EEN 1043/EE452 Wireless and Mobile Communication

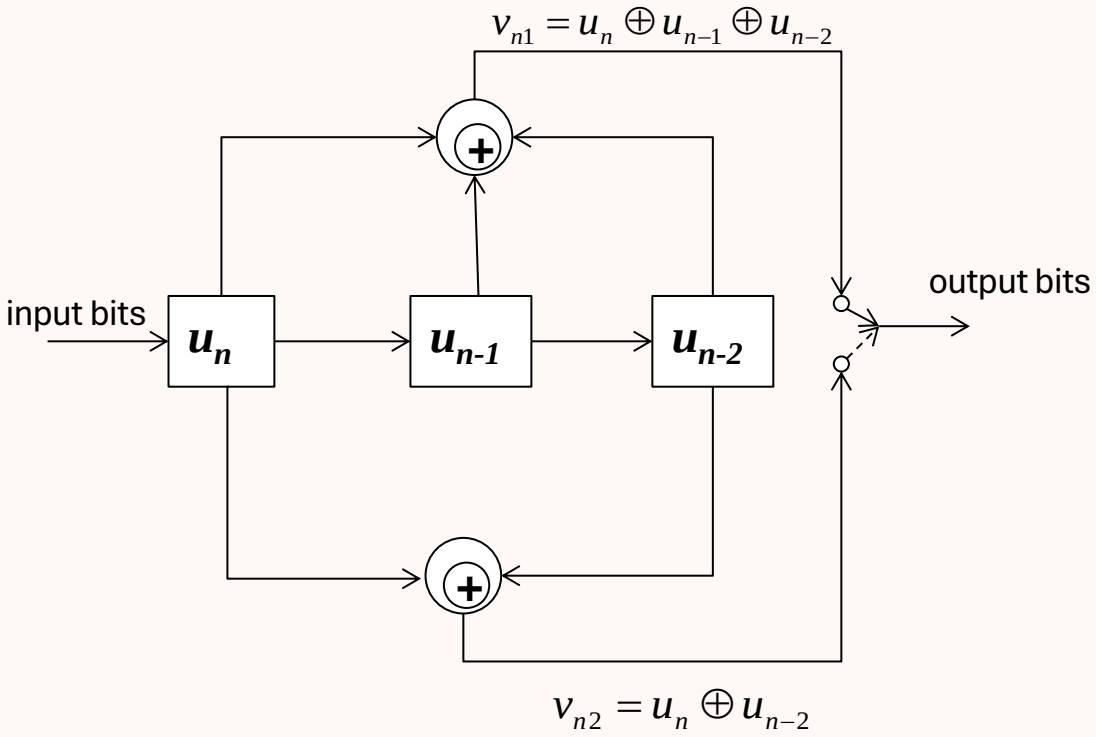
Channel Coding II

Sobia Jangsher

Assistant Professor

School of Electronic Engineering

Channel Coding: Convolution Coding Encoding example



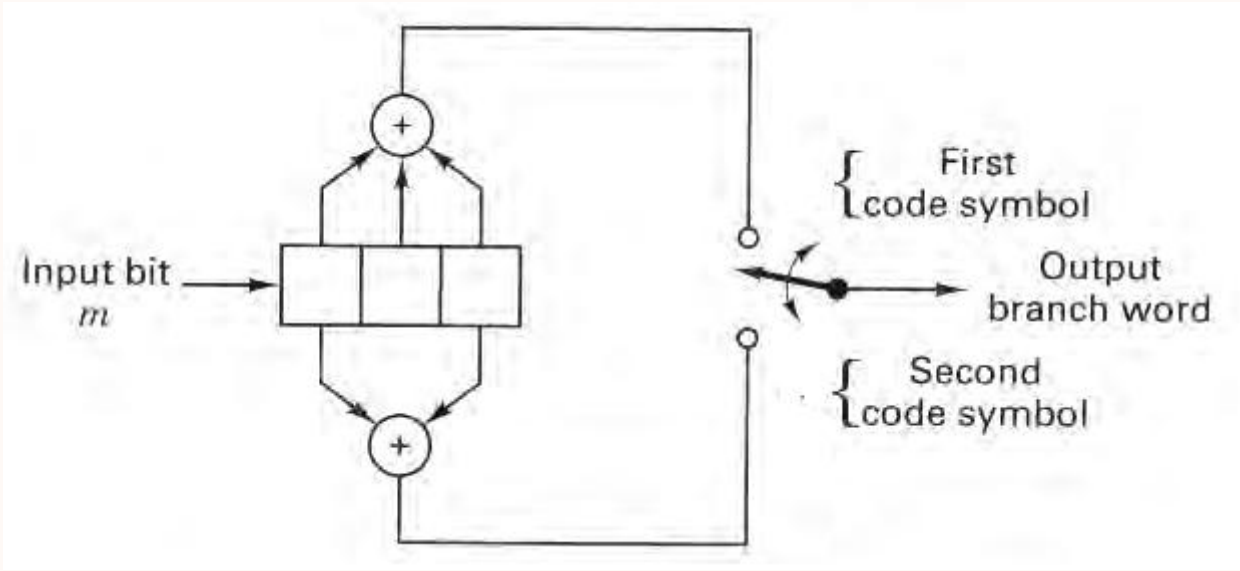
- Example
  - (2,1,3) encoder
  - Input stream u
  - Output v

