Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Scattered MIMO Pilot Allocation using cyclic shift**
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Re:	IEEE 802.16m-07/047 - Call for Contributions on Project 802.16m System Description Document (SDD), shoot for “Multiple access and multi antenna techniques, specifically as related to frame structure” topic.
Abstract	Scattered MIMO pilot allocation using cyclic shift (Scattered CS pilot) is proposed. The Scattered CS pilot has better channel estimation performance in high mobility case than a legacy pilot allocation and a TDM based MIMO pilot allocation using the cyclic shift [1] keeping the total pilot density less than the legacy pilot allocation. Scattered CS pilot in MIMO case can be applied in zones such as AMC in the frame structure for 16m system.
Purpose	For discussion of MIMO Pilot Allocation in MIMO case
Notice	
Release	
Patent Policy	

Scattered MIMO Pilot Allocation using cyclic shift

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Introduction

We showed in [1] a TDM based MIMO pilot allocation using the cyclic shift (TDM CS pilot), which improves the channel estimation accuracy while keeping less pilot density compared with a legacy pilot allocation.

In this contribution, a scattered MIMO pilot allocation using the CS (Scattered CS pilot) is presented. By using scattered allocation, the Scattered CS pilot has better channel estimation accuracy in high mobility case than the legacy pilot allocation and the TDM CS pilot allocation, while keeping the total pilot density less than that of the legacy pilot allocation.

This pilot allocation technique in MIMO case can be applied in zones such as AMC in the frame structure for 16m system. It would be worth introducing the CS pilot concept in SDD as a new main function.

Scattered CS Pilot

The TDM CS pilot uses all subcarriers in a pilot OFDM symbol as pilot signals as shown in Figure 1.

In the Scattered CS pilot, taking into account both tracking to the channel fluctuation in time domain and less total pilot density, pilot density in time axis is M times increased, while pilot density in frequency axis is decreased to 1/M in order to keep the total pilot density same as the TDM CS pilot.

Figure 2 shows the block diagram of the Scattered CS pilot in case that M equals to 2. At the transmitter, in frequency domain, pilot symbols with same amplitude and phase[1] are allocated on M (=2) spaced subcarriers in M (=2) pilot OFDM symbols per pilot allocation unit. After IFFT operation, each transmitter of N transmission antennas transmits pilot OFDM symbols with K samples cyclic shift. This results in N impulse signals with K sample transmission intervals, and its N*K sample signals are repeated M times in time domain. After each impulse signals propagates individual multipath channel, total multipath channels in time domain can be observed in the shape of multiplexing of time shifted impulse responses. The receiver can observe the total multipath channels in time domain after extracting the pilot symbol in frequency domain. When the transmission interval of the CS pilot transmission from each antenna (K samples) is longer than the maximum multipath channel delay, the receiver can extract the multipath channel from each transmission antenna using time windows based on the transmission interval.

Regarding transmission antenna number which can be multiplexed, assuming that transmission interval (K samples) is same as the CP length, pilots up to 8/M (=N) antennas can be allocated in one OFDM symbol, since the CP length of reference system is 1/8 useful OFDM symbol time[3].

Following two sections compare pilot density and channel estimation performance among the Scattered CS pilot allocation, the TDM CS pilot allocation, and the legacy pilot allocation.

[1] It is possible to scramble the pilot patttern in order to reduce PAPR of pilot OFDM symbol [2].

