

# **Subcarrier Resource Allocation Based Cooperative OFDMA Systems with QPSK Modulation**

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**ABSTRACT:** This project proposes the cooperative multiuser OFDMA systems with subcarrier resource allocation technique. A particular subcarrier resource allocation approach about which this paper proposes is a method, based on nodes that transmit and receive on adjacent OFDM subcarriers simultaneously. I propose a transceiver structure to reduce the interference between transmitting subcarriers and receiving subcarriers. The transceiver structure includes QPSK (Quadrature Phase Shift Keying). In this two sets of signals would be mixed; the required 90° of phase separation between the carriers allows the sidebands to be separated by the receiver using phase discrimination. Its performance in terms of signal to interference and noise ratio (SINR) is evaluated by simulation and is incorporated into a recently proposed cooperation strategy for OFDMA systems to examine its performance under the realistic structure. It is shown that SINR increased when QPSK modulation used.

**KEYWORDS:** Cooperative communication, OFDM, OFDMA, Subcarrier based duplexing

## **I. INTRODUCTION**

Cooperation is the process of working together, opposite of working separately in competition. Recently, such a concept has been adopted from social sciences and economics to constitute a major research area in wireless communication networks. When cooperative communication is incorporated in OFDMA systems, overall performance enhanced further. Potential benefits of cooperation are improved channel reliability, improved system throughput, seamless service provision, and operation cost reduction. Improved channel reliability includes mitigating channel impairments and interference reduction. The wireless communication channel suffers from several phenomena that decrease its reliability. These phenomena include path loss, shadowing and fading. An improved system throughput can be a direct benefit from enhanced wireless channel reliability through employing cooperative transmissions at the physical layer. Seamless service provision is needed because mobile users are more sensitive to call dropping than call blocking.

Orthogonal frequency division multiplexing (OFDM) introduces the concept of allocating more traffic channels within limited bandwidth of physical channel. Here the available bandwidth is split into several narrowband channels for simultaneous transmission. In frequency division multiplexing (FDM) a guard band is provided between individual channels, which separates the spectrum of different channels and enables a practical band pass filter to detect individual channel. But the situation is completely different in OFDM where spectrums of adjacent channels are overlapped which resembles adjacent channel interference, but interference is avoided by maintaining orthogonal relation between sub-carriers. First of all high speed serial data is converted to low speed parallel data. Therefore transmitted signal is a vector addition of orthogonal modulated carriers, makes large peak to average power ratio, therefore dynamic range of devices should be large enough

**II. LITERATURE REVIEW**

**1) RESOURCE ALLOCATION BASED ON OFDM SYMBOL BASED RELAY SELECTION**

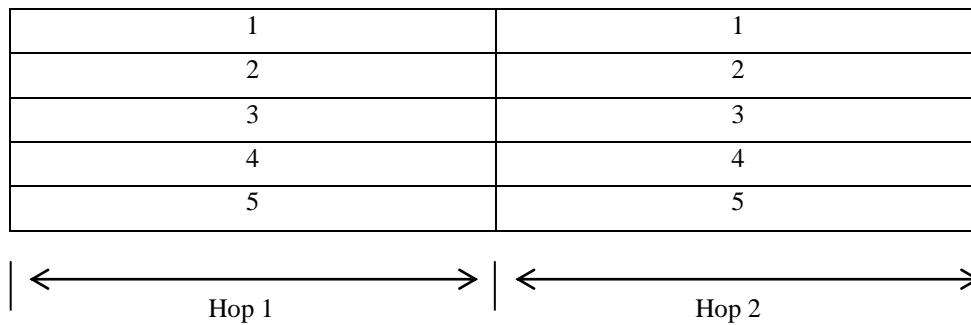


Figure 2.1: OFDM symbol based relay selection.

A common selection strategy is to choose the relay with the best equivalent end to end channel gain. End to end equivalent channel gain is calculated as the minimum number of channel gains of the first and second hops under the decode and forward protocol or the harmonic mean of both channel gains under the amplify and forward protocol. This can be extended to OFDM systems. Here one relay is selected based on the channel condition of the whole OFDM symbol. Such a symbol based relay selection may not be efficient since the differences of channel conditions among different subcarriers are not fully utilized.

**2) RESOURCE ALLOCATION BASED ON SUBCARRIER BASED RELAY SELECTION**

Subcarrier based relay selection resource allocation selects one best relay for each subcarrier. This exploits both node diversity and frequency diversity. Such a scheme can be called as subcarrier to relay assignment. This subcarrier to relay assignment assumes that signals received over one subcarrier (say i) is amplified (or decoded) and forwarded by the relay also over subcarrier i in the next hop. This doesn't exhibit optimal system performance.

**3) RESOURCE ALLOCATION BASED ON SUBCARRIER PAIR BASED RELAY SELECTION**

System performance can be improved if the subcarriers in the first and second hops are paired according to the channel conditions. This is called subcarrier based relay selection. Ordered subcarrier pairing is optimal for AF protocol.

