

Study on a Delay Measurement Algorithm using Timing Correct Channel (TCCH) in Extended Global Platform (XGP)

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Abstract

In extended global platform (XGP), each mobile station (MS) needs to correct transmission timing by using timing correct channel (TCCH). This paper proposes new delay measurement algorithm using TCCH and shows the performance of the algorithm for wide-range carrier to noise ratio (CNR). Simulation result shows that the performance improves 4dB of CNR at 90% detection success rate.

Key words : XGP, OFDMA, TCCH, Delay Measurement Algorithm

1 Introduction

Extended global platform (XGP) as next generation personal handyphone system (PHS) is being developed in Japan. It enables high-speed and large-capacity communication through OFDMA technology.

In XGP, the base station (BS) simultaneously processes signals from a number of MS. But the distance from each MS to BS is different. Each MS needs to correct transmission timing depending on the distance (delay time) between MS and BS. This paper proposes a new delay measurement algorithm to correct the transmission timing by TCCH.

2 Extended Global Platform

2.1 Frame Structure

Fig.1 shows a frame structure in XGP. One frame is composed of both uplink (UL) and downlink (DL). In time axis, UL and DL are divided into TDMA-slots. In frequency axis, the effective channel bandwidth is divided into subchannels. One of the subchannels is used for common channel (CCH) to control a call connection.

One unit, divided by TDMA-slot and subchannel is defined as physical resource unit (PRU). Each MS uses PRU to communicate with BS. PRU is composed of 24 subcarriers and 19 symbols.

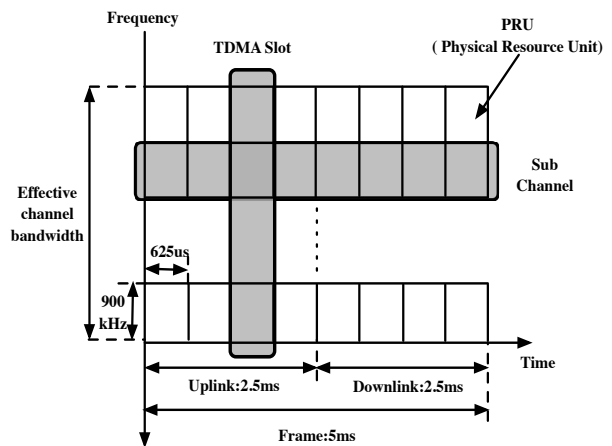


Figure 1: Frame Structure

2.2 Timing Correct Channel

TCCH is a pre-defined signal used in UL of CCH. The number of patterns is 6 in OFDM mode. Table.1 shows data patterns of TCCH. TCCH is primarily used to request connection from MS to BS, and to control transmission timing and transmission power.

Fig.2 shows PRU structure for TCCH and TCCH data format. There are 4 sub-slots for TCCH. each MS uses one subslot to transmit TCCH. TCCH is composed of 3 symbols and guard interval. Each symbol has same waveform.

2.3 Receiver Block Diagram for TCCH Detection

Fig.3 shows receiver block diagram for TCCH detection. The size of FFT changes depending on channel bandwidth. This block diagram is composed of the following processes.

1. Remove the guard interval (GI) from received wave.
2. Demodulated by FFT
3. Take 24 subcarrier in CCH
4. Multiply conjugate complex of each TCCH pattern

Table 1: Data Patterns of TCCH

Subcarrier Number	Data Patterns of TCCH					
	$A_i = \exp(j \cdot i/4) (i = 1, 3, 5, 7)$					
	1	2	3	4	5	6
1	0	0	0	0	0	0
2	A7	A1	A5	A7	A7	A3
3	A5	A1	A3	A5	A7	A5
4	A1	A3	A5	A7	A5	A1
5	A3	A1	A5	A1	A3	A3
7	A3	A5	A7	A5	A3	A7
8	A5	A1	A5	A1	A3	A5
9	A1	A7	A3	A3	A5	A3
10	A5	A1	A5	A7	A3	A7
11	A5	A5	A5	A5	A3	A1
12	A7	A7	A7	A3	A1	A7
13	0	0	0	0	0	0
14	A7	A5	A7	A7	A3	A7
15	A1	A3	A7	A3	A1	A3
16	A5	A7	A1	A1	A3	A5
17	A7	A5	A5	A7	A7	A1
18	A7	A7	A1	A7	A1	A3
19	A1	A1	A1	A7	A5	A3
20	A1	A1	A7	A1	A5	A5
21	A1	A1	A7	A3	A5	A3
22	A3	A3	A3	A3	A5	A3
23	A1	A1	A5	A5	A7	A3
24	A3	A1	A7	A7	A3	A1