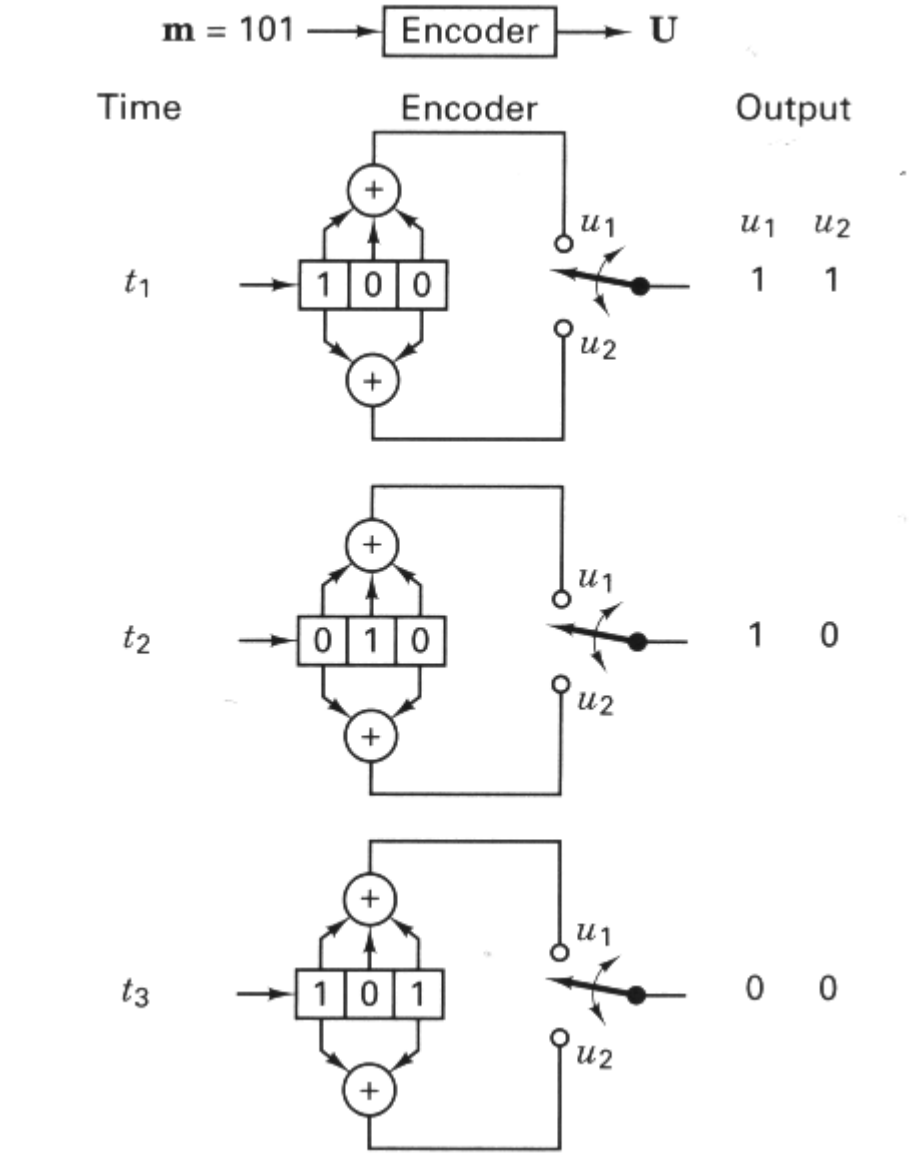
$$v_{n1} = u_n \oplus u_{n-1} \oplus u_{n-2}$$

