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Maritime Wireless Data Communications of Predictive Frequency Hopping Technique

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Abstract

In this paper, For 4th generation wireless communication systems, we propose a method to predict FH patterns in FH-OFDMA systems. OFDM is recognized as a promising modulation technique. Multi-user allocation in OFDM system can use FH that provides the spectrum-spread techniques. If one can generate more predictable FH sequences, then performance of the system can be easily improved. Current random FH and simple adaptive FH methods, however, are not considering predicting FH sequences. In this paper we show that the sampling of the wireless faded signal is not realized as a certain probability nature. With this regard, the proposed predictive FH allocation method is designed to embed the unknown probability models. Simulation study shows that the predictive FH method is more accurately predict FH sequences than the random or simple adaptive FH methods. We will further improve this proposed method to apply QoS control and MAC function development in OFDMA based wireless physical structures, especially maritime wireless data communications.

Key words : OFDM, FH-OFDMA, OFDMA

1. Introduction

Multi-user accesses in OFDM systems are accomplished thru time, frequency, and code division processes. These three techniques applied to OFDM are compared in[1]. In this comparison study, transmitter has no information on the channel state before sending data. When the transmitter has knowledge of the channel states for each of the receivers, the system performance can be better achieved. An algorithm to find the optimum sub-carrier allocation for OFDM-FDMA system is derived[2], and the algorithm is refined in[3] to lower the complexity and convergence rate. Dynamical allocating the sub-carriers based on channel conditions can utilize the channel resources more efficiently. Assuming knowledge of the instantaneous channel gains for all users[2], proposes multi-user resource allocation in OFDM systems with fixed bit rate for each user. If adaptive modulation is used with OFDM, significant performance is achieved[2]. The employment of high modulation scheme for sub-carriers with large channel gain can increase the spectral efficiency of the overall system. OFDM-FDMA multi-user allocation technique can be easily achieved the dynamic allocation of the sub-carriers and adaptive modulation than the OFDM-TDMA and OFDM-CDMA. Frequency hopping (FH) with OFDM-FDMA (or FH-OFDMA) can allocate the clustering sub-carriers to users causing frequency diversity. If some clusters are in deep null or existed the interferences from other users, FH-OFDMA can be hopped to other clusters. In multimedia traffic control in OFDMA systems, efficiently designed FH scheme can provide various different FH sequences in terms of required QoS demands.

In this paper, we investigate predictive FH pattern estimation method based on FH-OFDMA system over frequency selective fading channels. It maintains a monitoring of sub-channel gain then compares threshold and the gain at the predetermined OFDM symbol period. After the comparison, channel state is determined as good or bad. The channel state occurrences are averaged to estimate ensemble average of the state. This value is primarily used to sort the all the sub-channels. The highly ranked sorted sub-channels are predicted to

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be a good state at the next FH cluster starting time. Simulation result is provided indicating that the proposed method are better than the traditional FH schemes in terms of the accuracy of channel state prediction.

2. Experimental Section

2.1. Conventional FH methods

When OFDMA system allocates sub-channels with symbol clusters of FH pattern, many different methods can be applicable. The simplest method is random FH. In this method, we can suppose that FH cluster is selected by uniformly distributed probability. Also random cluster allocation assumes that the prior channel state information is not available. We use this random FH method for the comparison purpose in simulation study.

Recently appeared method in literature is the adaptive FH method[4]. In this method, usually SNR (signal-to-noise ratio) is measured and the FH clusters are allocated to the highest SNR among users. We find that this adaptive allocation method is becoming random FH if as more users are in the system. Simulation study on this statement, however, is not provided in this paper. In addition, when the sampling intervals of the faded signal are going to be larger, the measurement of SNR in the past short time period is not accurately reflected the sub-channel state changes. Because the sampled points can be represented as unknown random variables, it is hard to realize in the simple method. In this study, we assume that the adaptive FH method as follows,

1. Check the previous G state sub-channels.
2. Select the checked sub-channels to allocate users. In this case uniform distribution is used for the selection criteria.

