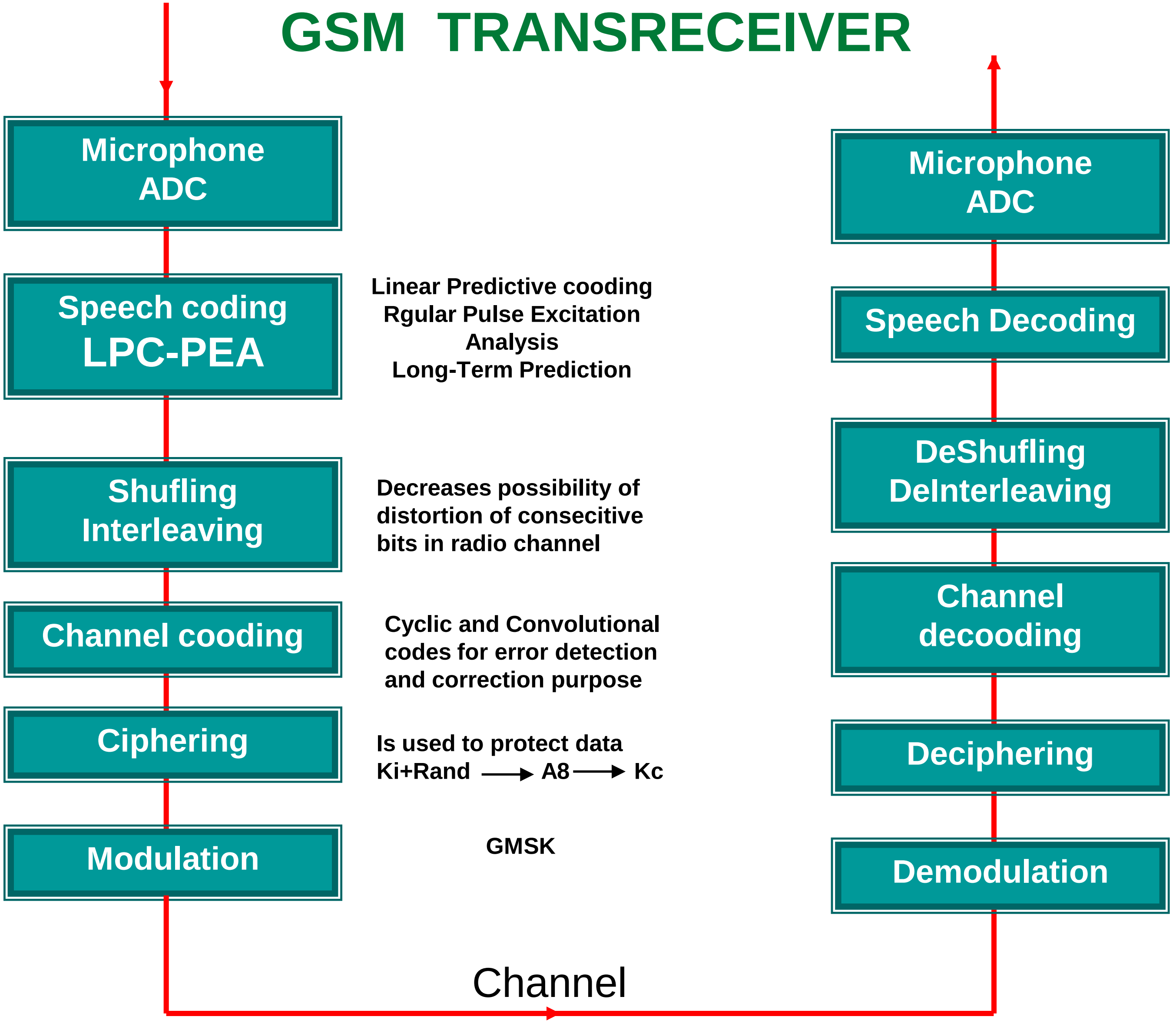
