fragmentary time-domain signal with another same sign of different cyclic movements which is only adequate in OFDMA framework and not in OFDMA construction modelling [17]. Other than that, the methods for diminishment legitimate for multiple-input multiple yield (MIMO) OFDM framework with space-frequency square coding (SFBC) [2], [53]-[54]. Next, this pro- posed plan likewise require stand out IFFT and produced distinctive hopeful signs through the component astute duplication of the original frequency-domain signal with different consistently moved stage successions [2]-[3],[54]. The well-known ICI self-cancellation scheme are appropriately mapping symbols to a group of subcarriers, the proposed algorithm in makes OFDM transmissions less sensitive to the ICI at the cost of much lower bandwidth efficiency [55]-[59]. Based on the piece-wise linear approximation on channel's time variations, two ICI mitigation methods are proposed for an OFDM system working in considerably large delay and Doppler spread environments, such as SFN and cellular networks [46].

III. COMPARISON ANALYSIS

Comparison of OFDMA network parameters are being discussed in this paper. Strength and weakness of the parameters summarized in Table 1. The parameters included OFDMA Uplink System, OFDMA Cognitive Radio Network, OFDMA Cellular Network and OFDMA interferences.

A. *OFDMA Uplink System*

An iterative maximum ML-based algorithm is a proposed technique to estimate the discrete-time channel parameters where the performance being analyzed by using a small perturbation technique. This algorithm is particular useful for an OFDM system which has already compensated the frequency offset due to local oscillator mismatch [60]-[63]. Based on the convergence rate, an improved fast converging iterative ML channel estimation algorithm has been proposed using a successive over relaxation, SOR method to achieve accelerated convergence. A system typically support lower data rates and can incur 3-4 dB penalties in signal-to-noise ratio (SNR) [64]-[68]. The proposed algorithm has comparable computational complexity to the non-iterative channel estimation algorithm. MMSE are present by exploited both time-domain and frequency-domain correlations of the frequency response of rapid dispersive fading channels. A robust implementation of the MMSE pilot-symbol-aided estimator, where it is do not depends on cannel statistic [69]-[71].

Low complexity scheme are proposed to construct low-complexity expression that requires only one Inverse Fast Fourier Transform (IFFT) [72]-[73]. The architecture of this proposed scheme is proven to be applicable to OFDMA uplink either an interleaved or a sub-band sub-carrier strategy. For the proposed scheme, the candidate signals for each user are generated in the time domain where basically a linear combination of the original time-domain transmitted signal and multiple cyclic shift equivalents [37],[74]-[75]. The sub-carriers are assigned to a user and the elements of the corresponding phase rotation vectors should have the same magnitude to make sure the signal powers of the different sub-carriers have the same gain. OFDMA systems inherit the principal disadvantage of traditional OFDM systems, namely a high Peak-to-Average Power Ratio (PAPR), various PAPR reduction schemes have been proposed for OFDM systems but still require a minimum of two IFFT operations. Low-complexity SLM architecture requiring just one IFFT where conversion vectors obtained by using the IFFT of the phase rotation vectors are adopted in place of the conventional IFFT operations [53],[76]-[79]. This scheme are proposed to low or reducing the computational complexity where the architecture requiring just one IFFT. The various candidate signals can be generated in the time domain in order to combine a fragmentary time-domain signal with other fragmentary time-domain signal of various cyclic shifts [80].

In OFDMA system, grouped a subcarrier into chunks and then it will regards as a minimum unit for subcarrier allocation. The number of subcarrier and chunk are predefined then consider the optimal chunk allocation that maximize a utility function of average user rates for wireless OFDMA system under different power being control [81]-[82]. This proposed technique required some problem in formulated it as non-convex mixed-integer programs. The formula shown the optimal scheme can be obtained through Lagrange dual-based gradient iterations with fast convergence and low computational complexity [64], [83]-[84]. The advantages of the technique where it capable of transmitting high-speed connections in a multi-path environment, where it will divide overall of channel into many subcarrier and for sure limits the available data rates [46], [65], [85]-[87]. For those subcarrier can be allocated dynamically among different users where it will provide a new degree of freedom in multiuser scheduling and becomes the workhorse for wireless applications. Purpose of resource allocation to jointly all the subcarrier and rate or power in order to maximize the weighted sum of the user rates under budget.

