An Efficient Dynamic Channel Allocation Algorithm for Wi-MAX Networks

G. Arul Dalton
Research Scholor,
Manonmaniam
Sundaranar University,
Tirunelveli,

T. Jeba Rajan, PhD.
Principal
Kings Engineering College,
Chennai

A.Bamila Virgin Louis
Asst Professor
St.Xavier ‘s Cathalic College of
Engineering

ABSTRACT
This paper presents an efficient algorithm for channel assignment problem in cellular radio networks. The task is to find channel assignment with minimum frequency bandwidth necessary to satisfy given demands from different nodes in a Wi-MAX network. This paper deals with a dynamic channel allocation (DCA) technique based on an energy function whose minimization gives the optimal allocation. The performance of the proposed DCA technique is here derived by computer simulations. Comparisons with a classical fixed allocation technique and a different DCA technique are shown to highlight the better performance of the proposed DCA technique.

Keywords
Wi-Max, Channel Assignment, OFDM, DCA, BER

1. INTRODUCTION
Wi-MAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. The name "Wi-MAX" was created by the Wi-MAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes Wi-MAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". Wi-MAX is based upon IEEE Standard 802.16e-2005, approved in December 2005. It is a supplement to the IEEE Standard 802.16-2004, and so the actual standard is 802.16-2004 as amended by 802.16e-2005.

The original version of the standard on which Wi-MAX is based (IEEE 802.16) specified a physical layer operating in the 10 to 66 GHz range. 802.16a updated in 2004 to 802.16-2004, added specifications for the 2 to 11 GHz range. 802.16-2004 was updated by 802.16e-2005 in 2005 and uses scalable orthogonal frequency-division multiple access Orthogonal Frequency-Division Multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wide band digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting (SOFDMA) as opposed to the fixed Orthogonal Frequency-Division Multiplexing (OFDM) version with 256 sub-carriers (of which 200 are used) in 802.16d.

More advanced versions, including 802.16e, also bring multiple antenna support through MIMO (Multiple Input & Multiple Output). This brings potential benefits in terms of coverage, self installation, power consumption, frequency re-use and bandwidth efficiency. Wi-MAX is the most energy-efficient pre-4G technique among Long Term Evolution (LTE) and High Speed packet Access (HSPA+).

Due to the increasing demand for high speed wireless services, OFDMA is required to use the bandwidth of the system more efficiently, while retaining a guaranteed Quality of Service (QoS). OFDMA is one of the multiple access transmission schemes for such high speed wireless systems due to its robustness in severe multi path fading channels. In OFDMA, the channel bandwidth is splitted into a number of narrowband subcarriers, which are orthogonal to each other. Each of these subcarriers undergo independent attenuation, thus provide frequency diversity. Within multiuser environment the degree of diversity is increasing as each subcarrier of a user have different attenuation, which lead toward having frequency diversity per user and multiuser diversity per subcarrier.

2. PREVIOUS RESEARCH
The principle of transmitting data by dividing the data frame into several interleaved bit stream and modulate with narrowband subcarriers, was first introduced by author in [1] and known as Multi Carrier Modulation (MCM). In [2], authors describe the performance of OFDMIFM modulation for digital communication over Rayleigh-fading mobile radio channels. The Bit Error Rate (BER) is reduced due to the averaging effects of fading over the bits in the block. Recently, a number of algorithms have been developed to increase the information throughput and efficient use of bandwidth for high speed data services. With a given constraints of user demand and required QoS, it is one of the challenging tasks to find out an optimum radio resources allocation scheme in enhanced of information throughput [3], [4].

The algorithm proposed in [4] required to estimate the number of minimum subcarriers required to meet data rate demand from the user. However, it assumes that each user has flat fading channel and available bandwidth is enough to meet all user demand. The same algorithm search for the best subcarrier with Rate-Craving Greedy Algorithm (RCGA) or Amplitude Craving Greedy Algorithm (ACGA) [4] is to provide maximum data rate to the users. However, in practice the bandwidth is limited and flat fading cannot always be guaranteed. Besides that, implementation of greedy algorithm is quiet computationally intensive.