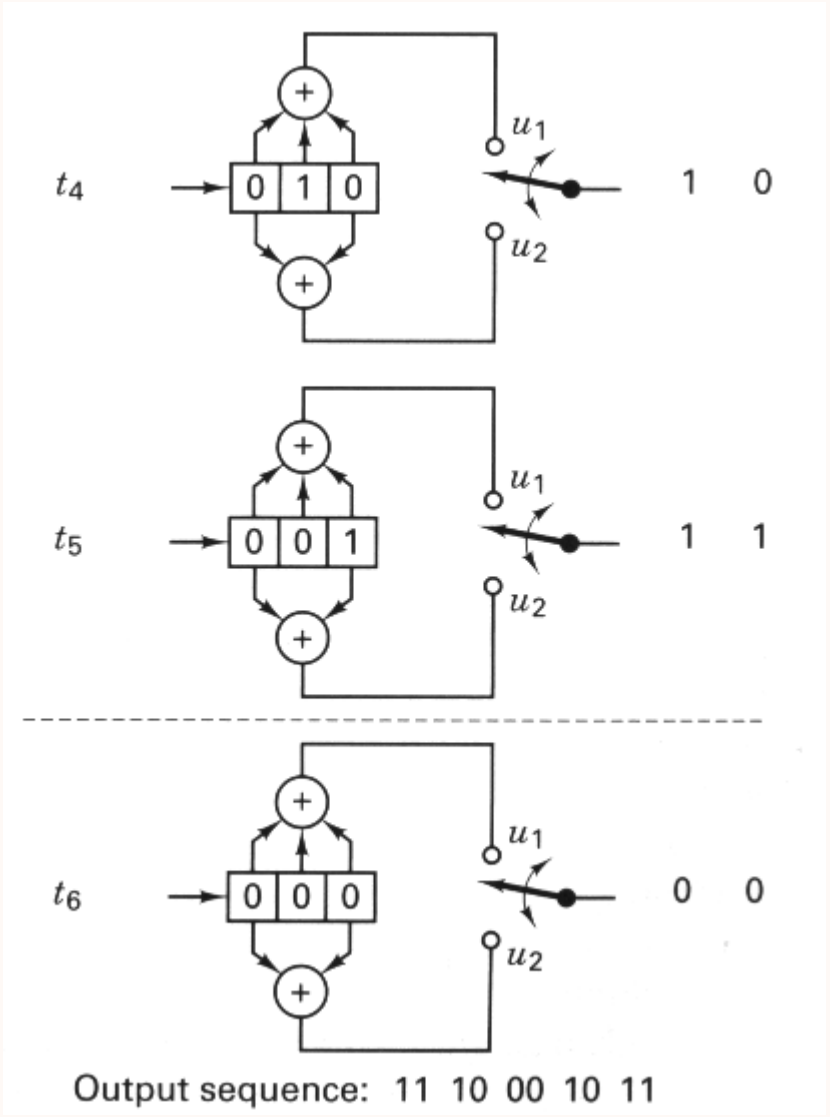
$$v_{n2} = u_n \oplus u_{n-2}$$

Convolutional Coding

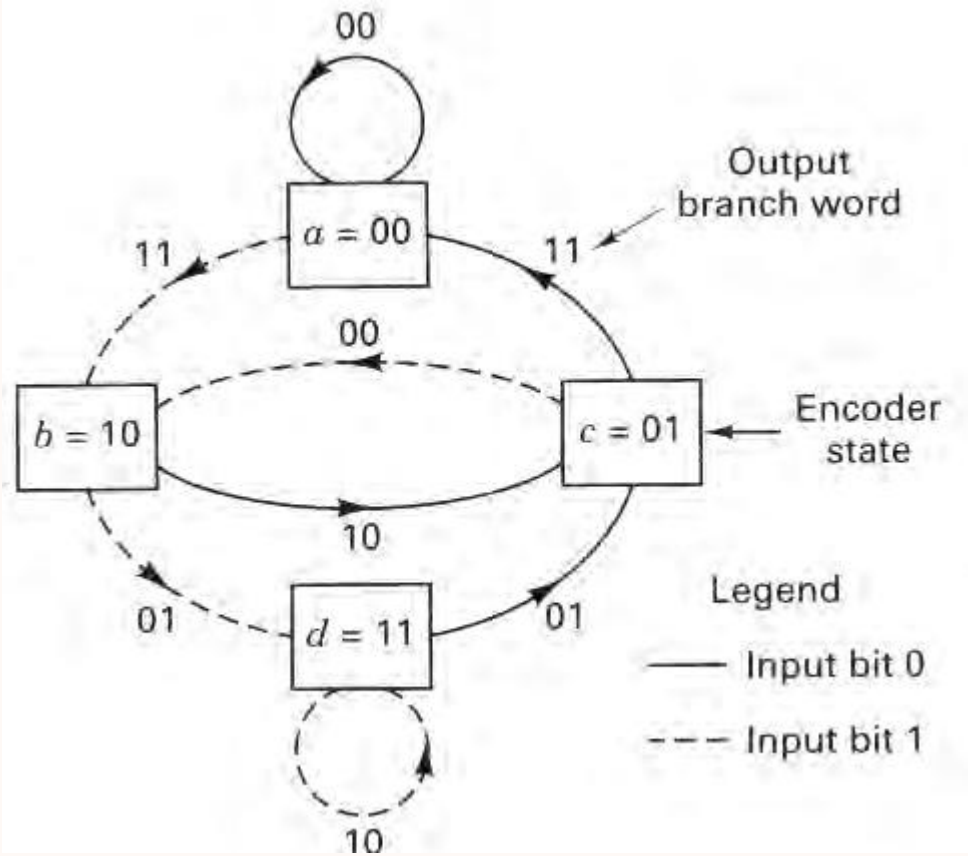
- (n,k,K)=(2,1,3)
- K is the constraint length
- State of the encoder : Bits in the register other than the input bit