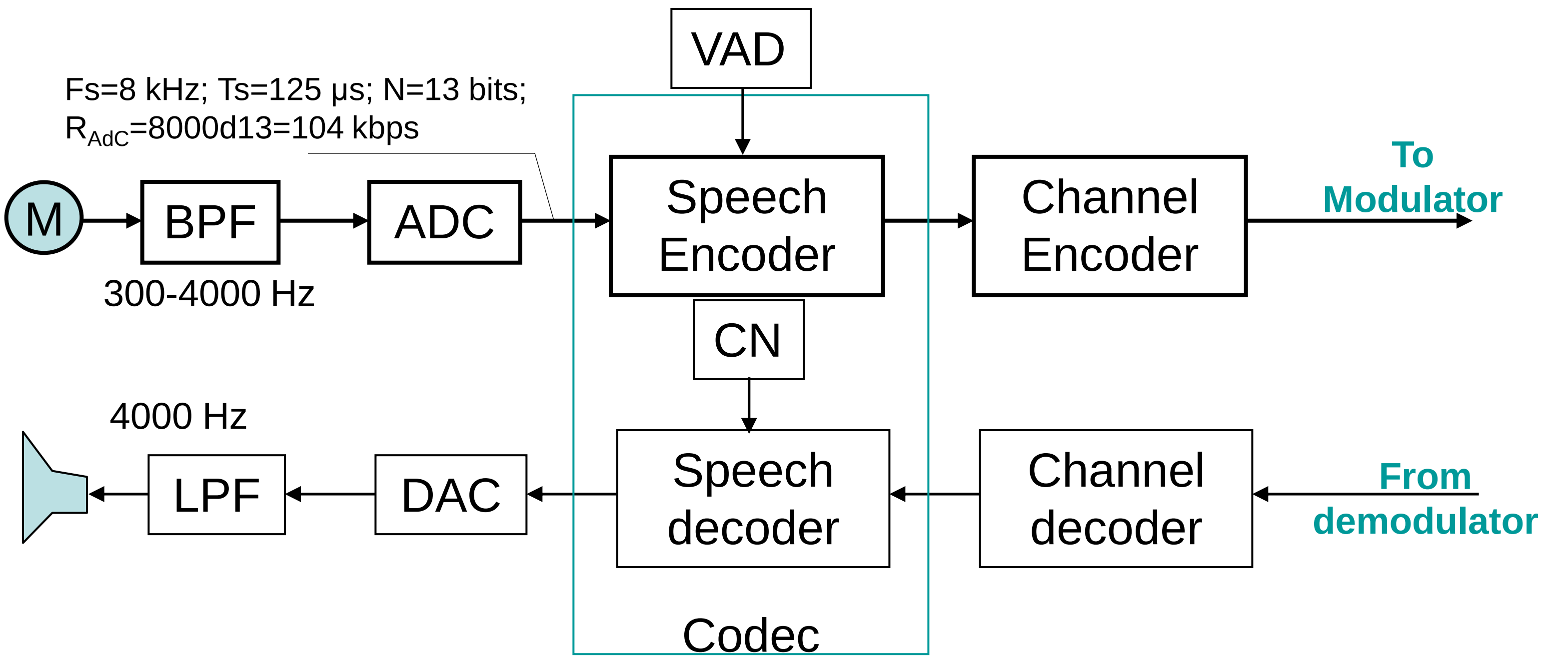
GSM TRANSRECEIVER