To maximize information throughput with the constraint of allocate-able maximum power, the algorithm proposed in [5] searches the maximum number of allocate-able bit per subcarrier in the form of adaptive modulation. But this algorithm becomes saturated within a deep fading channel. In [6], authors proposed an Aggressive Sub-channel Allocation (ASA) algorithm to maximize OFDMA system throughput, considering fairness of radio resource allocation among all users. In ASA, Channel State Information (CSI) is assumed to be known at the transmitter. Hence, the effectiveness of the algorithm depends on channel estimation algorithm employed at the receiver. In [3], an effective transmit power allocation and dynamic channel allocation schemes are proposed for partitioning based on OFDMA/FDD (Frequency Division Duplex) system. This allocation scheme improves sector throughput within cellular network, while considering QoS and fairness among users.

In [7], authors have proposed the combination of fairness insured Aggressive Sub-channel Allocation (ASA), along with Dynamic Power Allocation Algorithm (DPAA), to maximize fairness and throughput in OFDMA/TDD (Time Division Duplex) system. In [8], authors have proposed combined variable data transmission rate and power M_QAM (Multi_Quadrature Amplitude Modulation) to achieve a target QoS, where M is the number of points in each signal constellation.

The authors in [7], have proposed a radio resource management procedure to improve the outage probability as a tradeoff with information throughput. Authors proposed to allocate bandwidth, Sub-channel and power to users assuming each user received the same SNR (Signal to Noise Ratio) to achieve fairness among users.

The interest in global spectrum allocation techniques are growing with the always increasing spectrum demand for mobile communications. However, the best algorithms suffer from high computational times that reduce the possibility of a practical implementation. Each user needs a channel to communicate with the base station of the cell the user belongs. In order to make each channel assignment technique suitable for application in actual Wi-MAX systems, in this paper should limit the number of operations to be performed when a new call arrives.

In this paper assume that the rearranging operations must be carried out only in the cell involved in the new arrival. This paper proposes an algorithm for OFDMA system for Wi-MAX system, which dynamically assigns subcarriers and adapt the transmitted power based on CSI and traffic demand in multiuser environment. It also considers priority and cost among users and services within the system.

This paper is organized as follows. In section 3, the OFDMA system model is defined. Section 4, describes the proposed Dynamic Radio Resource Allocation Algorithm. In Section 5, the performance of the proposed algorithm is evaluated through the simulation results. Finally section 6, presented with concluding remarks.

3. OFDM SYSTEM MODEL

A multiuser communication system model with OFDMA, which has been considered for analysis in this paper, is presented in Fig. 1.