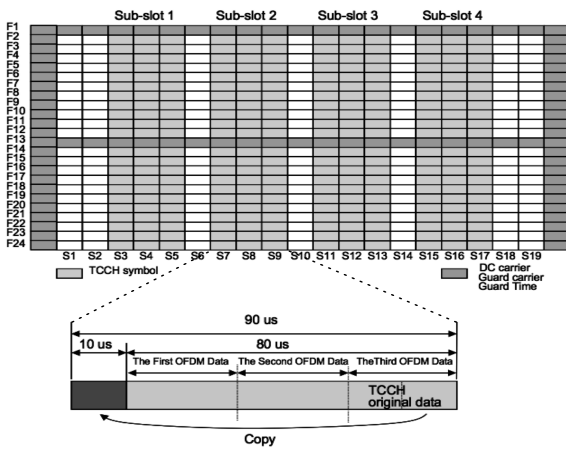


Figure 2: PRU Structure for TCCH and TCCH Data Format

5. Up-sample
6. IFFT to generate delay profile
7. Compute a signal power as delay profile used for delay measurement
8. Detect TCCH and measure a delay

In process 4, if the received wave is TCCH and matches TCCH pattern, constellations of each demodulated data shift same point. After process 7, delay

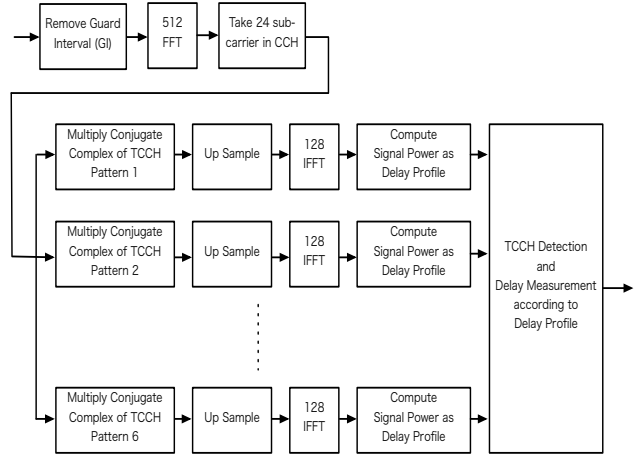


Figure 3: Receiver Block Diagram for TCCH Detection

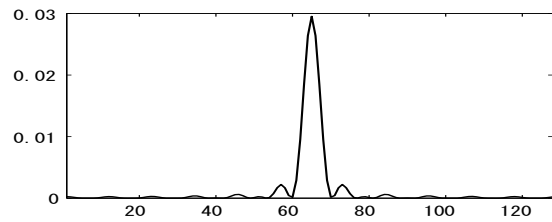


Figure 4: Simulated Delay Profile (matching TCCH pattern)

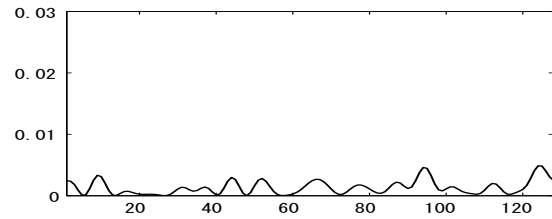


Figure 5: Simulated Delay Profile (mismatching TCCH pattern)

profile is obtained. Fig.4 shows simulated delay profile which matches TCCH pattern and Fig.5 shows simulated delay profile which doesn't match TCCH pattern.

3 Delay Measurement Algorithm

3.1 Delay Measurement

Fig.6 shows a simulated delay profiles. One row shows a set of delay profiles. If the amount of delay is less than 128 steps (1step=0.21 s), the peak position in symbol 5 (S5) is equal to the amount of delay. However, if the amount of delay is more than or equal to 128 steps, the peak position in S5 plus 128 is equal to the amount of delay.

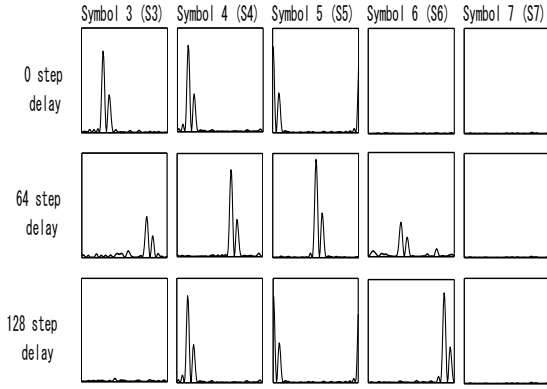


Figure 6: Simulated Delay Profiles

3.2 Peak Algorithm

The peak algorithm was proposed in [3]. The Algorithm is composed of the following processes.