The problem of resource allocation (power control and subcarrier assignment) is the downlink of sectored OFDMA networks impaired with multi-cell interference. Fewer works address the more involved multi-cell allocation problem. The power allocation as require by user can be minimize and the subcarrier system allowed satisfy all user' rate requirements while spending the least possible power at the transmitter sides [88]. Other than that, the asymptotic transmit power depends on the average rate requirement and on the density of users in each cell. It also depends on the value of the frequency reuse factor [81], [89]-[91]. We can therefore define the optimal reuse factor as the value of α which minimizes this asymptotic power [33]. The power of transmission on this algorithm tends, as the number of users grows to infinity to the same limit as the minimal power required satisfy all user's requirement. The weakness of this proposed algorithm is their allocation for multi-cell. This proposed technique algorithm can be implemented in a distributed fashion without any central controlling units [47], [92]-[94]. It performed fast fading channels and distributed multi-cell interference.

A suboptimal algorithm are proposed to develop an optimal power allocation algorithm for OFDM based on Cognitive Radio (CR) system with different statistical interference constraints imposed by different statistical interference constraints imposed by different primary users. The fact that the interference constraints are met in a statistical manner the CR transmitter does not require the instantaneous channel quality feedback from the PU receivers. A suboptimal algorithm with reduced complexity has been proposed and the performance has been investigated [95]. These proposed techniques are improved by using CR technology where it is flexible in allocating spectrum where being recognized as an air interface technology for CR systems [75]. The coexistence of CR and primary users in side-by-side bands give an advantage where mutual interference between these users is the limiting factor in order to achieve a good performance for CR systems [76].

Suboptimal subcarrier allocation scheme uses the spectral efficiency enhancement parameter. It is used to assign subcarriers to users. The proposed scheme has a lower computational complexity than that of the existing scheme which is shown to be close to the multiuser water-filling solution. It takes intensive computational time to obtain the optimum solution by using a numerical search method. Some suboptimal schemes are assigned by subcarriers to users iteratively to enhance the performance. With equal power allocation, an optimum subcarrier allocation scheme for the single user problem is presented for DFT-precoded OFDM systems [30], [96]-[97]. It is based on a brute force search approach to obtain the maximum achievable rate. When the optimum set of subcarriers, the optimum number of subcarriers, and the equivalent CNR are found. The scheme consists of an initialization step and a multiuser "compare and compete" step. The basic idea of the brute force search is to sort the channel gains in descending order, and iteratively allocate subcarriers until the maximum rate is achieved [7], [72]. Selecting subcarriers with better channel conditions to users would achieve a higher spectral efficiency. This implies that a suboptimal scheme may use the channel gain related parameter of each subcarrier as a priority index to allocate subcarriers to users. The proposed suboptimal scheme assigns subcarriers to users sequentially to maximize the spectral efficiency according to the formulated spectral efficiency enhancement indicator of each user. Only one subcarrier is allocated by considering the spectral efficiency improvement [98]. But, somehow the Brute Force Search method need to recalculate the next iteration. The redundant processes make the allocation scheme inefficient and make it complex. Iterative subcarrier allocation refining schemes use to reallocate subcarriers. Some iterative refining subcarrier allocation schemes for OFDM-based systems are demonstrated to obtain better performances [99].