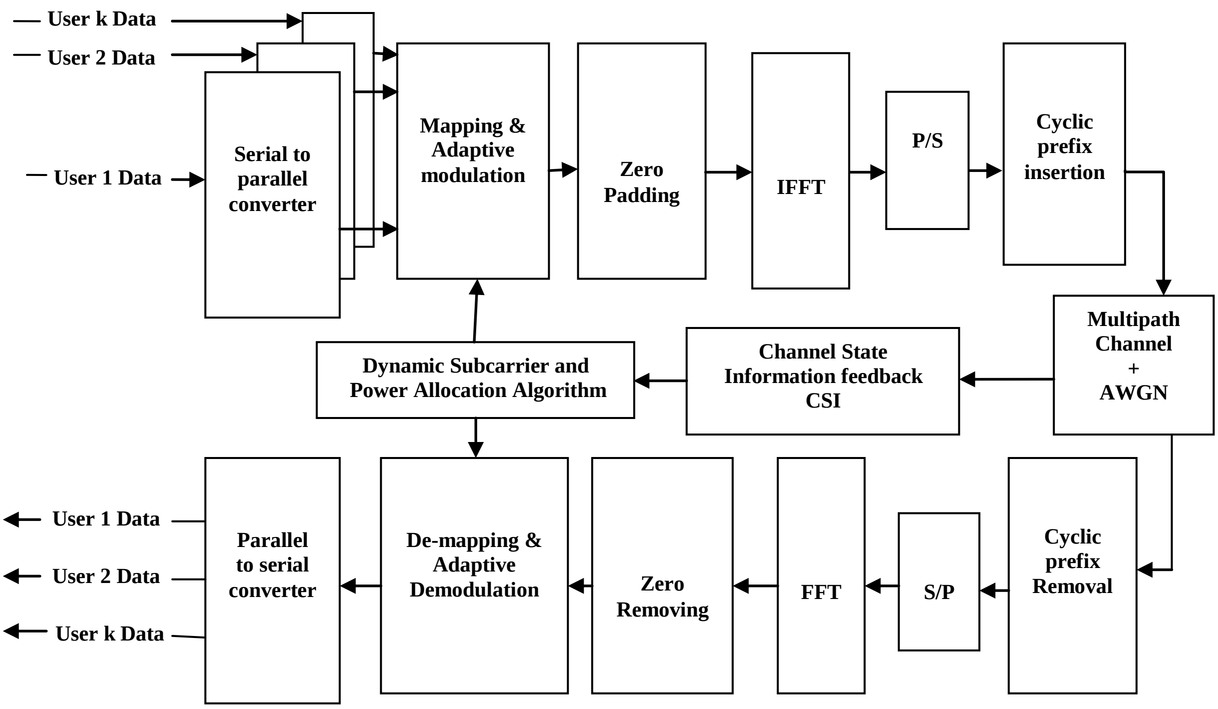

Fig.1 OFDM Modulation Scheme.

Information bits from each user are multiplexed and pass through the adaptive symbol mapper (modulator). Then the frequency domain complex symbols from the modulator are converted into time domain samples by taking IFFT (Inverse Fast Fourier Transform). Then cyclic prefix is added to ensure orthogonality between subcarriers and eliminate Inter Symbol Interference (lSI) and Inter Carrier Interference (ICI). At the receiving side, the cyclic prefix is removed and converted by Fast Fourier Transform (FFT). Finally samples are de-multiplexed and given to the user as frequency domain symbols.

Let's consider there are K numbers of users and each of them generating D number of bits at a time to transmit through multipath channel of different lengths L. Transmitted user's data (signal) is passed through different frequency selective fading channels due to user's location and mobility. Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL broadband internet access, wireless networks, and 4G mobile communications.

OFDM is essentially identical to Discrete Multi Tone Modulation (DMTM), and is a Frequency-Division Multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters.

Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate Inter Symbol Interference (ISI) and utilize echoes and time-spreading (on analogue TV these are visible as ghosting and blurring, respectively) to achieve a diversity gain, i.e. a signal-to-noise ratio improvement.

This mechanism also facilitates the design of Single Frequency Networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system.

4. DYNAMIC RADIO RESOURCE ALLOCATION ALGORITHM

The dynamic channel allocation algorithm proposed in this paper allocates the radio resources optimally within multiuser OFDMA system. Power and subcarriers have considered as the radio resources where frequency diversity is required. As the number of users increases, the frequency diversity also increases along with the optimum uses of the power.

Due to the flexibility nature of resource allocation, significant reduction in outage probability is measured. A notable amount of reduction in BER is observed with lower transmit power, while exploiting the proposed dynamic resource allocation scheme. The degree of accuracy of the dynamic channel estimation and update is one of the key challenges that is required to focus on, to make the proposed algorithm more robust and efficient. The OFDM scheme transmitter and Receiver structure is shown in Fig. 2.

