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THE COMPLEXITY OF HIGH PERFORMANCE METHODS OF ERROR-CORRECTING CODES DECODING

One of tasks solved during development of modern communication systems is coding/decoding methods selection. Often the main criterion of this choice is a decoding algorithm complexity implementation since it defines cost, reliability, speed and other important characteristics of communication systems.

Let us consider a computational complexity of the most effective decoding methods such as Viterbi algorithm (VA) [1], algorithms for turbo codes (TC) decoding [2] and multithreshold decoding (MTD) [3]. Below we shall consider that the computational complexity is number of operations required for an information bit decoding.

It seen from table 1, that the complexity of VA decoder is exponential increased with growing of code constraint length K, therefore this method is practically used for decoding of low efficient codes with $K \leq 9$ only.

Table 1. The complexity of error-correcting codes decoding

Operation	Viterbi	Max-Log-MAP	Log-MAP	SOVA	MTD iteration
max operations		$5 \cdot 2^{K-1}-2$	$5 \cdot 2^{K-1}-2$	$2^{K-1}+3 \cdot K$	
additions	$2 \cdot 2^{K-1}+5$	$10 \cdot 2^{K-1}+11$	$15 \cdot 2^{K-1}+9$	$2 \cdot 2^{K-1}+8$	d
multiplications by ±1		8	8	8	$(d+1)p$
bit comparisons	2^{K-1}			$6 \cdot K$	1
table look-ups			$5 \cdot 2^{K-1}-2$		

The complexity of TC decoder is defined by component codes decoding complexity and iterations count. Table 1 also shows the number of operations required Max-Log-MAP, Log-MAP and SOVA decoding methods [4] are used for decoding of TC component codes. It is obvious the complexity of these algorithms exponential depends on codes constraint length K, too. However, for TC construction only codes with small $K=3 \div 5$ are applied as interleaver size exerts influence on TC performance in the mainly. That is why TC decoder is much less complex then same performance Viterbi decoder.

For MTD, as it is shown in table 1, number of operations for an information bit decoding depends on code distance d, channel error probability p and count of decoding iterations I. As MTD is used for decoding codes with $d=7 \div 13$ on $p<0.1$, it is about ten times less complex then efficiency comparable TC decoder. Besides, it is need the little modification of MTD to reduce number of decoder operations to $c_1 d + c_2 I$ where c_i are small numbers and I is decoding iterations count. As a result the complexity of MTD becomes in tens times less complex then another decoding methods on a high noise level.

The modeling results shows that for the code rate 1/2 more powerful TC decoder is about 13 times as slower as MTD on same efficiency. For the code rate 3/4 TC decoder needs to use more decoding iterations and convolutional codes with higher constraint length K. These result to a considerable slowing of turbo decoding process while MTD speed is increased as it becomes possible to use codes with less minimum distance d. As a result MTD is found more then 70 times faster then TC decoder.

References

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