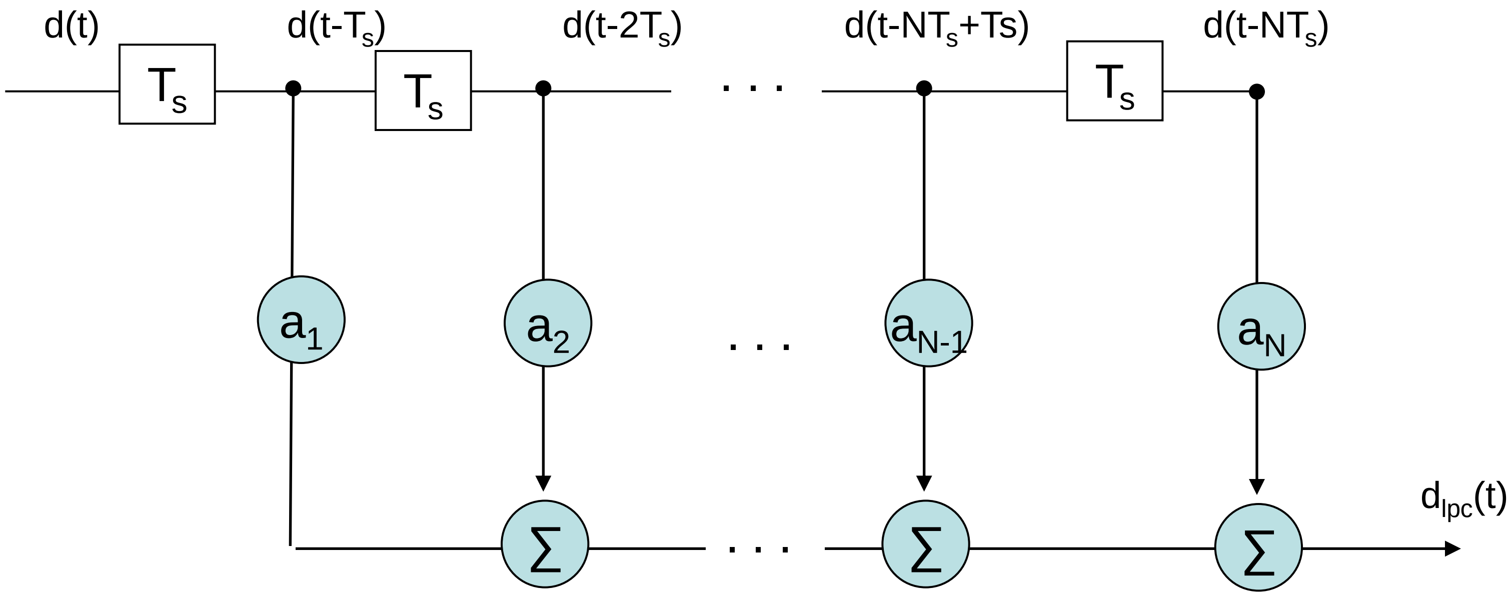
SPEECH CODING



VAD- voice activitydetector-to determine the presence or abcence of speech at the microphone.Pauses in normal speech is about of half the time of speaker using a telephone. during pauses is sent silence descriptor (SId) frame onse every 480 ms. Upon receiving SId frame Comfort Noise **CN** **or backround noise is generated by decoderthat gives the system "presence"**

Speech encoder LPC/RPE = Linear Predictive Code with Regular Pulse Edcitation Analysis

Linear Predictive Code



$$\tilde{\mathbf{x}} = \sum_{n=1}^{N} \mathbf{a}_n \mathbf{x}(\mathbf{t} - \mathbf{n}\mathbf{T}_s) = \mathbf{a}^T \mathbf{x}$$

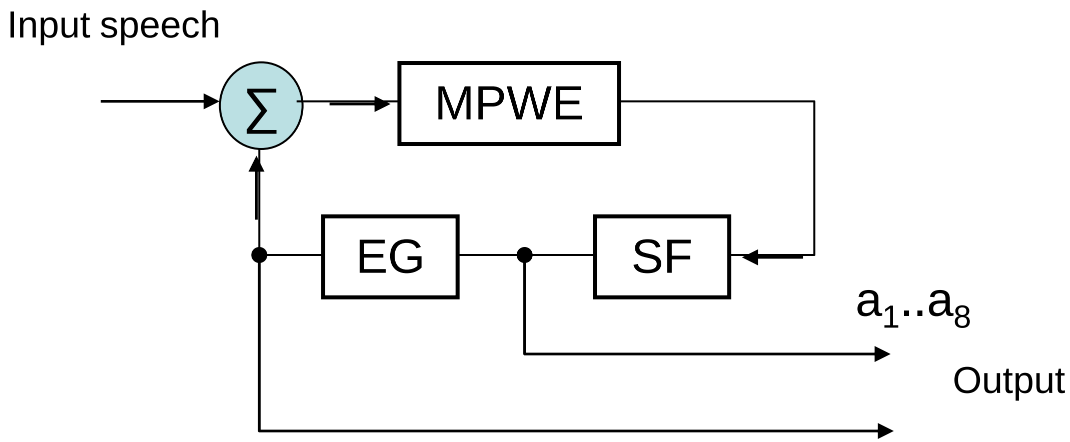
$$\mathbf{x} = [\mathbf{x}(\mathbf{t} - \mathbf{Ts}), \mathbf{x}(\mathbf{t} - 2\mathbf{Ts}) \ldots \mathbf{x}(\mathbf{t} - \mathbf{nTs})]$$