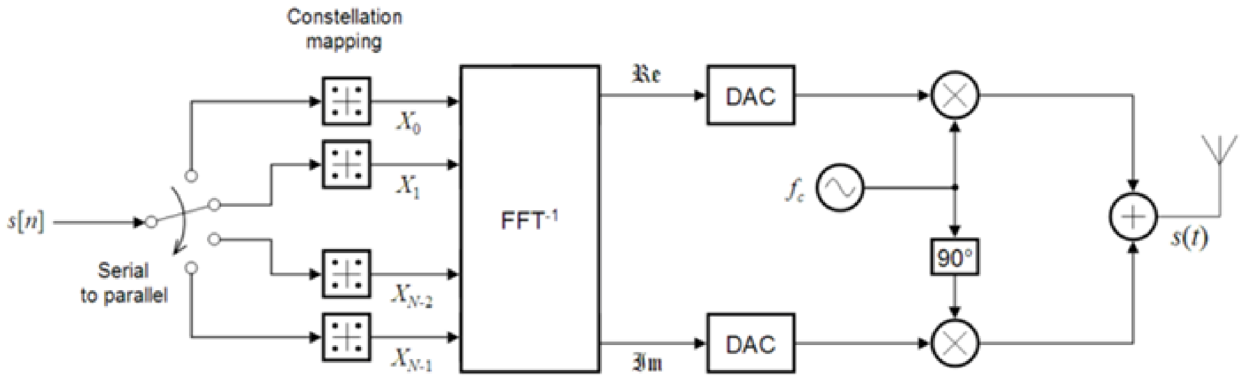

Fig. 2a OFDM Transmitter

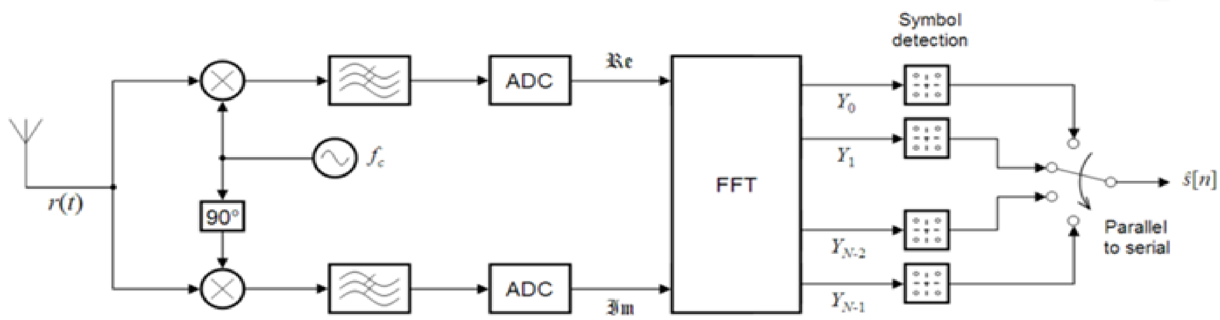

Fig. 2b OFDM Receiver

An OFDM carrier signal is the sum of a number of orthogonal sub-carriers, with baseband data on each sub-carrier being independently modulated commonly using some type of Quadrature Amplitude Modulation (QAM) or Phase-Shift Keying (PSK). This composite baseband signal is typically used to modulate a main RF carrier. If N sub-carriers are used, and each sub-carrier is modulated using M alternative symbols, the OFDM symbol alphabet consists of M^N combined symbols.

Incoming calls at each cell can be served by any of the system channels. In a cellular system, channels used at one cell site may be also used at other cell sites in case of absence of co-channel interference. Co-channel interference is the radio interference between channels using the same frequency.

Zhang *et al.* [9] introduced three algorithmic channel schemes: the Locally Optimized Dynamic Assignment (LODA), the Borrowing with Channel Ordering (BCO), and the Borrowing with Directional Channel Locking (BDCL). LODA is a DCA scheme that tries to optimize system performance by means of minimizing a cost criterion. In this scheme, channels are assigned so that the estimated blocking probability is minimized for future calls. BCO and BDCL re advanced channel-borrowing-based DCA strategies that lead to a more improved performance. A Hopfield neural network and a genetic-based DCA scheme provided in [10] and [11] are also considered.

5. PERFORMANCE ANALYSIS

To evaluate the performance of proposed algorithm; the system with three users is considered. The channel impulse response lengths are L1, L2 and L3 respectively and three different modulation schemes (i.e. BPSK, QPSK, M-QAM) have been considered. The subcarrier frequency response threshold vector is considered as [60 61]. If the frequency response of the channel in is less than 60, then that subcarrier is eliminated from allocation list. If 50 < in < 51 QPSK modulation scheme is considered during OFDM symbol mapping. Finally, the frequency responses with in > 51) are considered with M-QAM modulation scheme.

The performance of the channel allocation schemes has been derived in terms of the blocking probability for the incoming calls. The blocking probability is computed for the nine central cells. Simulation results were obtained and are shown in Figs. 3–6 for the cases of uniform and non-uniform traffic load conditions.