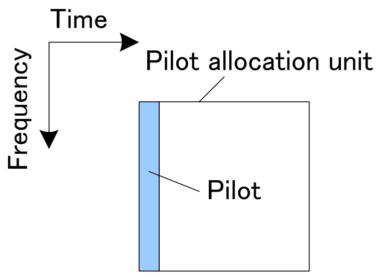

Figure 1 TDM CS pilot allocation

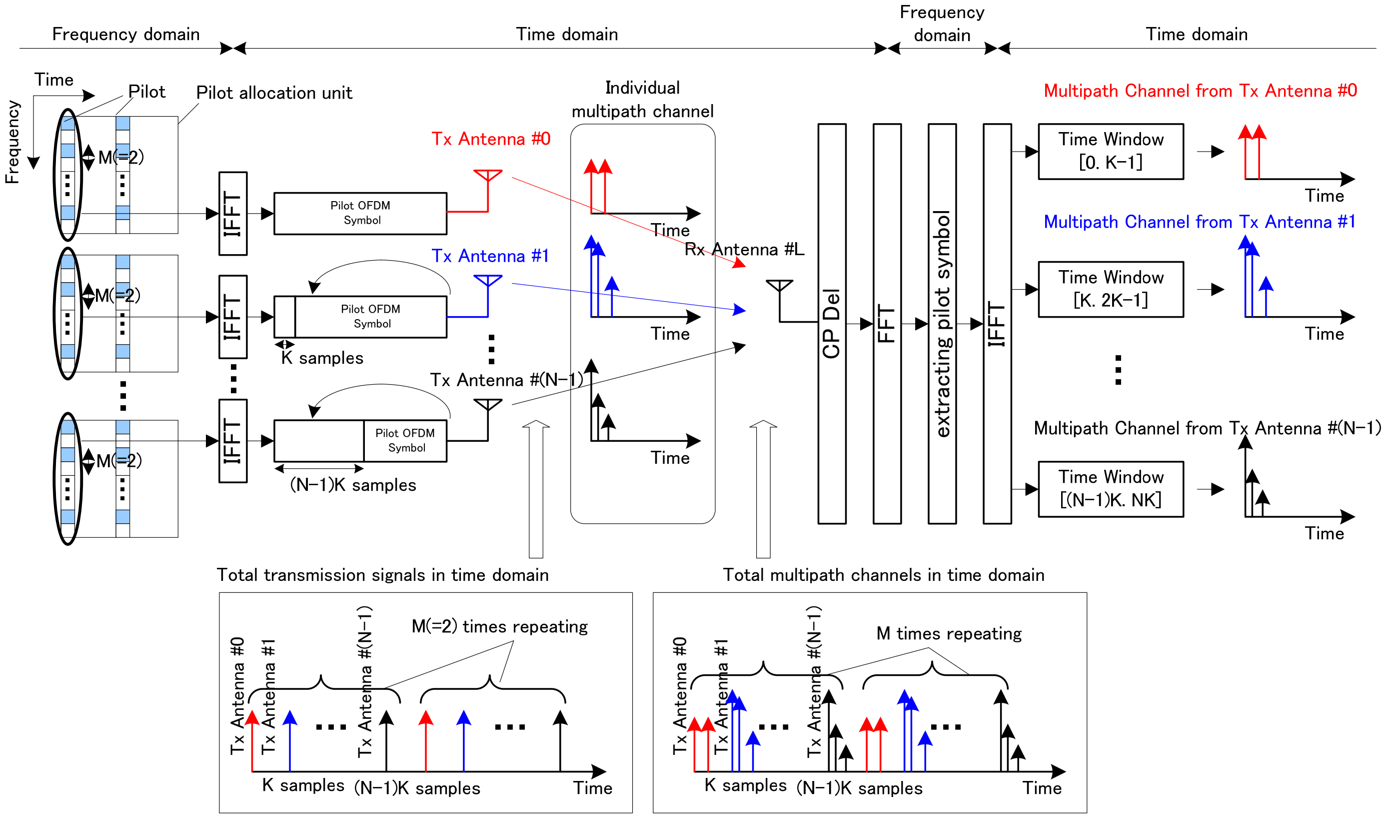

Figure 2 Block diagram of Scattered CS pilot (M=2)

Pilot Density Comparison in 4 antennas case

Figure 3 illustrates the legacy pilot allocation (a), the TDM CS pilot allocation (b), and the Scattered CS pilot allocation (c) in 4 transmission antennas case. The legacy pilot allocation is extracted from 8.4.8.3.1.1 of [4]. In the Scattered CS pilot allocation, two OFDM symbols including Scattered CS pilot in six OFDM symbols (corresponding to time cycle of legacy pilot) exist and Scattered CS pilot is allocated with two subcarriers interval (M=2).

Table 1 shows the pilot density comparison of the legacy pilot, the TDM CS pilot, and the Scattered CS pilot allocation. The Scattered and the TDM CS pilot allocation has approximately 30 percent less total pilot density and 3 times more pilot density per antenna than the legacy pilot allocation. This is caused by the characteristic 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 [1].

