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APPLICATION OF TRELLIS DECODERS:
MULTI-FUNCTIONAL TRELLIS DECODING OF BLOCK CODES

6.1 ELEMENTS OF MULTI-FUNCTIONAL CODING

In conventional communication systems employing block error control codes, various signal processing sub-systems perform specific tasks, e.g. carrier recovery, demodulation, block and symbol timing recovery, error control, channel state estimation, etc. In an all digital communication system, the operation of the individual processing sub-blocks can be combined, thus providing a lower-complexity, more efficient and more effective means of combating errors.

Recently [38,39], the concept of "multi-functional coding" was introduced. This term was applied as a description of the system designed to perform two or more simultaneous functions within the overall architecture of a communication system, e.g. error control, modulation, synchronisation and channel evaluation. In the context of mobile and personal communication systems, such combinations are particularly attractive since for these type of systems, error performance is not necessarily dependent upon the single function of error control coding (or even upon the combined function of coding and modulation). It also may involve other aspects of signal processing, e.g. bit, symbol and block synchronisation, channel state estimation, etc. There is little point in providing a high level of error control if the performance of the synchronisation system is low and if, in consequence, the system will be incapable of meeting its operational requirements.
Multi-functional coding seeks to amalgamate as many of the communication system functions as possible into a single integrated procedure, with the objective of improved overall system performance and economy of implementation. In this Chapter we discuss, and attempt to formalise to some extent, a concept which will be termed "Multi-Functional Trellis Decoding", where the following aspects of the communication system are considered:

(a) soft maximum likelihood trellis decoding;

(b) modulation/demodulation;

(c) bit, symbol and block synchronisation;

(d) real-time channel evaluation (RTCE) for channel characterisation [40,41]

The benefits of SMLTD for block codes have already been identified in the previous Chapters. The other functions of the multi-functional trellis decoding will be discussed in the next Sections.

6.2 BLOCK-CODED TRELLIS MODULATION

6.2.1 Combined Coding And Modulation Schemes

In conventional error control coding schemes the redundancy of the code is proportional to the channel bandwidth. Thus, for the larger minimum Hamming distance of the code, the wider channel bandwidth is required for data transmission [208]. It is apparent that this disadvantage can be overcome by using higher level modulation schemes (e.g. \((M + 1)\) ary instead of \(M\) ary) for a given data rate. This allows the transmission of more information bits per symbol period (e.g. \(\log_2(M + 1)\), instead of \(\log_2M\)), and narrowing of the channel bandwidth [181].

However, the results of considering error control coding and higher level modulation schemes as two separate processes were rather disappointing until Massey J. [138] showed that they should be integrated by matching the code to a particular modulation scheme. He also mentioned that this concept