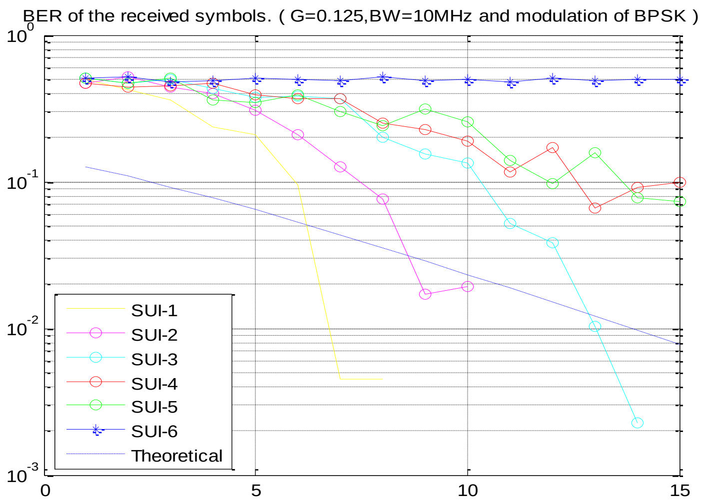

Fig.3 Performance of System with Bandwidth=10 MHz and Cyclic Prefix =0.125;

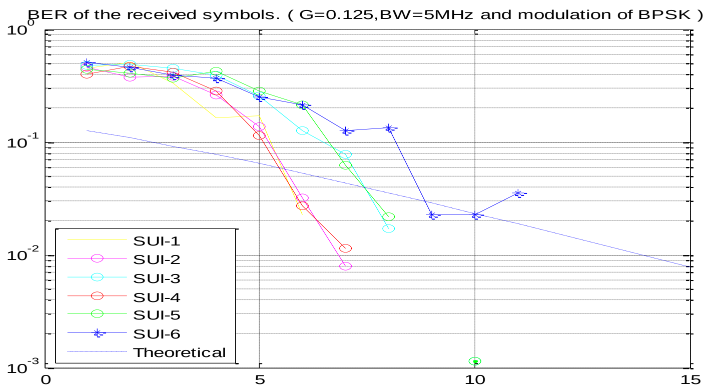

Fig.4 Performance of System with Bandwidth=5 MHz and Cyclic Prefix =0.125;

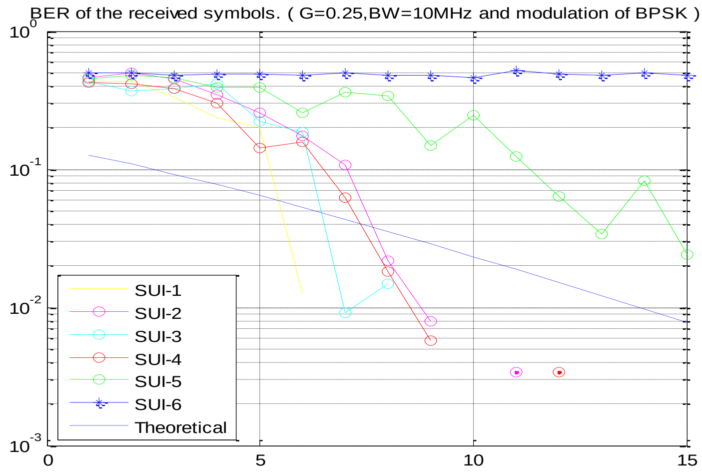

Fig.5 Performance of System with Bandwidth=10 MHz and Cyclic Prefix =0.25;

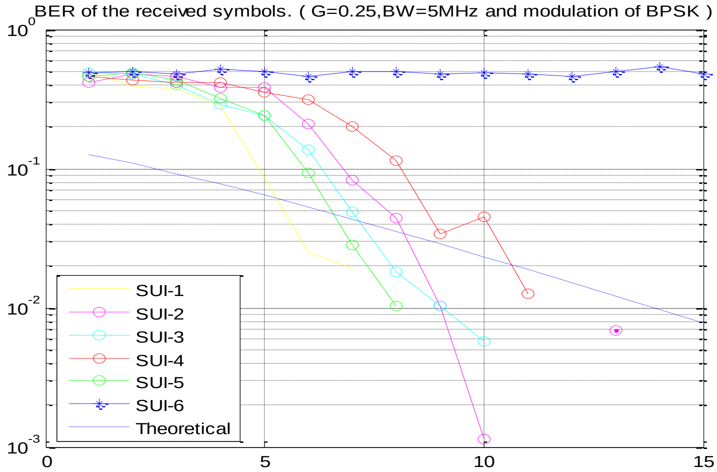

Fig.6 Performance of System with Bandwidth=5 MHz and Cyclic Prefix =0.125

The Dynamic channel assignment schemes provide many advantages, as explained before, compared to fixed channel methods and for that reason various deterministic DCA schemes have been proposed. The implementation complexity of the common deterministic DCA approaches together with the time requirement for their on-line operation, however, are two basic serious problems that led to the possible use of heuristics.