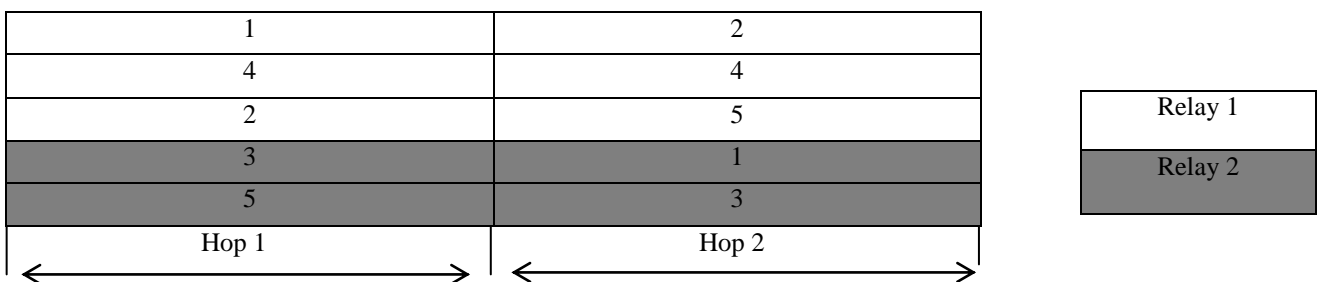


Figure 2.2: Subcarrier pair based relay selection

Such subcarrier-by-subcarrier based pairing is not sufficient for DF protocol, where the information from one set of subcarriers in the first hop can be decoded and re-encoded jointly and then transmitted over a different set of subcarriers in the next hop. By using the dual method, the mixed integer programming problems are solved with polynomial complexity. To reduce the complexity of the problem with power constraints, two suboptimal approaches

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are introduced. The suboptimal algorithm which decouples the power allocation with the subcarrier pairing and relay assignment performs close to optimality with less complexity.

### III. PREVIOUS WORK

A particular subcarrier resource allocation scheme based on nodes that transmit and receive on adjacent OFDM subcarriers simultaneously is proposed. This is referred to as “subcarrier based duplexing”. Using of decode and forward strategy for cooperation helps to achieve near upper-bound performance. Subcarriers when allowed to be concurrently allocated to multiple links can improve system throughput. Although subcarrier based duplexing appears possible in ideal OFDM systems, the orthogonality between different subcarriers is lost in realistic communication system. This is due to the non-ideal characteristics of different subsystems. Subsystem imperfections include frequency offset of local oscillator, nonlinearity of power amplifiers, quantization errors, I/Q imbalance, time jitter of ADC/DAC, time synchronization.

A transceiver structure is proposed to reduce the interference between transmitting and receiving subcarriers and also care has to be taken to avoid the above mentioned subsystem imperfections. This structure utilizes baseband echo cancellation to suppress interference between transmitting and receiving subcarriers. It is possible to achieve subcarrier based duplexing in short range low transmit power communication systems by this transceiver structure. By incorporating this with cooperation strategy performance under realistic conditions can be derived. Although the performance of the cooperative networks degraded due to the residual interference imposed on the receiving subcarriers by the transmitting subcarriers, it still outperforms conventional cooperation schemes. Optimal decode and forward has power consumption less than that of AF&DF cooperation scheme. This is a major advantage of optimal DF scheme.

Quadrature Amplitude Modulation is used for modulation. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by  $90^\circ$  and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation.

### IV. PROPOSED WORK

Estimation of signal to noise ratio for the received signal is an important task in communication systems. The knowledge of the SNR is a requirement on many systems in order to perform efficient signal detection and link adaptation. In adaptive modulation system a way is needed to decide which modulation level is best suited for the present channel condition. The channel estimation using Quadrature Amplitude modulation technique (QAM) was used in the previous work. When the range of communication increase QAM gives poor performance. So QPSK modulation scheme is used to increase the SINR.

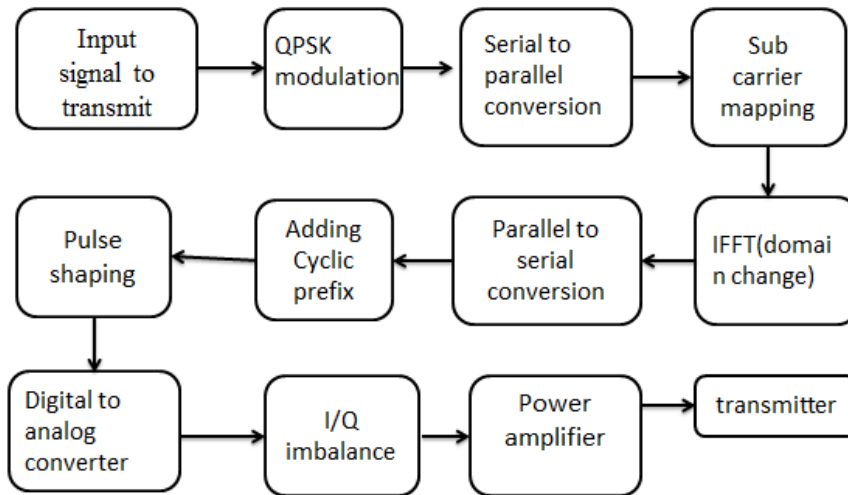


Fig. 4.1 Block diagram of proposed transceiver structure.