1. Find the peak position index in S5
2. Calculate the sum of maximum values in S3 and S4 as X and sum of maximum values in S6 and S7 as Y
3. Multiply X and Y by weighting factor (α or β) depending on index value and obtain them as X' and Y'

- 0 $index < 32$

$$\begin{aligned} X' &= X \leq (1 - \alpha) \\ Y' &= Y \leq \alpha \end{aligned}$$

- 32 $index < 64$

$$\begin{aligned} X' &= X \leq (1 - \beta) \\ Y' &= Y \leq \beta \end{aligned}$$

- 64 $index < 96$

$$\begin{aligned} X' &= X \leq \beta \\ Y' &= Y \leq (1 - \beta) \end{aligned}$$

- 96 $index$

$$\begin{aligned} X' &= X \leq \alpha \\ Y' &= Y \leq (1 - \alpha) \end{aligned}$$

$$(0 \quad \alpha \quad 1 \quad 0 \quad \beta \quad 1)$$

4. Add offset to index value depending on X' and Y'

- $X' \geq Y'$

$$amount\ of\ lay = in\ x$$

- $X' < Y'$

$$amount\ of\ lay = in\ x + 128$$

3.3 Distance Algorithm

If the peak position in S5 shifts even by 1 step by noise, delay measurement fails. Fig.7 explains distance algorithm to improve the detection performance. In distance algorithm, not only the peak of the delay profile but also its surrounding profiles are used. The following is the processes of distance algorithm.

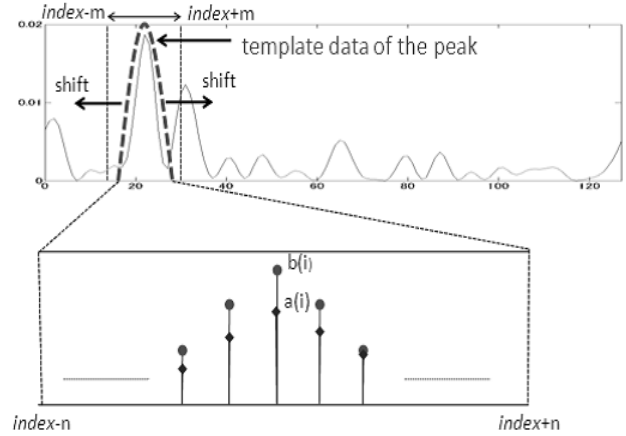


Figure 7: Distance Algorithm

1. Shift the template data around the index and compute the distance between real data and the template data. Equation 1 is used to calculate the distance.

$$d(k) = \sum_{i=k-n}^{k+n} a(i) \quad (i) \quad (1)$$

$$(in \quad x \quad m \quad k \quad in \quad x + m)$$

2. Search a position which $d(k)$ reach minimum and re-define the position as index.
3. Calculate the sum of maximum values in S3 and S4 as X and sum of maximum values in S6 and S7 as Y
4. Multiply X and Y by weighting factor (α or β) depending on index value and obtain them as X' and Y'

- 0 $index < 32$

$$\begin{aligned} X' &= X \leq (1 - \alpha) \\ Y' &= Y \leq \alpha \end{aligned}$$

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$$(0 \quad \alpha \quad 1 \quad 0 \quad \beta \quad 1)$$

5. Add offset to index value depending on X' and Y'

- $X' \geq Y'$

$$amount\ of\ lay = in\ x$$

- $X' < Y'$

$$amount\ of\ lay = in\ x + 128$$

Table 2: Simulation Parameters

Parameter	Value
Channel	2-wave multipath, AWGN
Delay Time of Delay Wave	2.1 μ s
CNR	0~20 dB (step size=1dB)
DUR	5 dB
Amount of Delay of TCCH	0~255
Used TCCH Pattern	6 (all TCCH patterns)
α	0.66
β	0.57

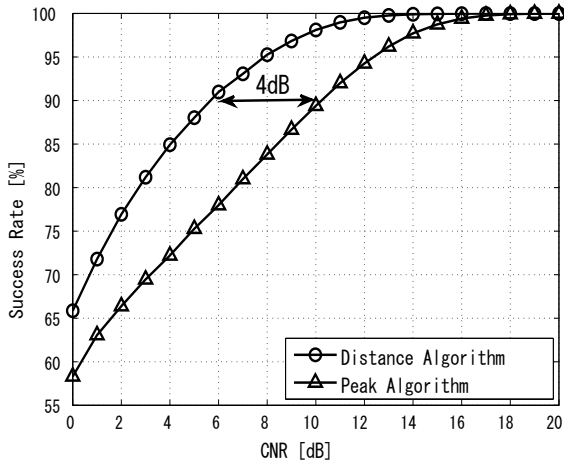


Figure 8: Simulation Result

4 Simulation

The detection performance is evaluated by computer simulation by changing CNR. Table.2 shows parameters of the simulation. The optimal values of α and β was obtained in [3]. Figure 8 shows the simulation result. Horizontal axis is CNR, and vertical axis is success rate of delay measurement. A line with triangle marker is a result in peak algorithm. A line with circle marker is a result in distance algorithm. Compared to peak algorithm, the performance improves 4dB of CNR at 90% detection success rate.

5 Conclusion

This paper focused on delay measurement algorithm using TCCH to correct a transmission timing of each MS and proposed a new distance algorithm. In distance algorithm, not only the peak of the delay profile but also its surrounding profiles are used to improve the detection performance. The detection performance of distance algorithm is evaluated by computer simulation by changing CNR. Simulation results showed that the performance improves 4dB of CNR at 90% detection success rate.

References

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