B. ***OFDMA Cognitive Radio Network***

Based on the study on paper "Blind estimation of OFDM parameters in cognitive radio networks", the proposed blind parameter estimation algorithm for orthogonal frequency division multiplexing (OFDM) signal affected by a time-dispersive channel, timing offset, carrier frequency offset and additive Gaussian noise [13]-[14],[99]-[100]. This technique makes use of estimation algorithm to determine the communication link in which incoming connection should be link to, in other to establish communication [85], [99]. Based on the problem, the secondary user of OFDM is not to allow to be connected when the primary user is engaged. With the use of time-dispersive channel which allocate time based estimation to users for next priority connection. Moreover, this technique comes with some weakness which unaddressed parameter estimation is analysis for time-dispersive channel, and this process consumes time in allocation of the users to the right frequency [8]-[10], [21]-[22]. Based on this weakness, CR has the intelligence of dynamically changing its parameters. It identify the weak signal parameter and is able to reallocate the parameters to a stronger signal for connection and communication, this comes with the demand to develop blind OFDM parameter estimation algorithms to efficiently demodulate the OFDM signals in hostile wireless channels [75].

An efficient pilot design method for OFDM-Based cognitive radio systems examined a new practical pilot design method for OFDM-based CR systems. This was done by formulating a pilot design as a new optimization problem and minimizing an upper bound which is related to this MSE [19]-[20]. In addition, the researchers proposed an efficient scheme to solve the optimization problem. The optimization problem is one of the weakness of OFDM, because it has to overcome the issues of CR systems, in which when the subcarriers already occupied by the primary users, the same subcarriers cannot be used by the secondary users and this problem leads to possibly non-contiguous position of the available subcarriers for the secondary users. Furthermore, when there is a selection of pilot tones, it has the benefits of not affecting the channel estimation performance [62]. The proposed techniques by the researchers with its algorithm can apply to pilot tones selection.

Downlink sub channel and power allocation in multi-cell OFDMA cognitive radio networks proposed a novel sub channel and transmission power allocation scheme for multi-cell orthogonal frequency division multiple access (OFDMA) networks with CR functionality [29]. The multi-cell CR-OFDMA network not only has to control the interference to the primary users (PUs) but also has to coordinate inter-cell interference in itself. This techniques is able to allocate different power signal between the users, in other to prevent interference among two different users and able the logic of allocating multi-cell CR-OFDMA, which controls the interference problem and establish a communication link for good signal connection [15], [54]. The researchers proposed power management schemes under the condition that all cells share the same spectrum, i.e., frequency reuse factor (FRF) of one. However, the weakness of difficulty with FRF being one is that the mobile stations (MSs) located in the edge of a cell can suffer severe inter-cell interference [97]. In addition, An OFDMA system can turn off subcarriers on which a PU is active, while maintaining the connection via the rest of the subcarriers which reduce the inter-cell interference among users. This gives more life to the proposed technique.

As elaborated in paper relay and power allocation schemes for OFDM-Based cognitive radio systems. The proposed method where the capacity of CR user employing relays is maximized while total transmission power is kept within a budget and the interference introduced to the primary user (PU) band is kept within a prescribed threshold. The aim of this technique is to reduce the total transmission power used among the users, mostly the primary user in other to overcome interference [78]. This is because the more power the primary uses to transmit the more interference it will get from other users running on higher frequency. Nevertheless, for the case when CR systems have a weak channel between source and destination, reliable communication might not be possible because the CR users cannot transmit at high power as they might introduce unacceptable interference to PU in the adjacent bands [3]-[4]. Moreover, an OFDM based CR system is considered in which the channel between the source and destination is under a deep fade and hence, a direct link is not available. Therefore, the source transmits to the destination via CR based relays.

Queue-Aware Resource Allocation for Downlink OFDMA Cognitive Radio Networks Multi-step allocation approach is proposed that first computes the number of channels that should be allocated to each user [6], [9], [37], [74]-[75]. This computation is based on the average channel gain of each user and implicitly assumes that other than for differing sub channel gains, all sub channels are equally good, while this is clearly not the case in the cognitive setting as some sub channels may have stringent transmit power constraints while others are free of any primary user.
Optimization of OFDMA-Based Cellular Cognitive Radio Networks is using Cognitive radio technique and Lagrange duality based technique. The Cognitive radio technique has been proposed as a promising solution where secondary users (SU) detect either white or gray space in the primary user (PU) spectrum, and implement opportunistic communication using either spectrum overlay (orthogonal channel sharing) or spectrum underlay (non-orthogonal channel sharing) and a Lagrange duality based technique to optimize the weighted sum rate (WSR) of secondary users (SU) over multiple cells [1], [5], [17], [81]. Next, to flexibly implement spectral sharing between PU and SU and maximize the weighted sum rate (WSR) of SU, a dynamic spectrum allocation (DSA) design is required, using the orthogonal frequency division multiple access (OFDMA) technique which is a promising candidate modulation and access scheme for 4G communication systems. Various DSA methods have been developed for CRN optimization coexisting with primary radio network (PRN)

