Channel Statistical OFDM Transmission System Resource Allocation Algorithm

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Abstract. In order to achieve high spectral efficiency in OFDM transmission system, it is necessary to put forward the corresponding efficient subcarrier and power allocation algorithm. Therefore, on the basis of understanding the basic principle and system structure of OFDM, this paper analyzes the corresponding allocation algorithm according to the multi-user water injection theory, and studies the final results, so as to provide an effective scientific basis for future channel statistics research.

1. Principle and system of OFDM
This is a unique means of multi-carrier transmission, which can transform high-speed serial data into multiple parallel sub-data streams for synchronous transmission. [1-3]Assuming that N represents the number of sub-channels and T represents the width of OFDM, then di (i = 0,1,2... , N-1) is the data symbol of all subchannels, and fe represents the frequency of the carrier. From t=Tz, the OFDM symbol can be expressed as:

\[ s(t) = \text{Re} \left[ \sum_{i=0}^{N-1} d_i \exp \left[ j2\pi \left( f_e - i \frac{0.5}{T} \right)(t - Tz) \right] \right] , t_z \leq t \leq t_z + T \]  

(1)

In addition, many literatures will use the formula shown below to represent its output signal. The real and imaginary parts of this formula correspond to the identical and orthogonal components of OFDM symbols respectively. [4-7]In practical application, the cosine and sine components of corresponding subcarriers can be multiplied, and finally the signals of subchannels and the synthesized OFDM symbols can be obtained.:

\[ s(t) = \sum_{i=0}^{N-1} d_i N/2 \exp \left[ j2\pi \frac{i}{T} (t - Tz) \right] , t_z \leq t \leq t_z + T \]  

(2)

2. Multi-user water injection theory
The OFDM transmission theory and process are briefly understood above, and the multi-user water injection theory is analyzed below. If the transmission function of the U user in the KTH word channel is Gu (k), and the value of equilibrium power spectral density of noise is N0, then the defined formula can be obtained as \[ T_M(k) = g_u(k)/N_0 \]. [8-11] The essence of this theory is to
distribute the subcarriers to a user with the highest SNR. After technical allocation, user U on the KTH channel can obtain the transmission power formula as follows:

\[ \sum_{k=1}^{l_1} \left( 1 - \frac{b(2)N_0}{g_2(k)} \right)^* = b(2)p(2) \]

\[ \sum_{k=1}^{l_1} \left( 1 - \frac{b(3)N_0}{g_3(k)} \right)^* = b(3)p(3) \]

(3)

It should be noted that although this theory plays a positive role in solving the multi-user channel statistical transmission problem, the complexity of the specific algorithm will become higher and higher with the substantial increase in the number of users. Therefore, it is the core content of the project to obtain an efficient wireless resource allocation algorithm.

3. How to design the correlation scheduling algorithm based on channel statistics

In the OFDM system with multiple users, because the channel has some statistical correlation, it can be used as the basis to replace the channel state change to allocate, which can not only reduce the amount of channel control, but also reduce the application difficulty of the algorithm in combination with the discrete time mode.

3.1. Two users

The channel statistics can be expressed as \( g_N(k) = W_u^H R_u^{(u)} w_u(k), (u = 1, 2; k = 1, 2, ..., L_m) \). Among them \( R_u^{(u)} \) is the correlation matrix for the channel, and \( H \) is the conjugate transpose. If the channel statistical parameter coefficient of the U user is set as, and the number is LU, then we can get \( R_u^{(u)}(i, j) = R_u^{(u)}(i, j)^* \). By using the relevant information of channel statistics for analysis, in order to meet the requirements of multi-user water injection theory and allocate power and subcarriers scientifically, the following formula should be complied with:

\[ I_1 = \frac{k b(1)N_0}{g_1(k)} \leq \frac{b(2)N_0}{g_2(k)} \]

\[ I_2 = \frac{k b(2)N_0}{g_2(k)} \leq \frac{b(1)N_0}{g_1(k)} \]

(4)

If \( p(u) \) is the power limit value of user \( u \), then it can be expressed as, and the formula as follows can be obtained:

\[ \sum_{k=1}^{l_1} \left( 1 - \frac{b(1)N_0}{g_1(k)} \right)^* = b(1)p(1) \]

\[ \sum_{k=1}^{l_1} \left( 1 - \frac{b(2)N_0}{g_2(k)} \right)^* = b(2)p(2) \]

(5)

Then, combining with the dichotomy, we quickly search the optimal user factors B (1) and B (2), as well as the segmentation point of the channel, to ensure that the following inequality is true,
and finally it is easy to infer that all the subcarriers left of the segmentation point must give the user 1.
\[
\frac{g_1(0)}{g_1(1)} \geq \frac{g_1(2)}{g_1(3)} \geq \ldots \geq \frac{g_1(k_{\text{odd}})}{g_1(k_{\text{odd}+1})} \geq \frac{g_1(k_{\text{odd}+2})}{g_1(k_{\text{odd}+3})} \geq \ldots \geq \frac{g_1(N)}{g_1(N-1)}
\]
multi-user