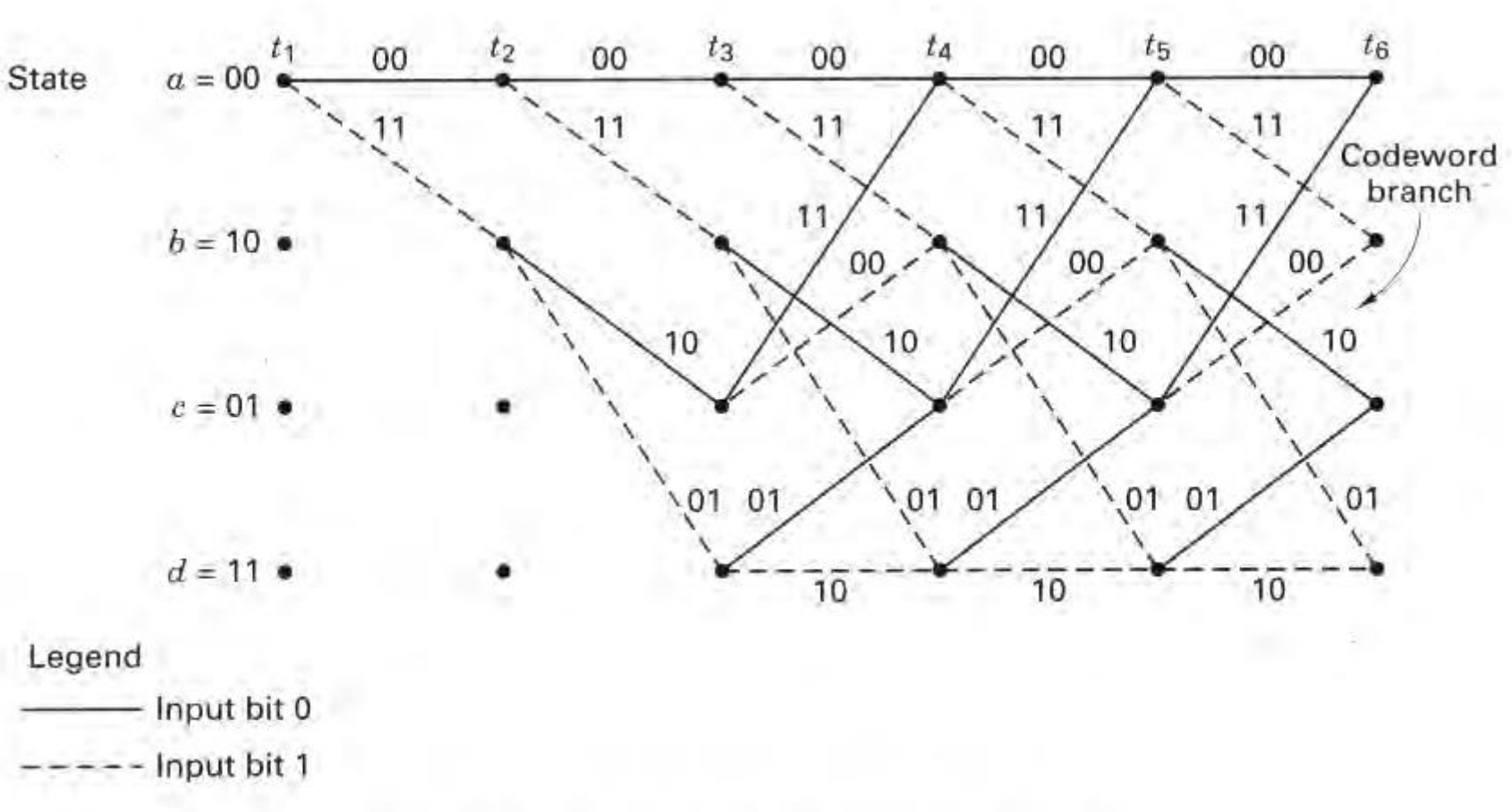

m = 101
Encoder
U
Time
Encoder
Output
u_1 u_2
t_1
1 0 0
1 1
u_1
u_2
t_2
0 1 0
1 0
u_1
u_2
t_3
1 0 1
0 0
u_1
u_2


t_4
0 1 0
1 0
u_1
u_2
t_5
0 0 1
1 1
u_1
u_2
t_6
0 0 0
0 0
u_1
u_2
Output sequence: 11 10 00 10 11

State Diagram



Encoder Trellis



Encode: 1110

Code word

Encode: 1110

11 01 10 01 (without clearing the register)