and references there in [71], [98]. The weakness on this paper is the spectrum resource becomes scarce today and yet many available spectrum resources are not efficiently used.

Optimal Power Allocation for OFDM-Based Cognitive Radio with New Primary Transmission Protection Criteria is using OFDM-Based cognitive radio (CR) system technique that considers a spectrum underlay network, where an OFDM-Based cognitive radio (CR) system is allowed to share the subcarriers of an OFDMA-based primary system for simultaneous transmission [8]-[9], [21]. The high transmission efficiency and the great capability in combating the inter-symbol interference caused by frequency selective channels, orthogonal frequency division multiplexing (OFDM) is regarded as a potential transmission technology for broadband wireless systems. Moreover in the strength, due to its flexibility in allocating transmit resources. OFDM is also considered as a promising candidate for the future CR systems [7], [16]. In early wireless CR networks, an unlicensed user, also known as secondary user (SU), is only allowed to opportunistically access the spectrum originally allocated to a licensed user known as primary user (PU), when the PU is not transmitting over the band. SU is allowed to transmit with the PU over the same spectrum band simultaneously on condition that the resultant interference at the PU receiver is below a prescribed threshold, known as spectrum underlay in or spectrum sharing [15]-[16], [52]. The weakness is with the rapid development of wireless services and applications, the currently deployed radio spectrum is becoming more and more crowded [24]. Therefore, how to accommodate more wireless services and applications within the limited radio spectrum becomes a big challenge faced by modern society.

The technique of Resource allocation for OFDMA-based cognitive Radio multicast network with primary user activity consideration is valid for unicast and multicast transmissions and is applicable for a wide range of rate-loss function which the linear function is a special case [27]-[28], [43]-[45]. Besides that, it represents a significant reduction in computational burden at the BS, where it is desirable to rapidly find the optimal solution to mitigate the fluctuation of wireless channels. There are some problems based on the review paper. Resource allocation problem are to allocate power for one single cognitive user. Risk return model and upon defining a general rate-loss function that give a decrease and total throughput whenever primary users reoccupy the temporarily accessible sub channels [14], [77], [53]-[54]. Thus, the review papers also have some benefit. The nulling subcarriers adjacent to primary users band provides flexible guard band between both user (primary and secondary). It can reduce the interference and achieving the highest possible throughput of secondary. Other than that, it can handle both multicast and unicast transmission, and the complexity only in linear in the number of subcarriers.

To reduce the influence of interference on the OFDM-based cognitive radio overlaid with narrowband primary users, we consider a scheme called the variable sub band nulling (VSN), in which a VSN mode is selected adaptively according to the result of spectrum sensing for the frames following the sensing period. For reliable detection of the VSN mode embedded in the preamble, we consider two types of metrics [59]. The performances of the metrics are analysed in Gaussian channels with/without NBI and are confirmed by simulation results. In fading channels with/without NBI, the detection performance is examined via simulation results. The rapid emergence of various wireless services and high data rate systems has led to a shortage of spectrum favourable to wireless communications. In the meantime, according to a report of the Federal Communications Commission (FCC), many licensed bands are not used to their full efficiency. In other words, the bands remain unused in some times or in some regions [76]. The VSN mode information can be carried successfully to the receiver by engaging the metrics proposed. If the VSN mode is properly design at the transmitter, data communication and response in the following frames might be functioned more proficiently and constantly by triggering only the sub bands and not affected by the NBI. The proposed metrics can deliver dependable discovery of the VSN mode once the NBI is not strong, and one of the metrics can effective detection with high possibility even when the NBI is strong. In addition, this proposed algorithm has reduced the interference to and from the primary user (PU) and supports an efficient VSN-OFDM system [20], [51].