Fig. 1 shows that hopping scheme in FH-OFDMA system. Such as Flarion FH-OFDMA system, hopping sequences are cyclically assigned at every T interval. Also assigned hopping sequences within interval are distinguished to the neighboring cells. Symbol by symbol hopping is implemented in the duration T. Note here that if T is being larger, than sampled points at each end of T interval are probabilistically characterized to a random process. This fact can be revealed that random FH or simple adaptive FH methods can not be accurately predict the channel state information.

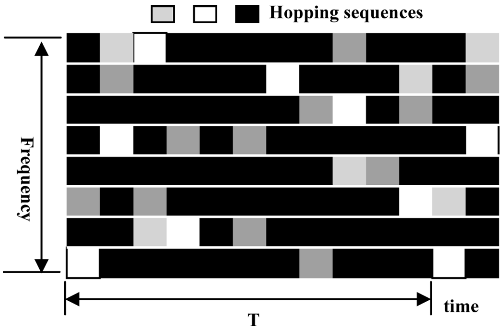

Fig. 1. FH and T relation in FH-OFDMA system.

2.2. Predictive FH Method

We suppose that FH cluster is defined in T of OFDMA symbol duration. At every time T, the system measures the channel gain from receiver's feedback information. Transmitter determines the current channel state by comparing threshold R and the sub-channel gain, $z(n)$ where n represents the number of interval occurrences. If $z(n)>R$, the sub-channel is considered to Good (G) state. Otherwise, the sub-channel is Bad (B) state. Using this comparison result, the transmitter can calculate the average length of the states as follows,

$$w_i^{(G)}(n) = (1-\beta)\cdot w_i^{G}(n-1) + \beta\cdot c_i^{(G)}(n) \qquad (1)$$

where c is the number of continuing occurrence of event G before the state changes to B state, i shows the sub-channel index, β, represents weighting factor ranged $0\le\beta\le1$ and w is the ensemble average of channel state length of the G state. This equation is similar to exponentially weighted moving average (EWMA) in time-series research. Using Eq. (1), we define the factor of channel state changing as follows,

$$y_i^{(G)}(n) = \beta\cdot w_i^{(G)}(n) + (1-\beta)\cdot z_i^{(G)}(n-1) \qquad (2)$$

where z represents the sub-channel gain at event n-1, and y is the value in which the transmitter uses to predict the state of the sub-channel i for the next event n. Eq. (2) means that the average length of the sub-channel state G is added to the most recently available sub-channel gain[5].

After the transmitter calculates yi for the sub-channel

I, the values of yi for all sub-channels are sorted by descending order. The highest yi is probabilistically being a state at the next event n.

3. Results and Discussion

In this section, the simulation results are discussed. Each sub-channel generates OFDM based transmitted signals over the wireless fading characteristics. Using MATLAB, we generate this faded OFDM signals. In this signal generation, we assume that each sub-carrier has a bandwidth much smaller than the coherence bandwidth of the channel and the channel is frequency selective Rayleigh fading for a user. We also assume the system with a fixed total power constraint, and assume that modulation scheme has a fixed bit rates for simplicity of simulation.

In Table 1, the simulation key parameters are shown. We only use one user in this simulation. The user requires different numbers of sub-channel in the unit symbol time, and simulation runs separately for each case.

Fig. 2 shows that sub-channel gain generated. This faded channel gain is used to test random, simple adaptive, and the proposed predictive FH methods. y is the value in which the transmitter uses to predict the state of the sub-channel i for the next event n.