$$\mathbf{a}^T = [\mathbf{a}_1, \mathbf{a}_2, \ldots \mathbf{a}_N]$$

$$\mathbf{MSE} = \mathbf{E}\left[(\mathbf{x}(\mathbf{t}) - \tilde{\mathbf{x}}(\mathbf{t}))^2\right]$$

$$\mathbf{a} = \mathbf{R}^{-1}\mathbf{r} \quad \textbf{Wiener-Hopf Equation}$$

Multiple Excited LPF



MPWE- **Block of** Minimization of perceptually weighted error

20 ms-160 samples – is used for computing the filter parameters
5ms – 40 samples – is used for optimizing edcitation parameters

Sequence 1- samples: 1, 5.9,.....37
Sequence 2- samples: 2, 6.9,.....38
Sequence 3- samples: 3, 7.9,.....39
Sequence 4- samples: 4, 8.10,....40

→ Speech encoder selects The sequence the most energy

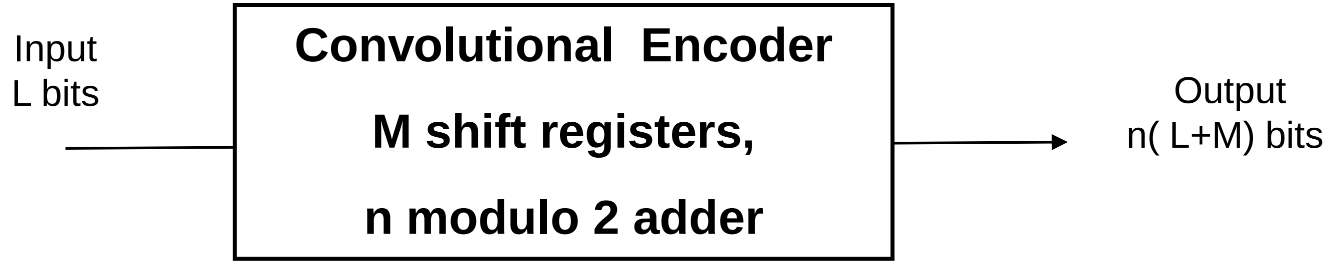
Short Term Prediction - using 8 to 16 samples to predict a present sample

Long Term Prediction(LTP)-Comparison present sequense with earlier sequences and finding sequence having highest correletion with presence. Transmit the difference between two sequences. This feature reduces the amount of transmitted data.

CONVOLUTIONAL CODING

The coder may be viewed as a finite stae machine that consist **M shift register** with prescribed connections to **n-modulo 2 adders** and **multipleder** that serializesthe outputs of the adders.