- Quadrature Phase Shift Keying (QPSK)-It is a form of Phase ShiftKeying in which two bits are modulated at once, selecting oneof four possible carrier phase shifts (0, 90, 180, or 270 degrees).QPSK allows the signal to carry twice as much informationas ordinary PSK using the same bandwidth.
- Cyclic Prefix method-It is a copy of last part of OFDM symbol to the beginning of the symbol and is removed at the receiver before demodulation. It should be at least as long as significant part of impulse response experienced by the transmitted signal.
- I/Q imbalance- The In-phase (I) and the Quadrature (Q) channels are necessary for any angle modulated signals because the two sidebands of the RF spectrum contain different information and may result in irreversible corruption if they overlap each other without being separated into two phases.

## V. EXPERIMENTAL RESULTS

Computer simulation is done to evaluate the performance of the proposed transceiver and these are also compared to the analytical results developed in the previous section. We target a system with parameters similar or related to those specified by the IEEE 802.11a/g standard. The transmit messages on each subcarrier are modulated by QPSK. The FFT size and CP length are 64 and 16, respectively and the total number of subcarriers utilized is 52. The pulse shaping filter is a Hanning windowed sinc function, with oversampling factor  $RTx=16$ . For simplicity no convolution coding or data scrambling is applied. Both the near-end and far-end channels are modeled as multipath Rayleigh fading, with the path loss model and power delay profile (PDP) given by standard IEEE 802.11 WLAN channel model.

Fig. 5.1 shows the increase in SINR when using QPSK modulation compared with QAM.SINR increases from 85dB for QAM to 150 for QPSK.By using QPSK in the transceiver structure,the SINR for the first stage is increased from 18dB to 42dB.Also the SINR for secondstage of echo cancellation is increased from 35dB to 90dB.

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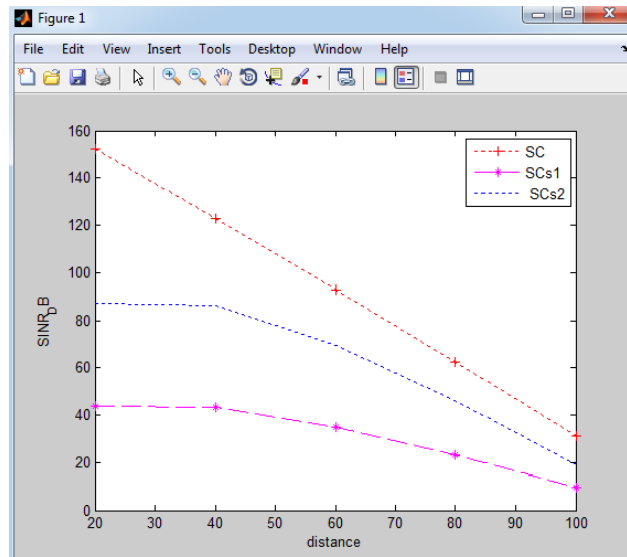


Figure 5.1 Performance of the proposed transceiver with interleaved subcarrier allocation

Fig. 5.2 shows the results when the data rate of user 1 and user 2 varies while  $d_{10}$  is fixed to be 50m. It can be seen that the difference between the power consumption of DF cooperation in the ideal case and that in the realistic case increases with the data rate. The reason is that the transmit power of user 1 increases with the data rate, therefore more interference is generated to the data streams from user 2 to user 1, and user 2 needs to scale up its transmit power in order to compensate for the SINR loss. As the data rate increases, the extra transmit power required by user 2 also increases, thus the total power consumption of optimal DF cooperation will finally exceed that of AF&DF cooperation and that of no cooperation. However, it can be seen from Fig. 5.2 that optimal DF cooperation is advantageous in most of the data rate region. This remains a power consuming method.

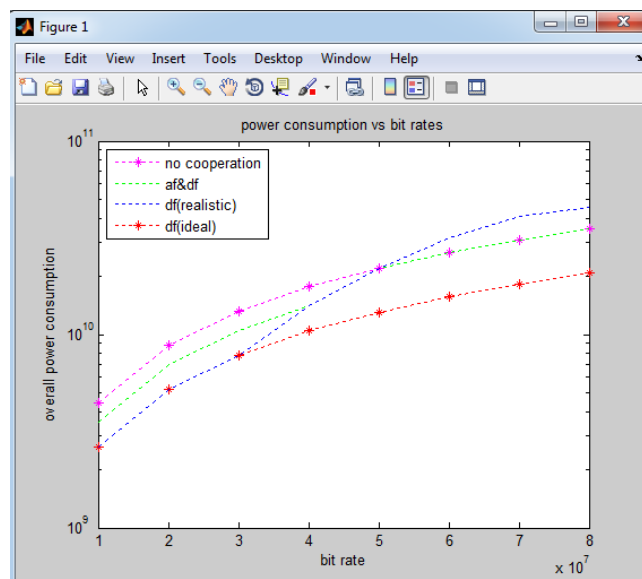


Figure 5.2 Total power consumption of 2-user cooperative OFDMA system for different data rates

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