Detection of non-contiguous OFDM symbols for cognitive radio systems without out-of-band spectrum synchronization proposed two bit metric calculation schemes for detection of NC-OFDM symbols based on hard-decision-based detection (HDD) and soft decision-based detection (SDD) schemes of sub channels, respectively [29]-[30], [96]. For the HDD scheme, we simply set the bit metrics of the decided inactive sub channels to zero. Since the hard decision of sub channels have poor performance in severe interference environments, we further develop a SDD scheme to improve the detection performance. One of the weaknesses of the proposed technique is that the secondary transmitter and receiver might practice diverse wireless situations and have different sensing results, synchronization between the switches at the transmitter and receiver might not be assured as a two-switch channel model was engaged for cognitive radio with distributed and dynamic spectral activity, in which the switch is open when a primary user is identified. The key is to allocate a dedicated out-of-band control channel for directing the synchronization information at the transmitter but this solution presents overhead and moreover, the licensed spectrum resource, which is required for dedicated channel, is not obtainable in numerous practical conditions. Another weakness is that the hard decision of sub channels has a reduced performance in severe interference situations. When the sub channels are not near to the edge of sub band, the performance of the hard decision is seamless. It only degraded when the sub channels approach the edge of the sub band. Theoretical analysis and simulation outcomes stated that the suggested schemes can deliver satisfactory performance of the frame error rate (FER). Especially, the proposed SDD scheme can attain a good performance with a wide-ranging range of the signal to interference (from primary user) ratio (SIR), which is very close to that of the ideal spectrum synchronization. The proposed algorithm also does not need any particular planned arrangements to recognize the spectrum usage patterns and they are robust to interference from primary users [27]-[28], [43].

C. OFDMA Cellular Network

Design and Evaluation of a Backhaul-Aware Base Station Assignment Algorithm for OFDMA-Based Cellular Networks based proposed technique of consideration the amount of backhaul capacity available in each cell site within the BS assignment process of a cellular OFDMA network. The selection of the most appropriate BS to handle radio transmission to mobile terminals constitutes a key component of overall resource allocation process. Due that backhaul could represent as much as one quarter of the total network costs , mobile operators are carefully reviewing their backhaul strategies before making further investments in the transport network infrastructure [48]. Because of too many tower that need to carry fibre to solve last mile bandwidth problem, the capacity upgrades in the backhaul are more to be expected for efficient backhaul. The strength of this proposed technique is to distribute traffic among BS station based on load balancing strategy that consider both radio and backhaul load status that eventually mapped into a Multiple-Choice Multidimensional Knapsack Problem (MMKP). The objective of MMPK is to select one item from each group to maximize the aggregated utility subject to knapsack's capacity to overcome the constraint of growing concern is that the backhaul of the cellular network can become the bottleneck in certain deployment BS decision making process [11].

Analytical Evaluation of QoS in the Downlink of OFDMA Wireless Cellular Networks Serving Streaming and Elastic Traffic overcome the problem of resource allocation and queuing theory of user in download Orthogonal Frequency-Division Multiple Access (OFDMA) by introducing wireless cellular network serving streaming and elastic traffic. Cellular networks can serve streaming (real-time) and elastic (non-real-time) traffic. Streaming calls require some given bit-rate for some given duration. Elastic connections aim to transmit some given volume of data at a rate that may be decided by the network. The strength it is much faster than simulation for streaming traffic since it is based on multi-Erlang loss model that calculate the blocking probabilities Kaufman-Roberts algorithm. If the admission condition doesn't have the multi-Erlang form, as for example the reference feasibility condition FC, then time-consuming simulations are needed to calculate the blocking probability [69]-[71], [81]-[82], [78]-[79].