In one case, it is assumed that there are 3 users. This assignment algorithm is very similar to that of 2 users, and both of them have the equation formula for constraining sub-channel assignment, as shown below:

\[
I_1 = k \frac{b(1)N_b}{g_1(k)} \leq \min \left( \frac{b(2)N_b}{g_1(k)}, \frac{b(3)N_b}{g_1(k)} \right)
\]

\[
I_2 = k \frac{b(2)N_b}{g_2(k)} \leq \min \left( \frac{b(1)N_b}{g_2(k)}, \frac{b(3)N_b}{g_2(k)} \right)
\]

\[
I_3 = k \frac{b(3)N_b}{g_3(k)} \leq \min \left( \frac{b(1)N_b}{g_3(k)}, \frac{b(2)N_b}{g_3(k)} \right)
\]

\[
\sum_{i=1}^{N} \left( 1 - \frac{b(2)N_b}{g_1(k)} \right)^{N} = b(2)p(2)
\]

\[
\sum_{i=1}^{N} \left( 1 - \frac{b(3)N_b}{g_1(k)} \right)^{N} = b(3)p(3)
\]

(6)

At the same time, by simplifying and merging the above formulas, the formula as shown below can be finally obtained. Thus, the scheduling problem of 3 users can be transformed into that of 2 users, so as to process channel transmission faster.

\[
\sum_{i=1}^{N} \left( 1 - \min \left( \frac{b(2)N_b}{g_1(k)}, \frac{b(3)N_b}{g_1(k)} \right) \right)^{N} = b(2)p(2) + b(3)p(3)
\]

\[
\sum_{i=1}^{N} \left( 1 - \frac{N}{\max \left( g_1(k), g_2(k), g_3(k) \right)} \right)^{N} = b(2)p(2) + b(3)p(3)
\]

(7)

On the other hand, if the number of system users is more than three, the following formula can be obtained:

\[
g_{2,3} = \max \left( \frac{g_2(k)}{b_{\text{old}}(2)}, \frac{g_3(k)}{b_{\text{old}}(3)} \right)
\]

\[
w_{2,3} = b_{\text{old}}(2)p(2) + b_{\text{old}}(3)p(3)
\]

(8)

Transforming it into the allocation mode of 2 users, the following formula can be obtained, where I = 1, 2, ..., u.

\[
I_1 = k \frac{b(1)N_b}{g_1(k)} \leq \frac{b_yN_b}{g_1(k)}
\]

\[
I_2 = k \frac{b_yN_b}{g_1(k)} \leq \frac{b(1)N_b}{g_1(k)}
\]

\[
\sum_{i=1}^{N} \left( 1 - \frac{b(1)N_b}{g_1(k)} \right)^{N} = b(1)p(1)
\]

\[
\sum_{i=1}^{N} \left( 1 - \frac{b_yN_b}{g_1(k)} \right)^{N} = \omega_b
\]

(9)
The allocation algorithm of two users is applied to the system to obtain \( B(1) \) and the subcarrier set allocated to user 1 or other users through correct calculation, and the subcarrier and power in the channel are allocated scientifically by the way of suboptimal processing. At this time, the allocation algorithm will become a discrete mode, combined with iterative calculation can effectively reduce the difficulty of calculation.

3.2. Result analysis

Under Rayleigh weakness, three scheduling algorithms of channel statistics, state and path loss are simulated respectively, among which the first and the third are very similar and belong to a form independent of channel state. If the total bandwidth of the simulation system is 5MHz, and it has 256 subcarriers, the frequency response is flat, and the signal to noise ratio (SNR) of the receiving end is static

\[
R_{SNR} = \left( \sum_{u=1}^{U} p(u) + G - P - I \right)(BN_u^t), \quad \text{Where C represents the capacity of the system, and the formula is}
\]

\[
C = \frac{1}{N} \sum_{u=1}^{U} \sum_{k=1}^{N_u} \log_2 \left( 1 + \frac{R_{SNR}(u,k)}{\beta} \right).
\]

In the environment with different signal-to-noise ratios, the system capacity curves of the two users are shown in Figure 1 below. By analyzing the actual curve changes, it can be seen that the capacity differences of the three scheduling algorithms are very small in the fast fading environment. However, under the condition that the number of users is limited to 8, the three scheduling algorithms under different SNR are shown in Figure 2 below, in which the scheduling algorithm of path loss is significantly increased. But compared with the channel state, the overall capacity is too weak.

![Figure 1. Two users](image-url)
If the SNR of the user receiver is always maintained at 10dB, and the relevant factors of channel parameters are always changing between [0,1], then the system capacity will change with the number of users, as shown in Figure 3 below:

Combined with the above simulation information analysis, it can be seen that when the number of system users is greater than or equal to 15, the channel transmission will be in the state of high load, and the channel statistical advantage at this time is significantly higher than the path loss, and the overall complexity of operation is very low, which effectively reduces the control channel.

**4. Conclusion**

To sum up, channel statistical OFDM transmission system is the core content of future communication technology research, and the allocation algorithm is also a difficult problem that needs to be explored and solved at present. Therefore, under the background of new era, scientific research institutions in time to strengthen capital and investment at the same time, also to do a
good job of professional personnel training, study more excellent examples at home and abroad for reference, mastering the basis of the existing theory and the scientific research technology, bold assumption, caution beg a certificate to verify in practice to get more high quality resource allocation algorithm.

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