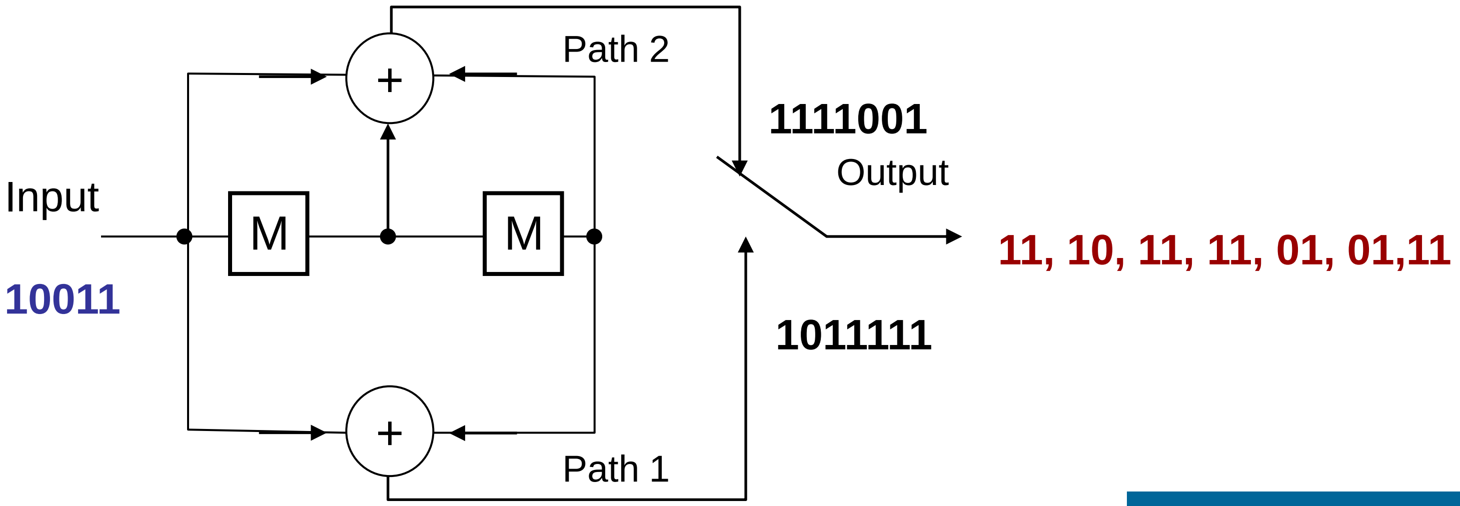
A convolutional coder generates redundant bits by using modulo-2convolutions . **L bits message** produces **output sequence of length n(L+M),** where M is number of shift register that contains coder.



data rate: $$\mathbf{r = \frac{L}{n(L+M)}\ bits/symbol}$$ **For L>>M; r=1/n**

K=M+1 - is constraint length of encoder

Convolutional Encoder with n=2and K=3



The impulse response of path 1 (101): $g_1(d)= 1+d^2$

The impulse response of path 2(111): $g_2(d)= 1+d+d^2$

The Message 10011 $m(d)=1+d^3+d^4$

The outputs:

$$c_1(d)= g_1(d)m(d)=1+d^2+d^3+d^4+d^5+d^6 \text{ - } 1011111$$

$$c_2(d)= g_2(d)m(d)=1+d+d^2+d^3+d^6 \text{ - } 1111001$$

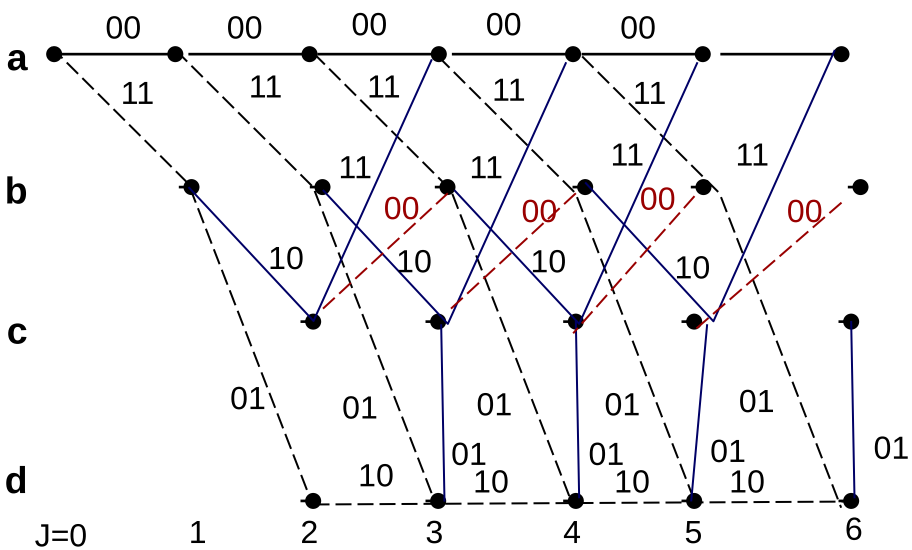
After multipleding: C =11, 10, 11, 11, 01, 01,11