The proposed technique in paper, Optimization Framework and Graph-Based Approach for Relay-Assisted Bidirectional OFDMA Cellular Networks are using Three Time Slot Time Division Multiplexing protocol. Propose an optimization framework for resource allocation to achieve the following gains the cooperative diversity, network coding gain (via bidirectional transmission mode selection) and multiuser diversity (via subcarrier assignment). Authors propose a hierarchical protocol for one and two way relaying in a two time slot time division duplexing (TDD) mode. In this protocol, the transmission mode of each MS as well as its assisting RS pre-fixed, and the downlink and uplink transmission modes for each MS are the same [66]-[67], [73]. This protocol for supporting direct transmission, one and two way relaying in bidirectional cooperative cellular networks is proposed. Each frame is divided into three time slots. Next, it is formulate a joint optimization of bidirectional transmission mode selection, subcarrier assignment and relay selection for maximizing the system total throughput. Besides, the strength of this paper is support relay assisted cooperative transmission which both downlink and uplink time slots can be further divided into two sub slots [1], [9], [21]-[22]. It considers a single cell OFDMA wireless network with one BsS, multiple MS, and multiple RS. Each MS can communicate with the BS directly or through one or multiple RS. The communication is bidirectional and subject to the half-duplex constraint [22]. A relay-assisted bidirectional cellular network is where the base station (BS) communicates with each mobile station (MS) using orthogonal frequency division multiple access (OFDMA) for both uplink and downlink. Orthogonal frequency division multiple access (OFDMA) is an enabling physical layer technology for spectrally efficient transmission as well as user multiplexing in broadband wireless networks [45]. To investigate the aforementioned three types of gains, namely, cooperative diversity gain, network coding gain, and multiuser diversity gain, in a relay-assisted bidirectional OFDMA cellular network. Next, the weakness is due to the half-duplex constraint in practical systems which a node cannot receive and transmit simultaneously; relay assisted communications suffer from loss in spectral efficiency [20].

While in the paper Fairness-Aware Radio Resource Management (RRM) in Downlink OFDMA Cellular Relay Networks the proposed technique illustrated how centralized radio RMM scheme give the best way in ensure the user fairness and reliability of network throughput [56]. Centralized RRM schemes is a novel formulation with a novel low-complexity centralized algorithm that achieves a ubiquitous coverage, high degree of user fairness and enables intra-cell load balancing in downlink OFDMA-based multicell fixed relay networks. The proposed scheme utilizes the opportunities provided in channel dynamism, spatial, and queue and traffic diversities [8]-[9], [21], [63], [81]. In the well-established literature of conventional cellular networks, several queue or traffic-aware fair scheduling algorithms have been proposed such as the channel state dependent packet scheduling (CSDPS), the channel independent packet fair queuing (CIF-Q), and the OFDMA-based algorithms [53]. However, such algorithms cannot be directly applied to relay-enhanced networks since the problem is not just a scheduling problem. Rather, it is in principle, a joint routing and scheduling problem. In addition, the desired user fairness may not be attained through the fairness-aware schemes that rely solely on achievable and allocated capacities such as proportional fair scheduling (PFS). The relay-based RRM algorithms developed for single-cell system models along with their performance results are not applicable to multi-cell scenarios since inter-cell interference is not considered [62]. Furthermore, the vast majority of RRM schemes decouple in-cell routing and resource allocation for simplicity. As such, limiting the opportunities in spatial diversity and channel dynamism the scheme could exploit. In fact, path loss-based and distance-based relay selection is a common and simple strategy [73]. Finally, by oversimplifying channel models, a transmission scheme selection algorithm where selection and resource allocation are solely based on the number of required subcarriers. However, in order to exploit the multiuser and frequency diversities, an RRM scheme has to cope with the channel variations.

