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Re:	Call for Contribution of SDD
Abstract	MIMO pilot allocation using cyclic-shift(CS pilot) is proposed. CS pilot has good channel estimation accuracy thanks to two characteristic, which are noise elimination and low total pilot density for large number of transmission antennas. This contribution proposes to discuss a MIMO pilot allocation method for more than 5 antennas.
Purpose	For discussion of MIMO Pilot Allocation in case of more than 5 antennas
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MIMO Pilot Allocation

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Introduction

Increasing the transmission antenna, the pilot density would be increased. The expansion of Legacy MIMO pilot allocation for larger number of antennas may waste the time-frequency resources and then reduce the system throughput.

In this contribution, a MIMO pilot allocation using the cyclic-shift (CS) is presented. Since CS pilot can eliminate noise with low pilot density, the CS pilot can improve not only the channel estimation accuracy but also the system throughput comparing Legacy pilot allocation.

It would be worth introducing the CS pilot concept in SDD as a new main function for more than 5 antennas transmission.

MIMO Pilot using Cyclic-Shift

The CS pilot concept is based on an channel estimation by impulse response and on the transmission interval using cyclic shift of an OFDM symbol. Figure 1 shows the block diagram.

The transmitter sends one impulse signal in time domain as a pilot signal, the receiver can observe a multipath channel.

When an interval of the CS pilot transmission from each antenna (K samples) is longer than the multipath channel delay the receiver can extract the multipath channel from each antenna using time-window based on the interval. The interval can generate from the cyclic shift of OFDM symbol.

In Reference System [3], the CP length is 1/8 useful OFDM symbol time. When the CS pilot transmission interval (K samples) is same as the CP length, pilots up to 8 antennas can be allocated in one OFDM symbol.

Following two sections describe two characteristic of the CS pilot.

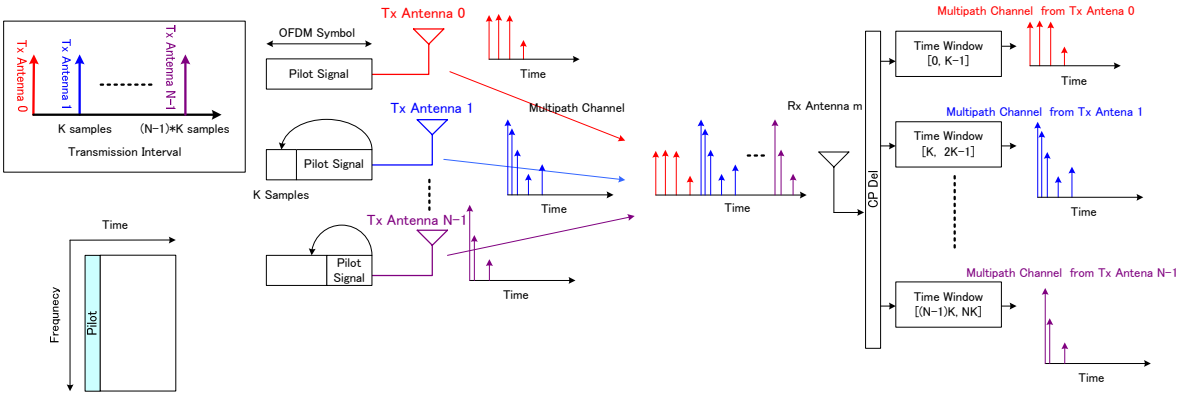

Figure 1 MIMO pilot using Cyclic Shift

Noise elimination

The first characteristic of the CS pilot is that the noise elimination effect using the time-window and the peak search can enhance channel estimation accuracy. Figure 2 shows the comparison of channel estimation between the CS pilot and Legacy. In the CS pilot allocation, firstly, the receiver extracts the CP pilot transmission interval of target antenna from the total samples of one OFDM symbol using the time-window, then the samples except the target samples of CP pilot transmission interval are replaced by zero(zero-padding). By the zero-padding, the noise except the target samples is eliminated. Secondly, the receiver finds the peak over a certain threshold (Peak search) and detects the multipath for target antenna, then the samples except the position of the multipath is replaced by zero (zero-padding). This zero-padding also can eliminate the noise except the multipath samples.

Comparing channel estimation for Legacy, the noise level before FFT for Channel estimation is quite small. For example, in case of 6 path model, the noise elimination effect is 19.3dB (=10 log(useful symbol samples/ 6)) comparing with Legacy.

