

The Cooperative Diversity-Based on the OFDM Modulative System

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Abstract. The cooperative diversity technology is combined with the orthogonal frequency division multiplexing (OFDM) technology, the study is made on 16QAM modulation mode, based on the OFDM systems of two kinds of CRC and convolution code coding of cooperative communications. Meanwhile, the simulations of the paper analyze two solutions of amplification forwarding and decoding forwarding communication with the 16QAM modulation. Also compare and analyze the simulative performance of the CRC coding cooperation and convolution code coding cooperation, then integrally compare the DF, AF, CRC coding, convolution code coding cooperative communication performance. Simulation results show that, the cooperative communication ,based on the coding cooperation of Convolution - OFDM ,gain remarkable diversity gains, the system performance get greatly improved. Visibly, the coding cooperation of Convolution - OFDM greatly improve the performance of the wireless communication system.

Keywords: OFDM, CRC coding, OFDM systems, Convolution code coding, Cooperative communications

1. Introduction

User cooperation is a kind of physical technology, which distribute effectively system resources by user cooperation in a wireless system, and improve diversity gain of each user , and also is a very promising spatial diversity technology. it can be practical use of space resources to improve the performance of communication system, it is currently a research hotspot of the wireless mobile communication researchs, and have important applications in the wireless communications of multipath channel and the strong noise.

In cooperative diversity system, the cooperation between the pattern mainly have two kind of patterns ,which are AAF(amplify-and-forward) andDAF(decoded-and-forwarding). H. Lu, h. Nikookar [1] researchers do related research in the AAF and DAF.

As a kind of high efficient Modulation (Multi Carrier Modulation, MCM) technology. OFDM (Orthogonal frequency division multiplexing) technology [7] has been concerned and become a core technology of the fourth generation mobile communication. This system can be well against frequency selective decline or narrowband interference because of its unique advantages, but also can improve the transmission rate. in some bad environment,so it will be very attractive in communication.

Jerry c. h. Lin [2] researchers do some related researchs about the technology of combining the OFDM technology and coding cooperative diversity technology. First ,this paper studies the basic principle of cooperative diversity , and OFDM systems design.then compare and analyze of performance the DF AF, also analyze the performance basing on OFDM systems of two kinds of channel coding (CRC, COV code) cooperative approaches. Eventually, convolution code cooperative diversity improves greatly diversity gain .

2. Cooperative Diversity Technology

Currently,cooperative diversity technology has quite a few related research achievements in wireless communication channel. Several common user cooperation schemes include: amplifier - sending (amplify - and - forward) scheme, decode -- sending (decode - and - forward) scheme, space-time cooperative solution and coding cooperative solution [3-4]. Among them, the coding cooperative solution belong to a half-duplex mode cooperative solution. Coding cooperation goal is to make the same user coding trnsmit as possible

through two independent transmission paths, make it reach the purpose of spatial diversity. The basic idea is that the user transfer the additional redundant information by its partner. When cooperative contributes to slow performance, user's partner will not transfer the information, and the redundant information transmission partners own redundant information to cooperative performance. Can be generally through the estimation error detection coding, such as cyclic redundancy check (CRC, Redun - dancycheck) Cych, means to realize, without the user and its partners estimates between feedback.

The basic wireless cooperation system [5-6]consists of the source end users USE1, the cooperative users SUE2 and the destination end BS, as shown in figure 1 .

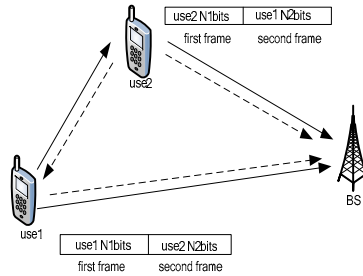


Fig.1. Two users cooperation model

Among them, the cooperative users is only the relay of the source end users, without its own data. The System uses half-duplex mode, namely the user cannot simultaneously receiving and transmitting signals. Assuming the system channel is Flat Rayleigh block declining channel, whose declining coefficient remain unchanged in a block ,but fading coefficient is mutual independent between different blocks. in coding cooperation, a working cycle is divided into two stages in the first phase, the source end users separately sends the modulation signal which the first code words(length for N1bit) correspond to the cooperative users and the destinative end, then the cooperative users demodulates the received signal , and then decodes the demodulation signal according to relevant technology , and the results are checked by CRC. The second phase, if the cooperative users successfully check , it may be engaged in cooperation, then decoding information and encode again, and then send the corresponding modulation signal of the check code word (length for N2bit) to the destination end. Otherwise, the cooperative users is in the idle state,not cooperative.The source end users send its corresponding modulation signal of the check code word to the destination end. Now USE1 is the source end users, the first phase, for the cooperative users USE2 and destination end BS the received signals respectively expresses as:

$$Y_{1,2}(t) = H_{1,2}(T)u_1 + N_{1,2} \quad (1)$$

$$Y_{1,d}(t) = H_{1,d}(t)u_1 + N_{1d} \quad (2)$$

Here, U1 means the signal which the source end users send ; $H_{1,x}(t)$ means the declining channel coefficient from user 1 to node x, obey variance σ_{1x}^2 of Rayleigh distribution ; N_{1x} means the channel noise from U1to node x , additive white gaussian noise which obey average 0 and variance σ_{1x}^2 .