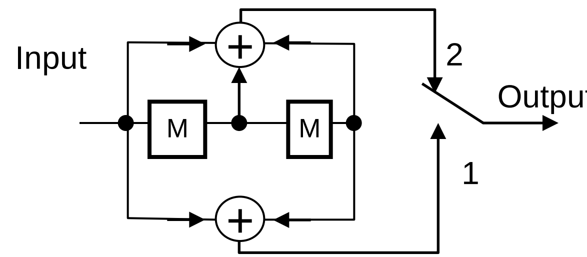
In GSM:

$g_1(d)= 1+d^3+d^4$

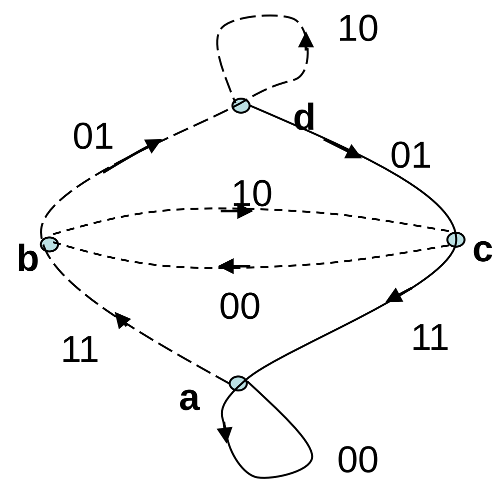
$g2(d)= 1+d+d^3+d^4$

CHANNEL CODING

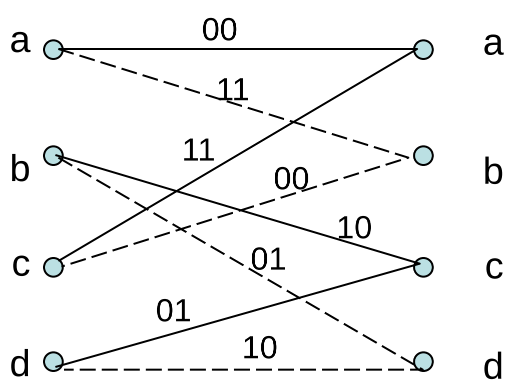




Trellis diagram



a	00
b	01
c	10
d	11



Satae diagram

Free Distance of a Convolutionaql Code

Hamming weights – number of nonzero elements in a code vector

Hamming distance between a pair code vectors- number of different elements .

Free distance d_{free}– minimum **Hamming distance** between any 2 code vectors.

Error correction ability of Conv. Code: **d_{free}>2t ; (t-number of error)**

Systematic CC- incomming message bits are transmitted in unaltered form, this constraint is removed in **nonsystematic CC**.

Konstraint length, **K**	Systematic	Non-Systematic
2	3	3
3	4	5
4	4	6
5	5	7
6	6	8

Maximum Likelihood Decoding (MLD)

m – message vector; **c**- code vector applied to encoder
r-received vector; $\mathbf{m_e}$- estimation of **m**

<u>The MLD decoders decision rule:</u>

Choose the estimate $\mathbf{c_e}$ for which log-likehood function log p(r/c) is maximum
p(r/c) denote aconditional probability of receiving **r** , given that **c** sent

Or

Choose the estimate $\mathbf{c_e}$ that minimizies Hamming distance **d** between a candidate Code vector $\mathbf{c_e}$ and the received vector **r.**

In such a decoder the received vector **r** is compared with each possible candidate vector $\mathbf{c_e}$, and tha particvular one closest to r is chosen as an estimate of the transmitted code vector(or with minimum Hamming distance)