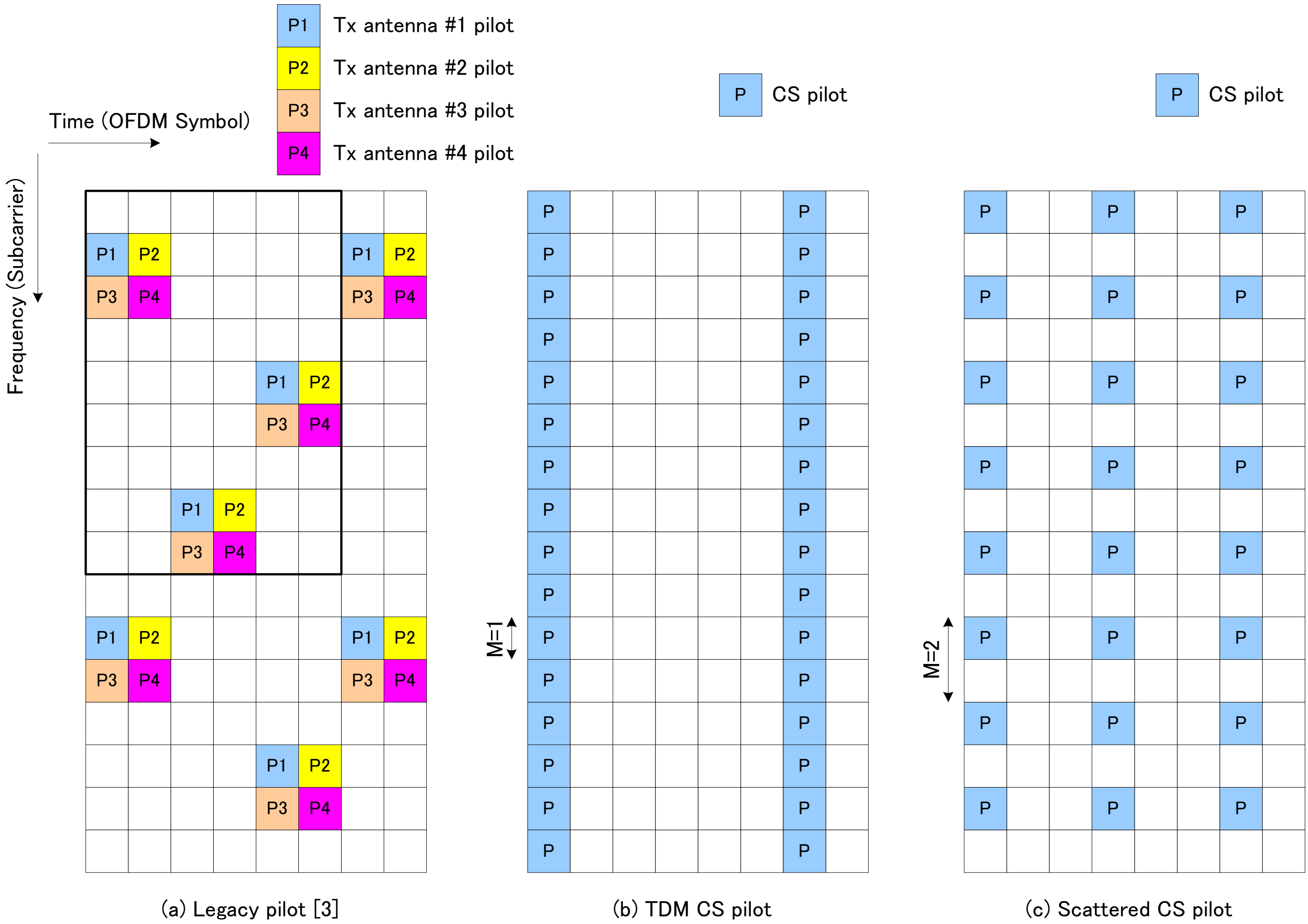

Figure 3 Legacy, TDM CS and Scattered CS Pilot Allocation in 4 transmission antennas case

Table 1 Pilot Density Comparison in 4 transmission antennas case

	Legacy pilot	TDM CS pilot	Scattered CS pilot
Total Pilot Density	12/54 = 0.2222	1/6 = 0.1667	1/6 = 0.1667
Pilot Density per Antenna	0.2222/4 = 0.0556	0.1667	0.1667

NMSE (Normalized Mean Square Error) Performance of Channel Estimation

NMSEs of the channel estimation for the Scattered CS pilot allocation, the TDM CS pilot allocation and Legacy pilot allocation are evaluated in order to compare the performance of channel estimation in high mobility case.