BER is improved by 60% compared to static OFDM system, due to the uses of the best subcarrier to send information symbol with highest modulation level. This improvement is achieved as trade off with the 12% of information throughput compared to its static OFDM counterpart. Dynamic power allocation also does not save any power within AWGN channel compared with static power allocation scheme. However, exploiting the proposed adaptive power allocation scheme saves power compared to static power allocation scheme.

6. CONCLUSION

The application of Channel allocation Schemes to models where traffic load conditions in Wi-MAX systems are changed dynamically is important to examine the robustness of the method. The implementation of the proposed scheme operating in a parallel machine which would minimize call service time sufficiently or otherwise would maximize the effectiveness of the particular channel assignment algorithm is also very challenging. By viewing the above schemes as combinatorial problems, their complexity is simplified and the allocation process becomes an optimization task for which the proposed scheme is able to give adequate solutions which can easily be implemented. The proposed scheme was found to be the most effective channel allocation scheme.

7. REFERENCES

[1] J. Bingham, may 1990. “Multicarrier Modulation for Data Transmission: an idea whose time has come”, *IEEE Communications Magazine*, vol. 28, no.5, pp 5-14.

[2] E. Casas and C. Leung, may 1991.”OFDM for Data Communication over Mobile Radio FM Channels. I.

Analysis and Experimental Results," *IEEE Transactions on Communications*, vol. 39, no. 5, pp. 783 -793.

[3] J. Heo, I. Cha, and K. Chang, June 2006. “A Novel Transmit Power Allocation Algorithm combined with Dynamic Channel Allocation in reuse partitioning based OFDMA/FDD system," *Proc. IEEE International Conference on Communications,* vol. 12, pp. 5654 -5659.

[4] D. Kivanc, G. Li, and H. Liu, Nov. 2003. "Computationally Efficient Bandwidth Allocation and Power Control for OFDMA," *IEEE Transactions on Wireless Communications*, vol. 2, no. 6, pp. 1150 -1158.

[51 M. Bohge, 1. Gross, and A. Wolisz, Dec. 2005. "The Potential of Dynamic Power and Sub-carrier Assignments in Multi-user OFDM-FDMA cells," *Proc. IEEE Global Telecommunications Conference*, vol. 5pp. 2932 -2936.

[6] S. Ko, J. Heo, and K. Chang, Sept. 2006. "Aggressive Sub-channel Allocation Algorithm for Efficient Dynamic Channel Allocation in Multi-user OFDMA System," *Proc. IEEE 17th International Symposium on Personal, Indoor and Mobile Radio Communications*, pp. 1 -5.

[7] S. Ko and K. Chang, Feb. 2007. "Capacity Optimization of a 802.16e OFDMA/TDD Cellular System using the Joint Allocation of Sub-channel and Transmit power," *Proc. The 9th International Conference on Advanced Communication Technology,* vol. 3, pp. 1726 -1731.

[8] A. Goldsmith and S.-G. Chua, Oct. 1997. "Variable-rate Variable-power MQAM for Fading Channels," *IEEE Transactions on Communications,* vol. 45, no. 10, pp. 1218 -1230,

[9] M. Zhang and T.-P. Yum, Nov. 1989. “Comparisons of Channel Assignment Strategies in Cellular Mobile Telephone Systems,” *IEEE Trans. Veh. Technol.*,vol. 38, pp. 211–215.

[10] E. Del Re, R. Fantacci, and L. Ronga, Feb. 1996. “A Dynamic Channel Allocation Technique based on Hopfield Neural Networks,” *IEEE Trans. Veh. Technol.,* vol. 45, pp. 26–32.

[11] H. G. Sandalidis, P. P. Stavroulakis, and J. Rodriguez-Tellez, June 1997. “Implementation of Genetic Algorithms to a Channel Assignment Problem in Cellular Communications,” i *Proc. 6th Int. Conf. Advances in Communications and Control (COMCON 6),* pp. 453–460.