INTERLEAVING

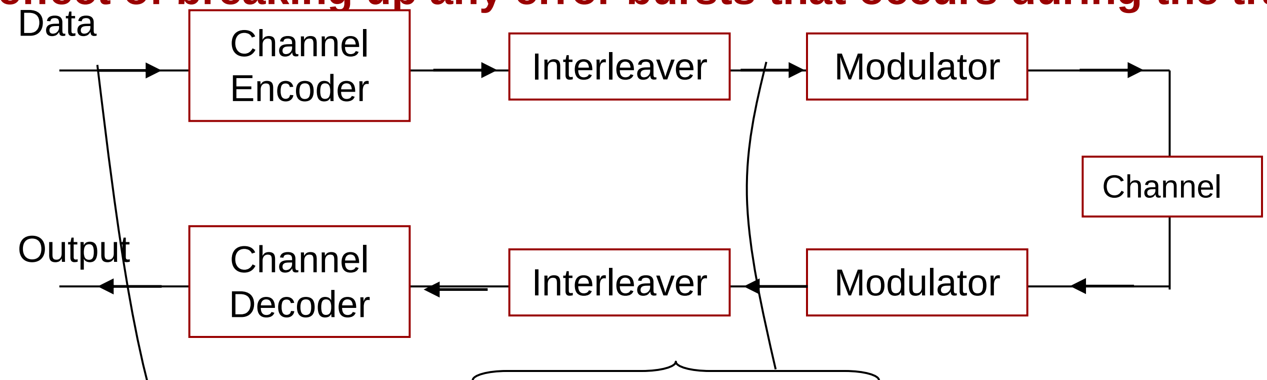
Wireless channel has 2 conflicting fenomena:

- **Presence a burst of error;**
- **Convolutional Encoding can not handle error bursts (**example due a mulipath fading).

(examples of burst of error-signal fading due a mulipath propogations, defect in the disc result clusers of errors).

Interleaving-Randomizing the order of encoded bits after channel encoder.

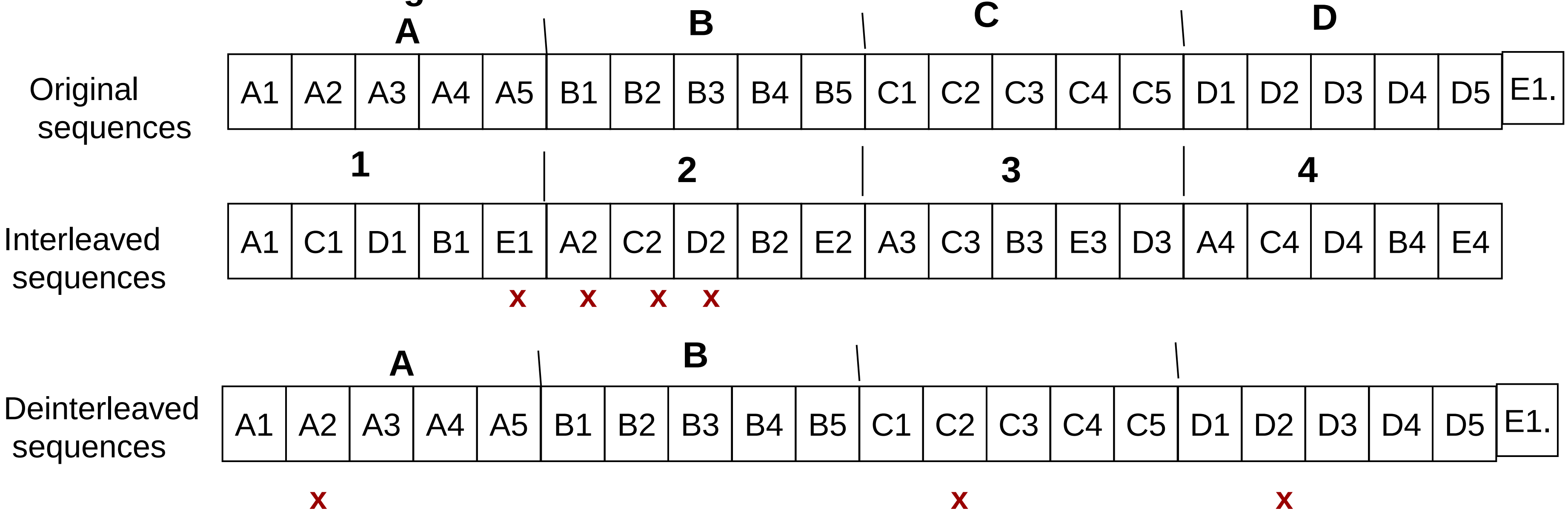
Has the effect of breaking up any error bursts that occurs during the transmission



1	8	15	22	..	
2	9	16	23	..	
3	10	17	24	..	
4	11	18	25	..	
5	12	19	26	..	
6	13	20	27	..	
7	14	21	28	..	

Block interleaver

1. Block interleaving



2. Convolutional Interleaver; **3. Random Interleaver**