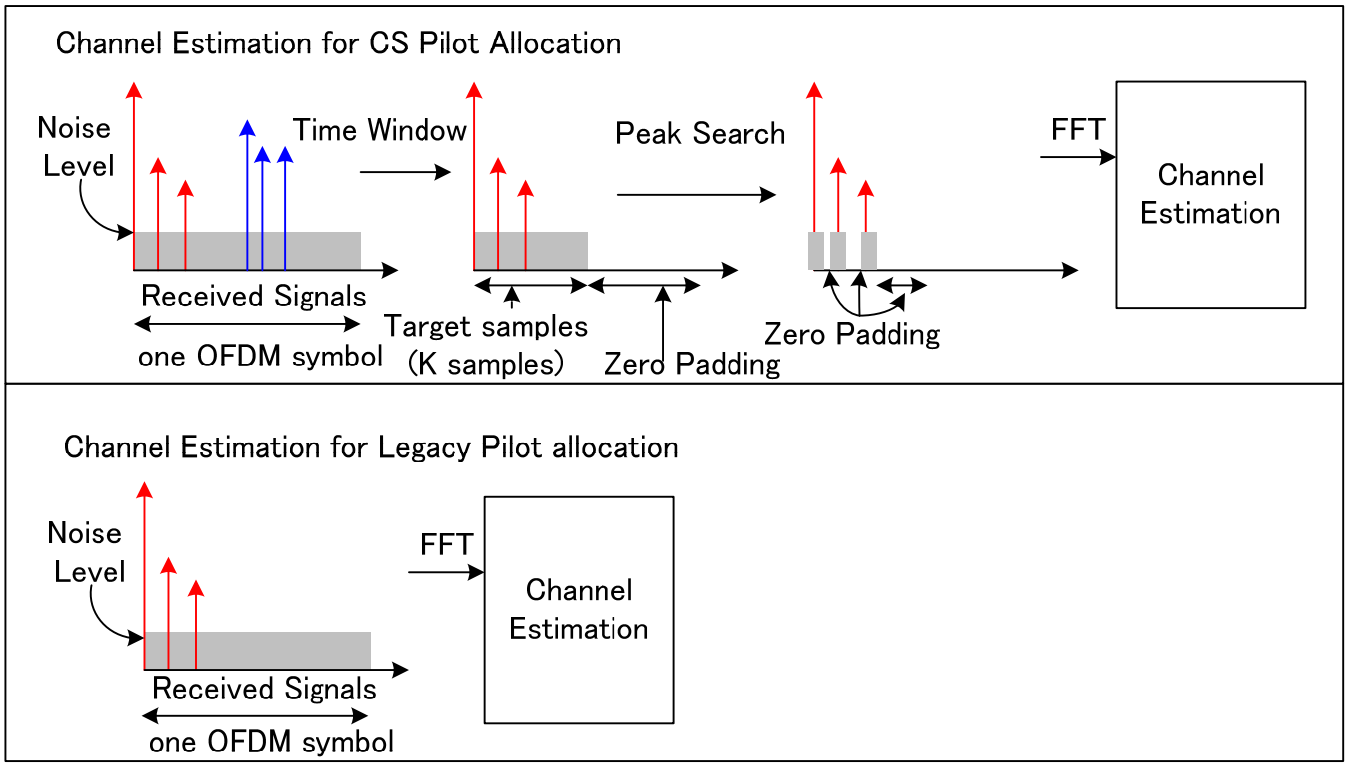

Figure 2 Channel Estimation Comparison

Pilot Density Comparison

The second characteristic is that CS pilot can reduce the “total pilot density” in time-frequency resource keeping the “pilot density per antenna” in case of large number of transmission antenna. In Legacy pilot, “pilot density per antenna” is equal to “total pilot density” divided by the number of antenna. So, if keeping the “pilot density per antenna” from small number of antenna to large number, the “total pilot density” is increased in large number of transmission antenna. On the other hand, in CS pilot, the “total pilot density" is same as the

"pilot density per antenna". Because CS pilot needs one OFDM symbol even if the number of transmission antenna is only one. However, CS pilot does not need more resource up to 8 antennas.

Figure 3 illustrates the CS pilot allocation and Legacy allocation (4x4 MIMO). In the CS pilot, two OFDM symbols in one frame are used as pilot. Table 1 shows that in case of more than 3 antennas, the CS pilot reduces the "total pilot density" comparing the Legacy system. Moreover, "pilot density per antenna" of CS pilot is higher than Legacy system in any cases. So the channel estimation accuracy of CS pilot would be better than Legacy thanks to the high "pilot density per antenna".

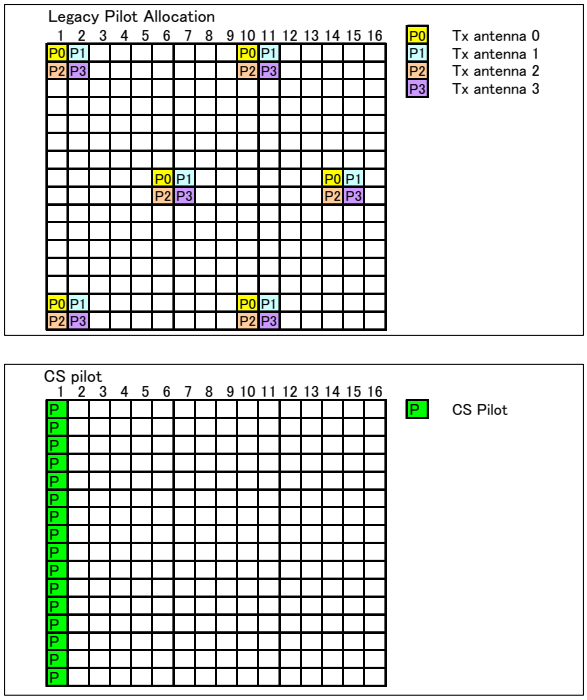

Figure 3 Legacy Pilot Allocation and CS Pilot Allocation (4x4 case for Legacy)

