Low Complexity Concatenated Two-State TCM Schemes with Near Capacity Performance[1]

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Abstract - **This paper presents a family of low complexity concatenated two-state trellis-coded modulation (CT-TCM) schemes. A joint design strategy of all component codes is established. This leads to the so-called "asymmetrical and time-varying" structures. Compared with the existing turbo TCM codes, the proposed CT-TCM schemes have significantly reduced decoding complexity and demonstrate comparable or even better performance.**

I. TREE CODES AND TWO-STATE TRELLIS

Tree codes can be characterized by loop-free Bayesian networks. As an example, Fig. 1 shows the Bayesian network for a tree code together with the related two-state trellis diagram. In the Bayesian network, white and black nodes represent information and parity bits, respectively. An information symbol consists of n=2 information bits, denoted by $\boldsymbol{d}_k = (d_{k,0}, d_{k,1})$. The state variable q_k is defined by

$$q_k = q_{k-1} + \boldsymbol{d}_k \cdot \boldsymbol{g}_k \quad (1)$$

where $\boldsymbol{g}_k = (g_{k,0}, g_{k,1}, \cdots, g_{k,n-1})^T$ is a binary connection vector defined by $g_{k,j} = 1$ if $d_{k,j}$ participates in parity check; otherwise, $g_{k,j} = 0$. Branches in the trellis diagram are labeled by the values of the coded symbol ($\boldsymbol{d}_k$, q_k).

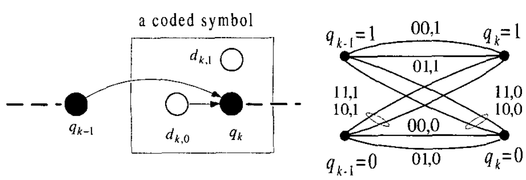

Fig. 1. An example of tree codes.

II. CONCATENATED TWO-STATE TCM SCHEMES

A global CT-TCM scheme consists of M component encoders linked by M symbol-based random interleavers, each constrained by $\pi(k) \bmod M = k \bmod M$. Each component encoder consists of a binary tree encoder introduced above followed by a signal mapper. For the mth component code, we puncture all the modulated symbols except those at position $\{k \mid k \bmod M = m\}$.

Let $\boldsymbol{g}_k^{(m)}$ be the kth connection vector in the mth component code. We adopt such a design strategy that *for a fixed m,* $\boldsymbol{g}_k^{(m)}$ *varies periodically with k and for a fixed k,* $\{\boldsymbol{g}_k^{(m)}\}$ *are different for different m.* This leads to an asymmetric and time-varying encoder structure.

Since the trellises involved are of only two-state, the decoding complexity is very low. For example, for comparable performances, the decoding cost of a CT-TCM code is about 6 times lower than that of the scheme in [1] and 12 times lower than that of the scheme in [2].

III. RESULTS AND CONCLUSIONS

Some good CT-TCM codes have been constructed based on the principles above. Their BER performances are illustrated in Fig. 2. The detailed design of these codes can be found in [3]. The results of [1] and [2] are also plotted in Fig. 2 for comparison. It can be seen that the proposed CT-TCM codes can achieve comparable performance to those in [1][2]. However, the CT-TCM codes have much lower decoding complexity, as mentioned above.

The performances of two alternative CT-TCM codes are also included in Fig.1. We can see that the error floor problem can be greatly improved with a properly selected code structure. This property has also been observed for high-order modulation systems.

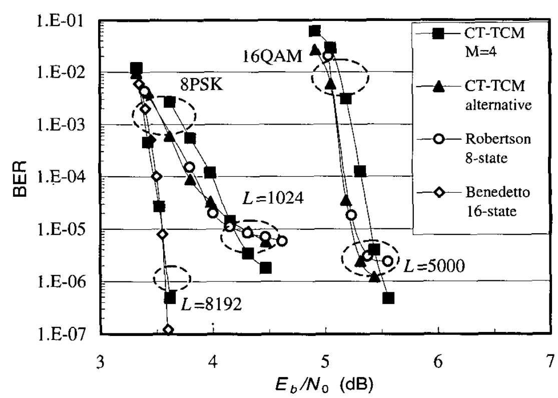

Fig. 2. Performance of CT-TCM schemes. "L" represents the interleaver size (in symbols). The code rates are 2 bits/symbol for 8-PSK and 3bits/symbol for 16-QAM, respectively.

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