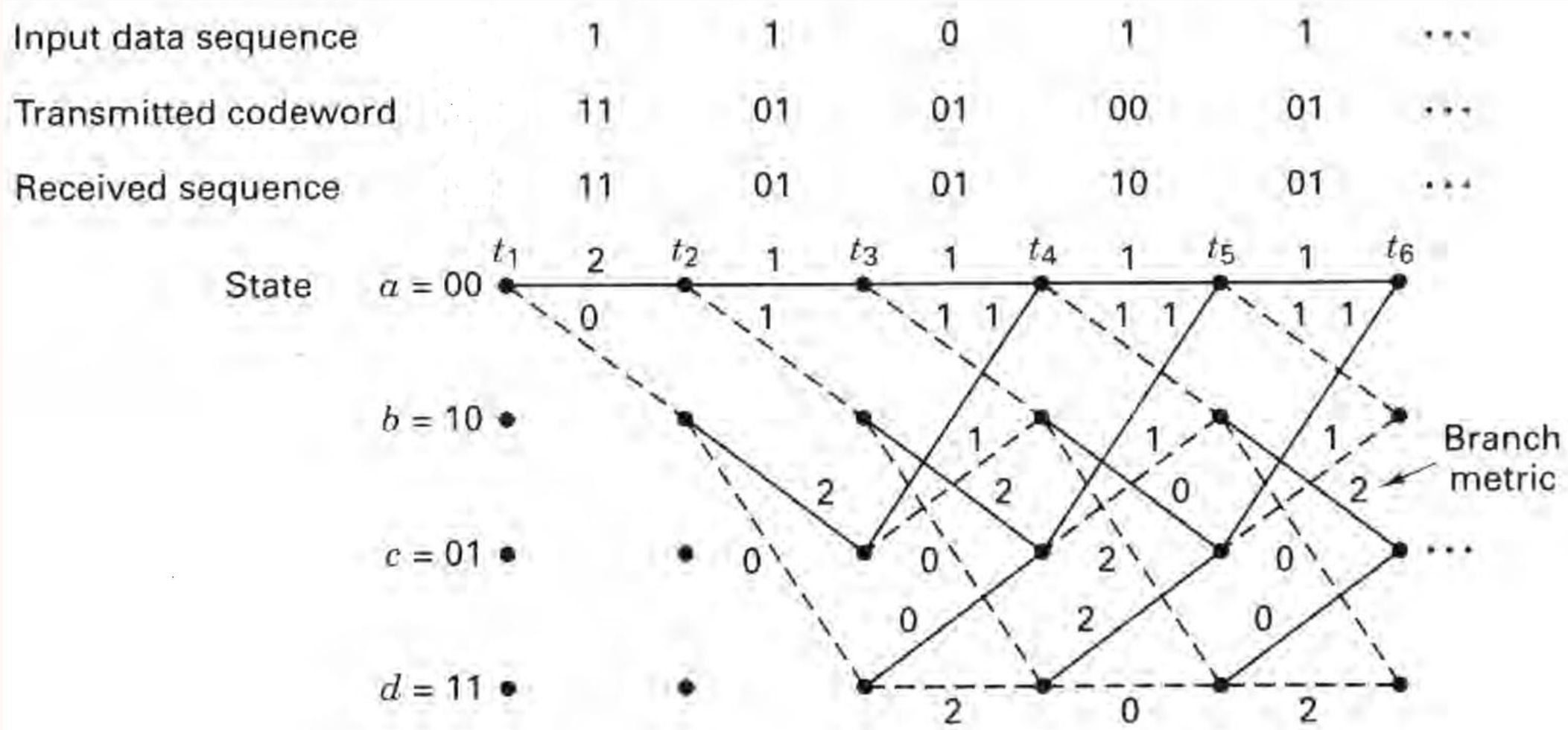
Convolutional Decoding

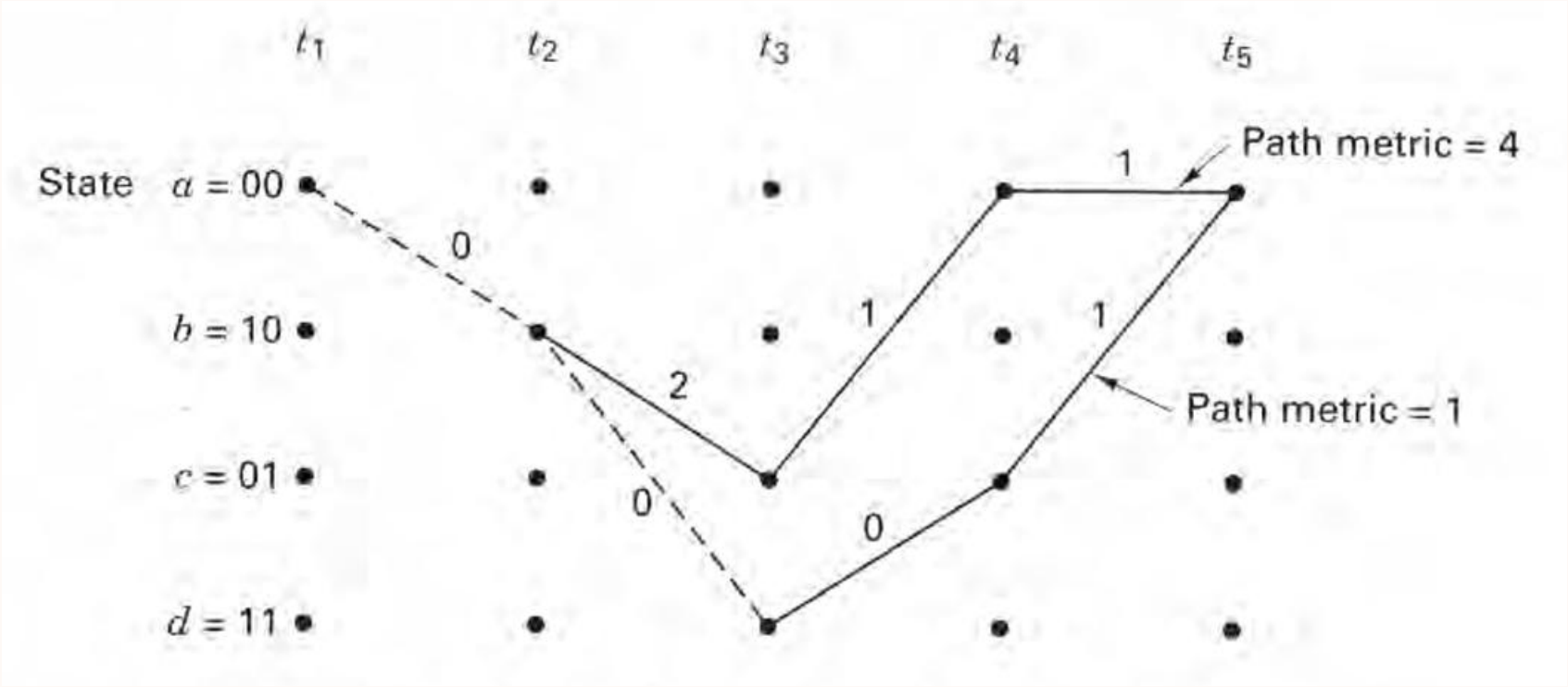
- Trellis
- It essentially performs maximum likelihood decoding.
- Idea: compare received sequence with all possible sequences, and choose the closest one.
  - One measure of closeness is the Hamming distance.