The second stage, for the destination end,its received signals can be expresses as:

$$Y_{x,d}(t) = H_{x,d}(t)u_x + N_{x,d} \quad (3)$$

Here, X means USE1 or USE2, when it cooperate,X is USE2 ,otherwise USE1. $Y_{x,d}(t)$ means the modulated signal which the check code word correspond and which node X send to the destination end.if CRC checking is successful, the destination receives the signal N2bit which USE2 send Otherwise ,the received signal is USE1's N2bit. Then the destination merges $Y_{1,d}(t)$,with $Y_{x,d}(t)$, and decodes , eventually recovers the original message.

3. OFDM System Design

OFDM is a basic technology. OFDM is easy to combine the space-time codes, diversity, interference suppression, smart antenna, and currently widely respected MIMO systems and wireless communication cooperative diversity system, greatly improve the reliability of physical layer's informative transmission.

Will OFDM technology [7] and the star 16QAM demodulation technology of together ,the basic structure diagram:

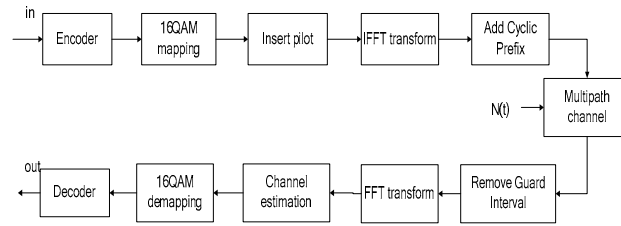


Fig.2. Basic structure principle diagram of 16QAM-OFDM

First, the input signal do channel coding, for instance: the CRC, convolutional coding. After channel coding,then do 16QAM modulation . 16QAM are used to realize 16QAM mapping.Compared with other QAM coding modulation technology, 16QAM can make full use of bandwidth, anti-noise ability and so on.meanwhile,16QAM has better performance than QPSK, and improves the transmission efficiency. Then do insert pilot, which make for undertake Fourier inverse transform.after it , outputing OFDM modulation symbols.

Through inserting Cyclic Prefix whose duration time is greater than the maximum channel transmission delay behind OFDM modulation Symbol , Cyclic Prefix can effectively eliminate Inter – Symbol interference (ISI). insert process figure of Cyclic Prefix as following:

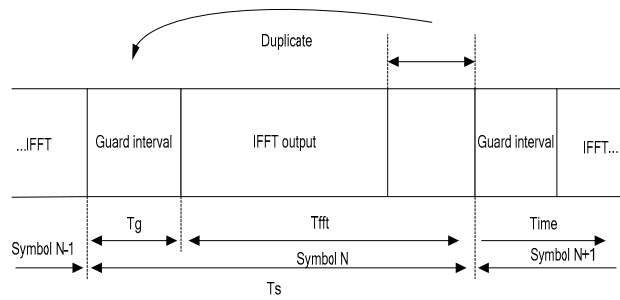


Fig.3. Insert course of Guard Interval

Assuming the number of OFDM systems's subcarrier is N, bandwidth for WHz, the length of symbols for To_f ,the length of CP for T_{cp}. Namely a OFDM frame symbols's transmission time is T = T_{cp} + T_{of}; Meanwhile, $x_{0,l} x_{1,l} \dots x_{N-1,l}$, is the L data which a OFDM symbol carries (already modulate), if the L baseband symbol of OFDM system is expressed as:

$$S_l(t) = \sum_{k=0}^{N-1} x_{k,l} \phi_k(t - lT) \quad (4)$$

$$\phi_k(t) = \begin{cases} \frac{1}{\sqrt{T - T_{cp}}} e^{j2\pi \frac{W}{N} K(T - T_{cp})} & t \in [0, T] \\ 0 & otherwise \end{cases}$$

Indicate the first k carrier wave

Such the emitted signal can be expressed as:

$$S(t) = \sum_{l=-\infty}^{+\infty} s_l(t) = \sum_{l=-\infty}^{+\infty} \sum_{K=0}^{N-1} X_{K,L} \phi_K(T - lT) \quad (5)$$

After that, do independent transmission by using two road multipath channel, and adopting code cooperative transmission signal, noise obeys Rayleigh declining distribution. First removing guard interval in received end, it usually always be 20% ~ 30% of symbol duration time. generally, Guard interval is used to launch a copy period of final border of symbol , such copy called cyclic prefix,to do it can still keep

receiving end's carrier synchronization after going through time dispersion channel, the length of cyclic prefix obviously is limited by Guard interval duration time, so need to do process to the cyclic prefix which system insert and remove in transmitting and receiving end. Then step by step recover the original signal.

