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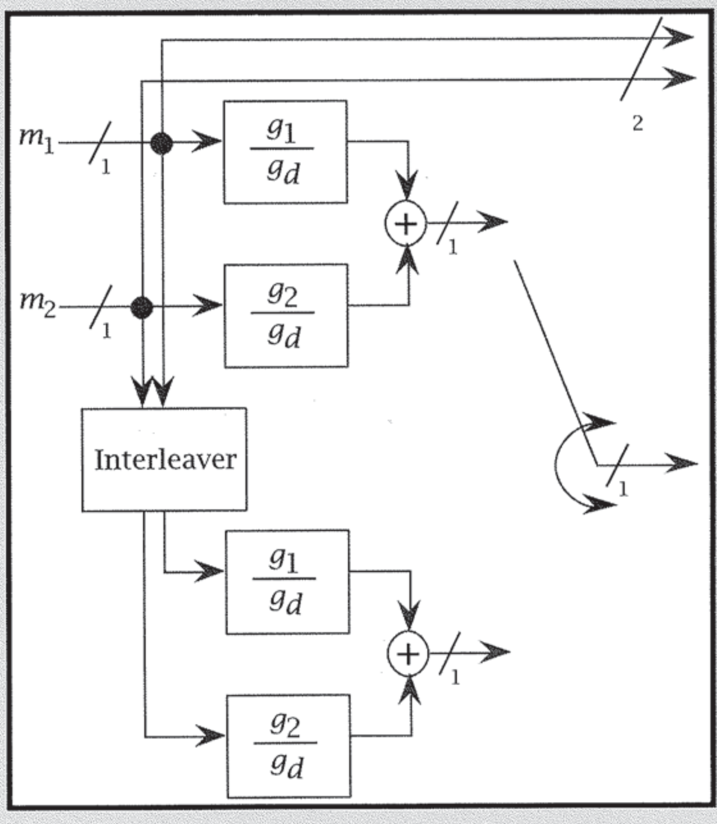
TURBO CODING

Chris Heegard
Stephen B. Wicker



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by

Chris Heegard
Alantro Communications, Inc.
and Cornell University

Stephen B. Wicker
Cornell University

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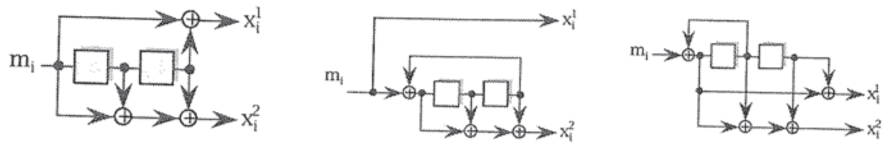

(a) FIR, Non-systematic (b) IIR, Systematic (c) IIR, Non-Systematic

Figure 2.1: Rate 1/2 ($n = 2, k = 1$) Encoders

A *Binary Convolutional Code* (BCC) is the set of codewords produced at the output of a BCE.

Figures 2.1 and 2.2 show various types of BCE's. A BCE can be *Finite Impulse Response* (FIR) (*also called "feed-forward", "feedback-free"*, or *"non-recursive"*) or *Infinite Impulse Response* (IIR) (*"feedback"* or *"recursive"*). Also, a BCE can be *systematic* or *non-systematic*.

An encoder is FIR (see Figures 2.1(a) and 2.2(a)) if its output can be computed as a linear combination of the current input and a finite number of past inputs. The linear combination is expressed in terms of the input bits and the *generator sequences* for the encoders. A given generator sequence $\{g_{i,p,l}\}$ relates a particular input sequence $\{m_l^i\}$ to a particular output sequence $\{x_j^p\}$. A particular value of $g_{i,p,l}$ denotes the presence or absence of a tap connecting the l^{th} memory element of the i^{th} input shift register to the p^{th} output. The n output equations have the form

$$x_j^p = \sum_{i=1}^{k} \sum_{l=0}^{\nu_i} g_{i,p,l} m_{j-l}^i, \quad 1 \le p \le n$$

The memory for each of the k inputs is enumerated by the *memory vector* $(\nu_1, \nu_2, \cdots, \nu_k)$ (i.e. the i^{th} input shift register has ν_i memory elements). It is assumed that for each i there is at least one p with $g_{i,p,\nu_i} = 1$. The *state complexity* of the encoder is determined by the *total encoder memory* $\nu \equiv \nu_1 + \nu_2 + \cdots + \nu_k$. The number of states in the encoder is 2^ν, while the *window length* is determined by the *memory order*[1] $\mu = \max_{1 \le i \le k} \nu_i$.

[1]The terminology in the literature is inconsistent; the *constraint length* of a

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