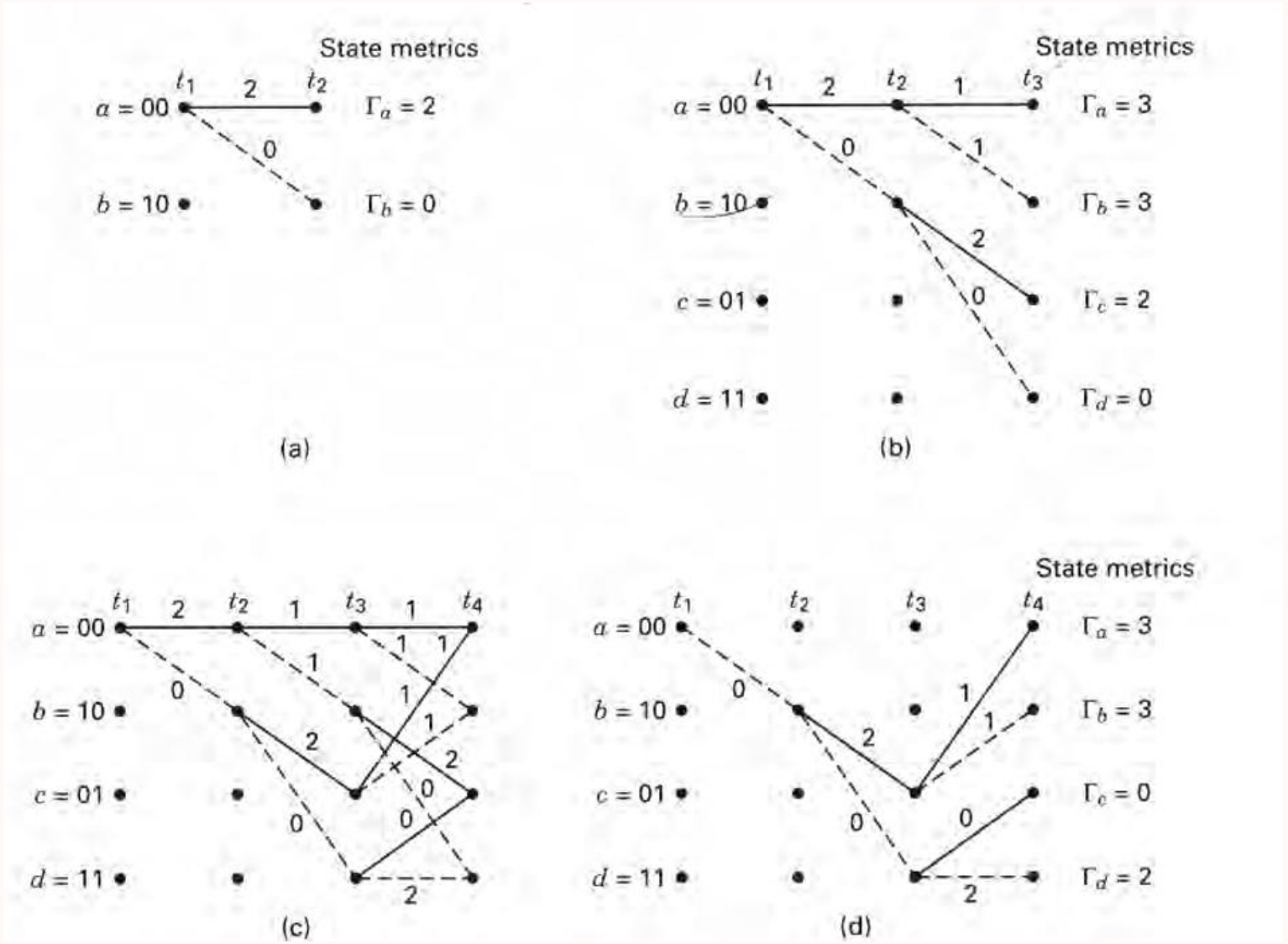
Convolutional Decoding

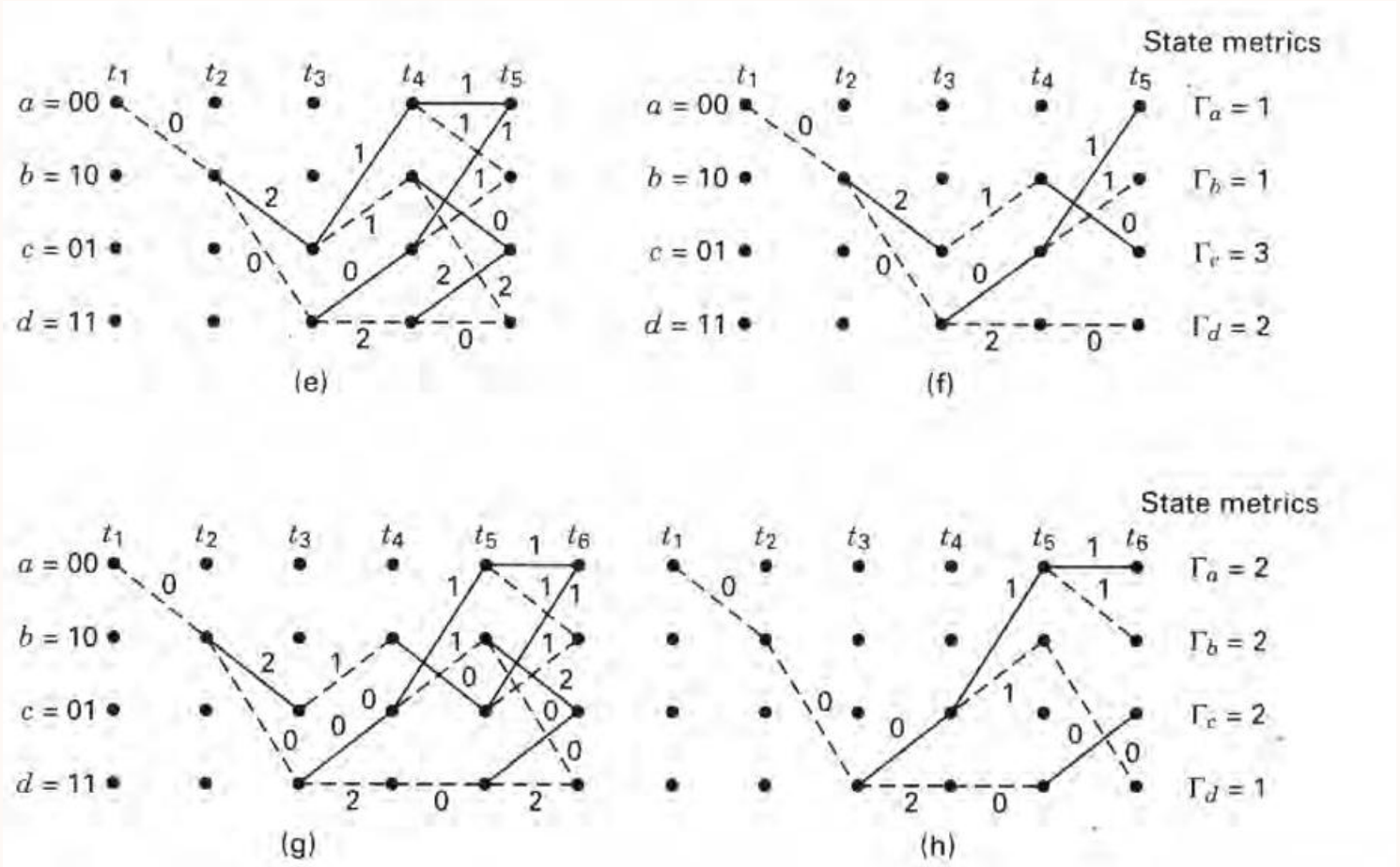
- Let the received code sequence be $w = w_0 w_1 w_2 \ldots$
- To find initial code block $w_0 \ldots w_{n-1}$
  - Step 0: at time 0 initial state is labelled 0 – there is no problem.
  - Step i+1: for each state S at time i+1, find all active paths (minimum Hamming distance) leading to S. Label S with the distance.
  - Step b: Stop at time b. If all paths have same first edge, this gives the first input block. If there are different first edges, the error is not correctable.
- To find the next code block, SLIDE WINDOW by *n* and REPEAT