The simulation assumes 4x4 MIMO ITU Pedestrian-B model (120km/h). Assumed pilot allocations are shown in Figure 3 and the frame structure is compliant with 5MHz downlink parameters of [5, table3]. For channel estimation method of the TDM CS pilot allocation and the Scattered CS pilot allocation, after peak search, complex amplitudes of each antenna’s peak and sinc funcntion replica are matched in time domain [6], since paths in time domain are observed in the shape of sinc function. After transforming into frequency domain, linear interpolation between pilot OFDM symbols is applied. For legacy pilot allocation, zero forcing with linear interpolation is applied.

Figure 4 shows the NMSE of the TDM CS pilot allocation, Scattered CS pilot allocation and the Legacy pilot allocation in high mobility case that velocity of mobile station equals to 120km/h. In low carrier to noise power ratio (CNR) region around 0dB, where noise is a dominant factor, the TDM CS pilot allocation and the Scattered pilot allocation are much better than legacy pilot allocation due to more pilot density per antenna and more effective noise elimination. In addition, also in high CNR region, where channel tracking ability is a dominant factor, the Scattered CS pilot allocation still has better NMSE than the legacy pilot allocation, while the TDM CS pilot allocation has worse NMSE than the legacy pilot allocation due to bad channel tracking ability caused by less pilot density in time axis.

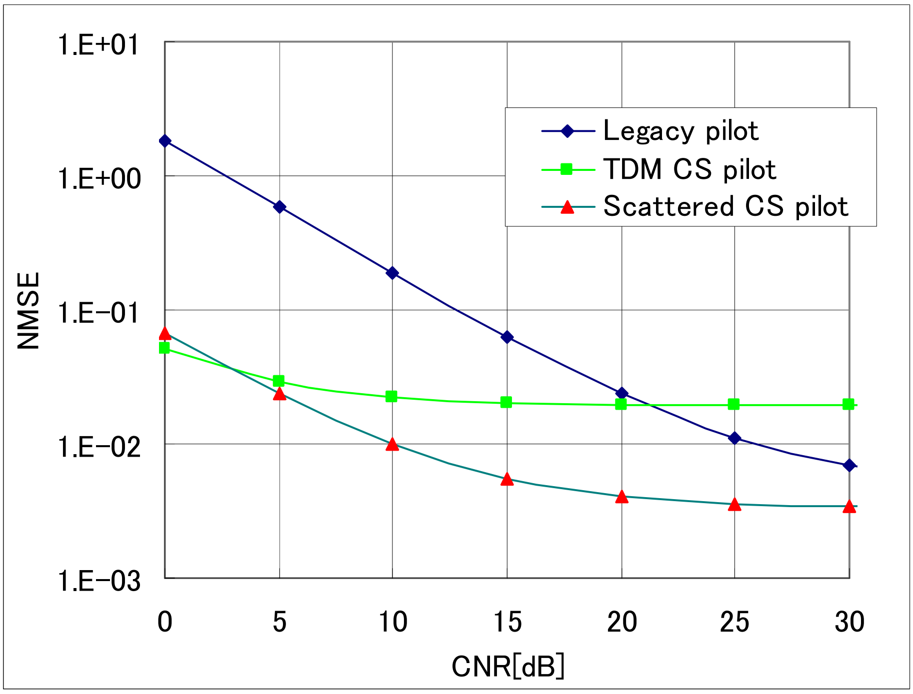

Figure 4 NMSE Comparison (4x4 MIMO, PB 120km/h)

Conclusion

This contribution proposed the Scattered CS pilot allocation in MIMO case. The Scattered CS pilot has good channel estimation accuracy in high mobility case compared with the legacy pilot allocation and the TDM CS pilot allocation while keeping the total pilot density less than that of legacy pilot allocation.

This pilot allocation technique in MIMO case can be applied in zones such as AMC in the frame structure for 16m system. It would be worth introducing the CS pilot concept in SDD as a new main function.

Reference

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[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
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