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Title: Complexity analysis of the multi-user channel estimation in TDD

1 Introduction

The current TDD standard, TS S1.21, specifies two different bursts, viz., one with a long midamble of length 512 chips, and the other with a short midamble of length 256 chips. Upon reception, the data independent part of these midambles is of length 456 and 192, respectively. We present calculations on the complexity of multi-user channel estimation using these current midambles. These calculations hold for the base station receiver, as well as the UE receiver in the presence of downlink transmit diversity.

Receiver complexity for the UE is a serious concern, whereas more complex receiver structures can be adopted for the base station. It should be noted that when downlink transmit diversity is present, the UE receiver complexity becomes similar to the base station receiver complexity for the multi-user channel estimation under consideration.

We compare our results with those provided in contribution [1] presented in 3GPP RAN WG1 meeting #4 which proposes a reduction in the length of the midamble. Our results show that the existing TDD working assumption yields a complexity that is lower than that proposed in contribution [1]. Section 2 presents the complexity analysis and Section 3 the conclusion of this contribution.

2 Complexity analysis of current TDD working assumption

One of the schemes of channel estimation involves taking a DFT and an inverse DFT, both of length N. Here N is the length of the data independent part of the received midamble. This can be achieved by, for instance, taking a radix-2 FFT of length M, where M is the smallest radix-2 integer that is greater than or equal to N. The complexity of a radix-2 FFT of length M is well known to be $M\log_2 M$ complex operations[2]. This stems from the fact that a radix-2 FFT computation can be sequenced into $\log_2 M$ stages, each stage having M/2 butterflies. Each butterfly then requires 2 complex operations, where a complex operation is defined as a combination of a complex multiplication and a complex addition[2]. Assuming that each complex operation requires 4 instructions (4 MACS, i.e., multiply and accumulate), we get $4M\log_2 M$ instructions per FFT. Further, the channel estimation requires a DFT and an inverse DFT, and the processing for a slot implies that these FFTs are computed @ the frame rate of 100 times per sec. This leads to $2*100*4\ M\log_2 M*10^{-6}$ million instructions per sec (MIPS). Table 1 summarizes our calculations for the two kinds of midambles.

Contribution[1] proposes a reduction in the length of the long midamble from the current working assumption. Table 2 compares our calculations for the current working assumption with those of contribution[1]. It can be seen that for the long midamble case, the current working assumption yields an estimate of 3.7 MIPS as compared to 4.6 MIPS of contribution[1]. The MIPS for the short midamble are comparable.

Table 1. Complexity of the working assumption

Midamble	N	M	No. of complex operations per FFT	No. of instructions per FFT	MIPS of multi-user channel estimate
Long	456	512	4608	18432	3.7
Short	192	256	2048	8192	1.6

Table 2. Comparison of MIPS of the working assumption with those in contribution[1]

Midamble	MIPS of working assumption (from Table 1., above)	MIPS for the new method proposed in contribution[1]
Long	3.7	4.6
Short	1.6	1.38

3 Conclusions

The results here show that the existing TDD specification yields a complexity lower than that proposed in contribution[1]. Hence, we conclude that the existing working assumption on the midamble length should not be changed.

References

1. Motorola TSGR1#4(99)389,"Complexity of Multiple channel estimations at the SU"
2. *Discrete-time Signal Processing*, Alan V. Oppenheim and Ronald W. Schafer, Prentice Hall, 1989.