Table 1. Key parameters for simulation

Number of sub-channels	64
OFDM symbol size	0.1 ms
Channel Characterization	Frequency selective fading
Sub-channel modulation	8
Number of user	1
User's required sub-channels	{1, 5, 10, 20}

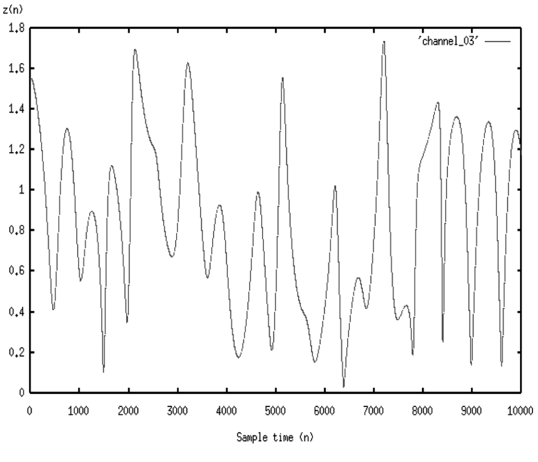

Fig. 2. Generated sub-channel gain.

The value of T is set to 100, 200 and 300 times the one symbol time, which means that the all generated symbol is sampled at every T interval to transmit the signal. Since the symbol time is set to 0.1 ms, if T=100 then 100 symbols are sent at every 10 ms. In Fig. 3 and 4, simulation results are presented to show the prediction accuracy for each mentioned FH methods. In Fig. 3 and 4, y is Success rate for G state prediction.

The proposed FH outperforms the random FH and performs better than the simple adaptive FH. In this simulation, we set R=0.6 for all FH cases and β=0.1 for

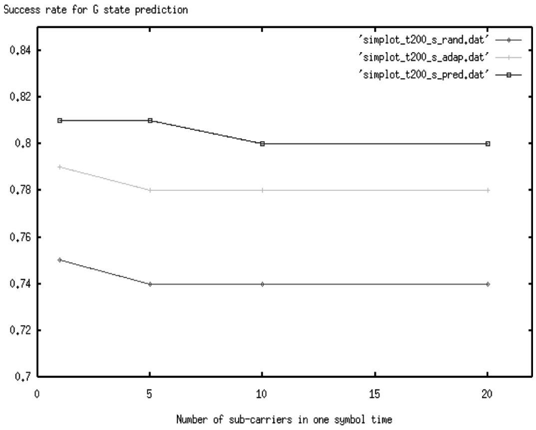

Fig. 3. Prediction success rate comparison with T=200 and all sub-carrier cases.

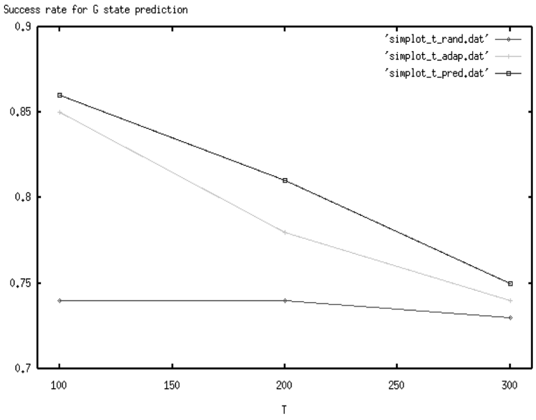

Fig. 4. Prediction success rate comparison with different T cases.

the proposed FH. Fig. 3 shows that all methods are not affected the number of sub-channels. Fig. 4 reveals that T interval is increased then the simple adaptive and predictive methods decrease the prediction accuracy rate. The random FH method, however, maintains the same success rate. It tells us that randomness is increased with T intervals.

4. Conclusion

In this paper, we propose the method to predict the future channel state in FH-OFDMA system. Simulation results show that the proposed method is better predictable the channel state than the random or simple adaptive FH methods. This is due to the sampling points are characterized to the unknown random process in terms of T interval lengths. Other FH methods could not be easily acknowledged the unknown characteristics however the proposed FH can embed the probability during operation. We should further investigate the proposed one in more dynamic and realistic wireless fading and structural environment. This work result is to prepare the development of QoS control algorithm in OFDM wireless physical structure. More predictable channel state information can be provided better fairness and throughput for multimedia traffic in such system. We will continue work to develop the scheduling algorithm and MAC control functions using the proposed FH method as a base model.

Acknowledgements

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