For coding cooperative diversity technology combined with OFDM technology. This makes channel more effectively withstand frequency selective decline or narrowband interference in multipath transmission. This article analyses the result of combining OFDM systems with cooperative coding through simulation .eg,CRC coding, convolutional code coding.

4. The Analysis of Simulation

Based on multipath declining channel, Simulation use two multipath channel to do independent transmission, obey Rayleigh declining distribution.The cooperative diversity system includes: a source node, a cooperative node and a destinaion node ,the path distance ratio between the three is 1:1:1.

The input number of bits is 2080000bit bits. Cooperative diversity system which based on the 16QAM modulation used respectively AAF and DAF cooperative strategy . Their bit error ratio simulations show:

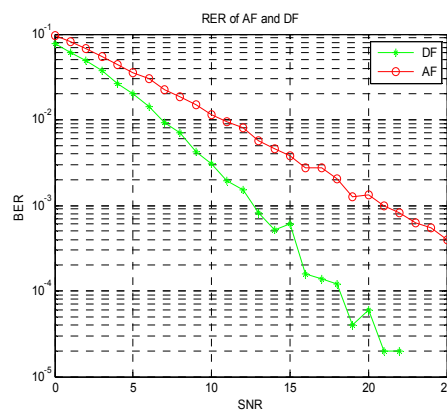


Fig.4. Performance simulations of AF and DF

From the display of FIG. 4, at the same SNR, bit error ratio of DF cooperation is lower than AF cooperation .visibly, using DF strategy to cooperate communication can improve communicative performance.

Based on the OFDM systems, using CRC, convolutional code as channel coding. The input signal is 2080000 bits, and each simulation produces 10 ^ 4 OFDM symbols, each symbol contains 52 bits, with 52 data carrier. The system does 64 points of FFT and IFFT transform . Their bit error ratio simulation as following:

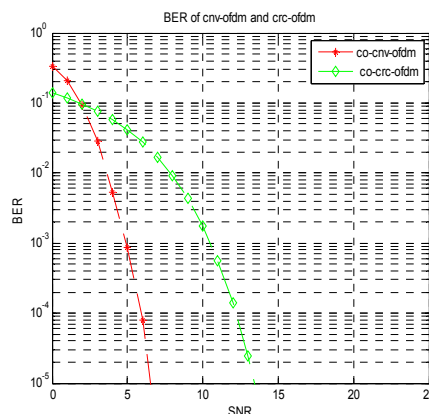


Fig.5. Performance simulations of the OFDM systems in different coding cooperation

The simulation results show that, when SNR is equal or greater than 2, the communication performance of co-convolution-ofdm improve significantly, and get a great diversity gain. So in designing coding cooperative diversity which based on the OFDM systems, we decide to prefer using convolutional code coding to CRC coding as cooperative coding.

Figure 6 are four cooperative simulation for AF, DF, CRC - OFDM, Convolution- OFDM.

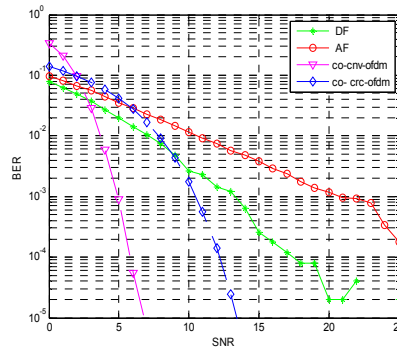


Fig.6. Performance simulations of the OFDM systems in different cooperative methods

Based on 16QAM modulation mode, the amplify forwarding need to calculate the amplification gain, and the parameters need to calculate in each module .Therefore, we would like to estimate the parameters of each channel properties. The performance DF which uses the OFDM systems is better than AF, but the relay end needs to do decoding to the receiving signal, then re-encode signal and send it to the destination, so it undoubtedly increases relay complexity, and spends a lot of computing time.

Based on the channel coding of the CRC and convolution code, they transmit the additional redundant information outside their information by itself user's partner. When the cooperative performance is poor, the user's partner will not transmit the user's redundant information ,but transmit its own redundant information. When the performance is good, they transmit the redundant information each other .

The simulation results show that, Relative to the basic two cooperative diversity , the channel coding which joins OFDM systems gets a remarkable diversity gain, the performance of the system greatly improve. In the simulation shows the Convolution - OFDM cooperative way is the most ideal.

5. Conclusion

This article mainly aims at two kinds of cooperative approach for OFDM systems , which are CRC - OFDM, Convolution - OFDM cooperative diversity. the simulation show that the cooperative communication can effectively reduce the frame error ratio or bit error ratio for the wireless communication system, improve signally communicative quality, and gain anticipative effect. This provides a achievable base for the further studies of the cooperative diversity in OFDM system, the future could put the coding cooperation into the actual experiment, use cooperative communication to improve data transmission.

6. References

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