A Probabilistic Study on OFDMA Ranging Process in IEEE 802.16e System

Doo Hwan LEE
Hiroyuki MORIKAWA

Abstract—The performance of OFDMA ranging process in IEEE 802.16e system is studied based on detection miss rate and detection failure rate. Furthermore, mean ranging access time is obtained utilizing state transition diagram.

I. INTRODUCTION

In IEEE 802.16e OFDMA system, ranging process has been proposed for uplink synchronization and power adjustment. A ranging channel is composed of CDMA code sets spread over multiple subcarriers in an OFDMA symbol, and each user transmits ranging signal through randomly selected subcarriers. Then, ranging signals are detected by base station (BS) exploiting the cross-correlation property of CDMA codes [1, 2]. There exists some researches regarding ranging process itself. However, the probabilistic study regarding ranging detection miss rate and detection failure rate is not conducted yet. Moreover, a study on mean initial access time is also necessary. In this paper we analyzed them based on well-known state transition diagram [3]. It will be beneficial for the system parameter design.

II. RANGING PROCESS

In the IEEE 802.16e system, a group of sub-carriers are allotted for the uplink ranging process. Multiple users are associated with BS by sending unique ranging sequences. Each ranging signal arrives at BS with different propagation delay and power due to its distance and mobility. Exploiting various time offset and received power among different users, BS performs initial uplink synchronization and power adjustment.

For the OFDMA system with K sub-carriers, the kth mobile station (MS) sends ranging signals with its unique ranging code set Ck = [c1, c2, ..., ck], then BS detects the ranging signal by the conjugated code set multiplied with exp(2πjfnΔn) to corresponding subcarriers. The exponential part is for compensation of transmission delay.

The frequency domain received signal R(f) is given by

\[ R(f) = \sum N(f)C_k^*(f)H(f) + \sum H(f) + N(f)C_k^*(f) \exp(2\pi j fn(\Delta n - n_{SG})) \]

where, N(f) is additive white Gaussian noise with variance \( \sigma^2 / 2 \), converted to the frequency domain. H(f) denotes channel impulse response of the kth subcarrier. The time delay caused by transmission is traced by adjusting \( \Delta n \), which maximize R(f).

III. METRICS OF PROBABILISTIC STUDY

A. Detection success rate (PDS), detection failure rate (PDf), and detection miss rate (PDM) are studied.

There are three metrics for the probabilistic study of ranging process.

1. PDS: the rate of ranging detection success.
2. PDf: the rate of ranging detection failure which defined as the difference between \( \Delta n \) and \( n_{SG} \) in Eq. (1) is bigger than predefined threshold.
3. PDM: the rate of ranging detection miss which defined as ranging signal power is smaller than predefined threshold.

The relation of PDS, PDf and PDM as shown in Eq. (2).

\[ P_{DS} + P_{DF} + P_{DM} = 1 \] (2)

In case of detection failure, BS carries out further process with wrong value. Thus, it takes time for BS to recognize that transmission delay estimation was wrong. The time for this recognition is defined as penalty time. In case of detection miss, MS will simply transmit the ranging signal again.

B. Mean ranging access time (ET)

ET refers the time for MS to succeed ranging process. It is obtained based on state transition diagram shown in Fig. 1.

\[ ET = \sum H(z_1) \]

\[ H(z_1) = \frac{H(z)}{1 - H_{SP}(z) - H_{DF}(z) - H_{DM}(z)} \]

IV. SIMULATION RESULTS

System parameters are chosen from [1, 2], 144 subcarriers of total 1024 carriers are allotted for the uplink ranging. One OFDM symbol length is 115.2 usec including 12.8 usec of cyclic prefix. RURAL and URBAN channels are adopted from [4] which are measured from the real environment. One frame duration is 5 msec and penalty time J is 4.

V. CONCLUSION

The performance of ranging process in IEEE 802.16e systems is analyzed regarding PDS, PDf and ET utilizing the state transition diagram. We will adopt the methodology of this work to the future wireless system. It will be beneficial for the system parameter design.

REFERENCES