D. OFDMA Interference

The interference power on each subcarrier is modelled as a nuisance parameter which is averaged out from the likelihood function resulting into a novel bit-metric that makes use of a suitable estimate the power obtained from previous data decisions. However, because the exact maximum likelihood (ML) solution does not lend itself to a practical implementation, an alternative suboptimal scheme is proposed where the power is estimated on the basis of previous data decision and is employed to properly weight the bit metrics in the currently decoded OFDM block [7], [61]-[63]. Numerical solutions indicate that the error rate performance of the proposed scheme is close to that of a decoder having perfect knowledge of the power across the signal spectrum. One of the strength of the proposed technique is that it delivers the scheme with a method of code diversity [46]. Furthermore, the proposed technique, compared with erasure decoding, can attain enhanced performance and can handle burst interference as it does not merely abandon information from congested subcarriers, but rather lessens the load of those bits that have been weakened. Since the proposed algorithm depends on an adaptation of the bit-metrics active in a standard receiver, the general complexity is close to that of a conventional decoder [74].

To reduce the influence of interference on the OFDM-based cognitive radio overlaid with narrowband primary users, we consider a scheme called the variable sub band nulling (VSN), in which a VSN mode is selected adaptively according to the result of spectrum sensing for the frames following the sensing period [84]. For reliable detection of the VSN mode embedded in the preamble, we consider two types of metrics. The performances of the metrics are analysed in Gaussian channels with/without NBI and are confirmed by simulation results. In fading channels with/without NBI, the detection performance is examined via simulation results [57], [67]-[68]. The rapid emergence of various wireless services and high data rate systems has led to a shortage of spectrum favourable to wireless communications. In the meantime, according to a report of the Federal Communications Commission (FCC) [19], [31], many licensed bands are not used to their full efficiency. In other words, the bands remain unused in some times or in some regions. The VSN mode information can be carried successfully to the receiver by engaging the metrics proposed. If the VSN mode is properly design at the transmitter, data communication and response in the following frames might be functioned more proficiently and constantly by triggering only the sub bands and not affected by the NBI. The proposed metrics can deliver dependable discovery of the VSN mode once the NBI is not strong, and one of the metrics can effective detection with high possibility even when the NBI is strong [29]-[31]. In addition, this proposed algorithm has reduced the interference to and from the primary user (PU) and supports an efficient VSN-OFDM system.

Successive multiuser detection and interference cancelation for contention based OFDMA ranging channel proposed a successive multiuser detector (SMUD) for contention based OFDMA ranging channel compliant to the WiMAX standard [29]. This technique detects the channel path of active ranging signals and cancels their interference for further detection. In addition, this approach significantly suppresses the multiple access interference (MAI) and improves both user detection and parameter estimation performance [30]. The conventional ranging detection methods simply treat MAI as a noise. This problem will increase result in the performance degradation as the number of RSSs increases. Besides that, the performance of a MC-CDMA channel is limited by multiple access interference (MAI) which increases with the number of RSSs [30], [96]. The new algorithm detects the most likely channel path of active RSSs at each iteration, then jointly estimates the channels for all the detected paths and removes their interference. Simulation results in a typical OFDMA wireless communication system confirm the performance improvement of the proposed ranging detector in realistic multipath fading channels.

IV. CONCLUSION

As a conclusion, a few papers have been reviewed based on their parameter to study how far an OFDMA framework is efficiency and obliged high information rate in their area. A parameter that been studied in this paper are based on OFDMA uplink system, OFDMA cognitive radio network, OFDMA cellular network and OFDMA interferences.

The papers are reviewed and compared to see the strength and weakness of the proposed technique. After that, all the information of the proposed algorithm has been gathered based on their parameter as shown in table 1. From here all the comparison can be seen to categorize the advantages and disadvantages of the proposed technique to the OFDMA parameter to work on their area. An apparently disabled parameter extraction computation is proposed for the improvement of OFDM movements by considering a comprehensive sign model that takes into record a period dispersive channel, included substance OFDM synchronization parameters. The proposed figuring isolates some crucial OFDM parameters that are basic for demodulation of OFDM signs. The proposed technique performs well even at tolerably low banner to uproar extents in frequency particular blurring channels with short recognition interims. This paper has understandable proposed techniques for strategy of the assessment of QoS in the downlink of OFDMA cellular networks. It is based on some adequate condition for the attainability of asset portion. The achievable rate of an OFDM based psychological radio framework sharing the spectrum with an OFDMA based essential framework is considered in this paper.

V. REFERENCES

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