Legacy System (more than 5 antenna case : Ref [4])

No of Antenna	1	2	3	4	5	6	7	8
Total Pilot Density	0.0149	0.0298	0.0595	0.0595	0.1250	0.1500	0.1750	0.2000
Pilot Density per antenna	0.0149	0.0149	0.0198	0.0149	0.0250	0.0250	0.0250	0.0250

Cyclic Shift Pilot

Total Pilot Density	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426
Pilot Density per antenna	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426

Table 1 Pilot Density Comparison

NMSE (Normalized Mean Square Error) Performance of Channel Estimation

NMSEs of the channel estimation for the CS pilot allocation and Legacy are evaluated in order to confirm the two characteristics of CS pilot. The simulation assumes 4x4 MIMO Pedestrian B model (3km/h). The CS pilot allocation is shown in Figure 3 and the transmission interval of the CS pilot on each antenna is same as the CP length. Channel estimation for Legacy is Zero-Forcing method with liner-interpolation. Figure 4 shows that the CS pilot is 20dB in NMSE better than Legacy and the effect is almost same as the noise elimination effect.

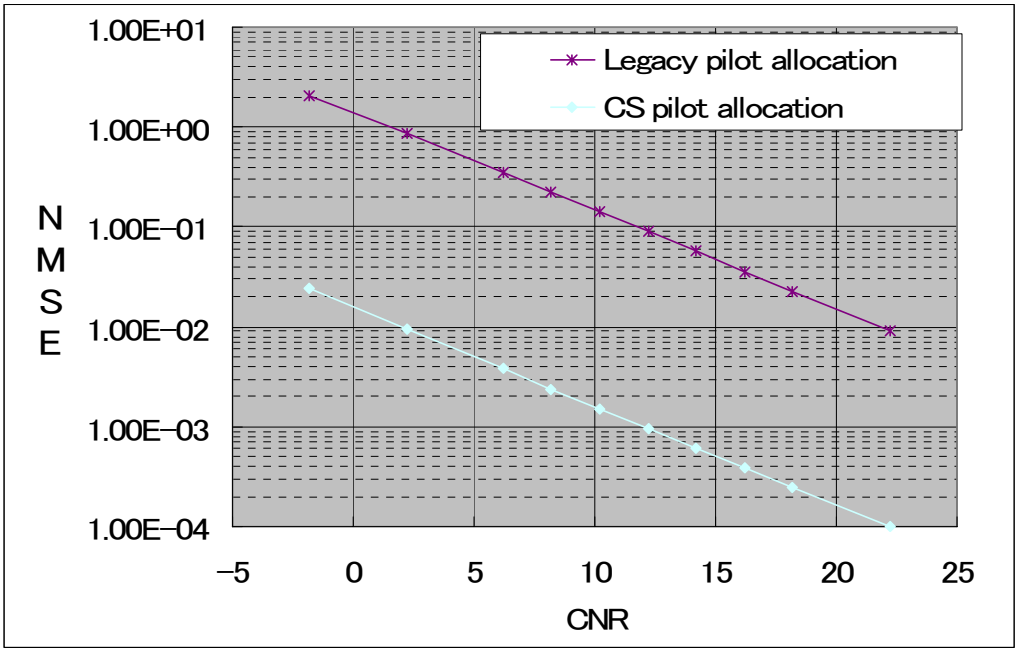

Figure 4 NMSE Comparison (4x4 MIMO) PB 3km/h

Conclusion

Increasing pilot density could be one issue in case more than 5 antennas transmissions. The CS pilot can reduce the pilot density in time-frequency resource comparing Legacy system without the channel estimation degradation. In SDD, pilot structure for more antennas than that of Legacy system should be discussed. It would be worth introducing the CS pilot concept in SDD as a new main function.

Reference

[1] 802.16m-07/002r3 “Draft IEEE 802.16m Requirements”
[2] K. YOKOMAKURA, S.SAMPEI, H. HARADA, N. MORINAGA, “A Carrier Interferometry Based Channel Estimation Technique for MIMO-OFDM/TDMA Systems,” IEICE Trans. COMMUN., Vol.E90-N, NO.5 MAY 2007
[3] 802.16m-07/037r1 “ Draft IEEE 802.16m Evaluation Methodology”
[4] IEEE C802.16e-04/563r1 “Comment on Pilot Allocation for 5,6,7 and 8 BS Antennas”
[5] IEEE Standard 802.16e-2005