Viterbi Algorithm



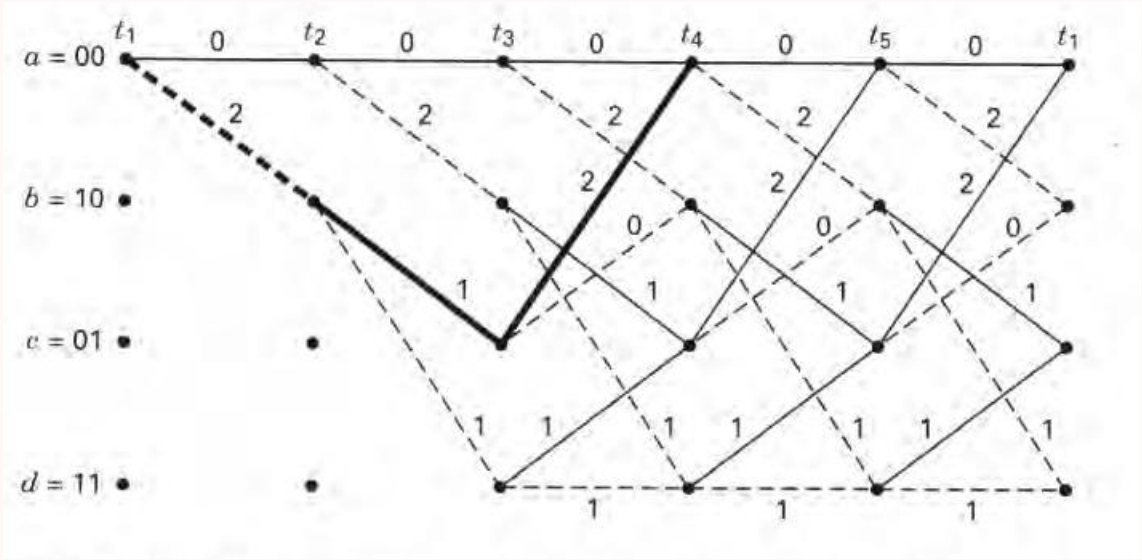

t_1
t_2
t_3
t_4
t_5
State
$a = 00$
$b = 10$
$c = 01$
$d = 11$
0
2
0
1
0
1
1
Path metric = 4
Path metric = 1


State metrics
t_1 2 t_2
$a = 00$
$\Gamma_a = 2$
0
$b = 10$
$\Gamma_b = 0$
(a)
State metrics
t_1 2 t_2 1 t_3
$a = 00$
$\Gamma_a = 3$
0
1
$b = 10$
$\Gamma_b = 3$
2
$c = 01$
0
$\Gamma_c = 2$
$d = 11$
$\Gamma_d = 0$
(b)
t_1 2 t_2 1 t_3 1 t_4
$a = 00$
1
1
1
0
$b = 10$
1
2
1
2
$c = 01$
0
0
0
$d = 11$
2
(c)
State metrics
t_1 t_2 t_3 t_4
$a = 00$
$\Gamma_a = 3$
0
1
$b = 10$
2
1
$\Gamma_b = 3$
$c = 01$
0
0
$\Gamma_c = 0$
$d = 11$
2
$\Gamma_d = 2$
(d)


State metrics
t_1 t_2 t_3 t_4 t_5
$a = 00$
$b = 10$
$c = 01$
$d = 11$
$\Gamma_a = 1$
$\Gamma_b = 1$
$\Gamma_c = 3$
$\Gamma_d = 2$
(e)
(f)
State metrics
t_1 t_2 t_3 t_4 t_5 t_6
$\Gamma_a = 2$
$\Gamma_b = 2$
$\Gamma_c = 2$
$\Gamma_d = 1$
(g)
(h)

Error Correcting capability

- Trellis with labelled distances from all zeros path

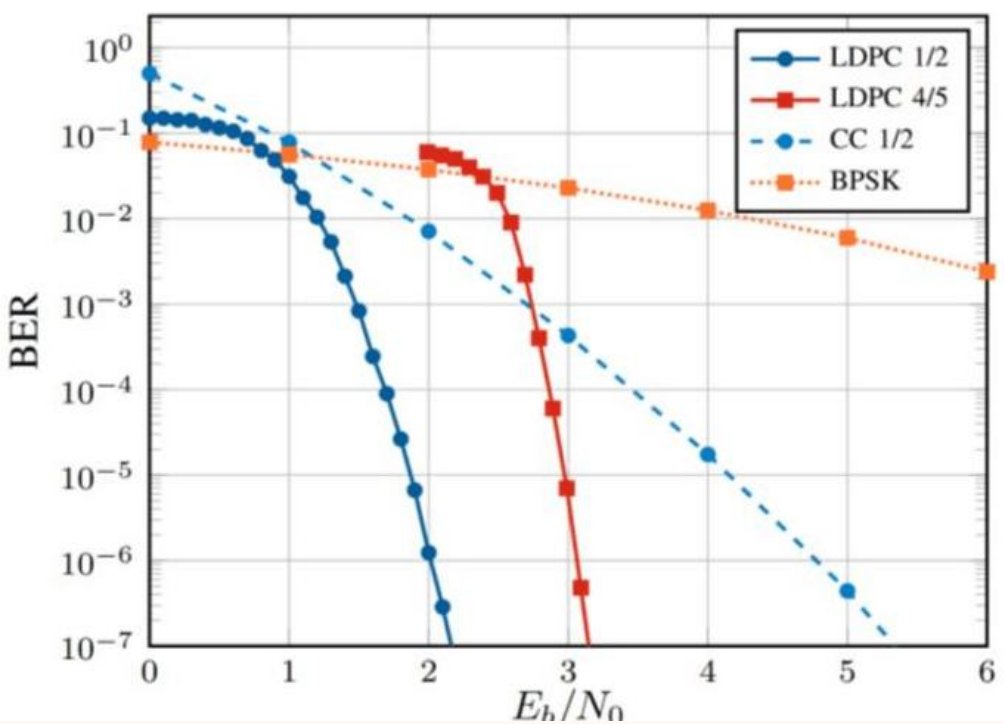


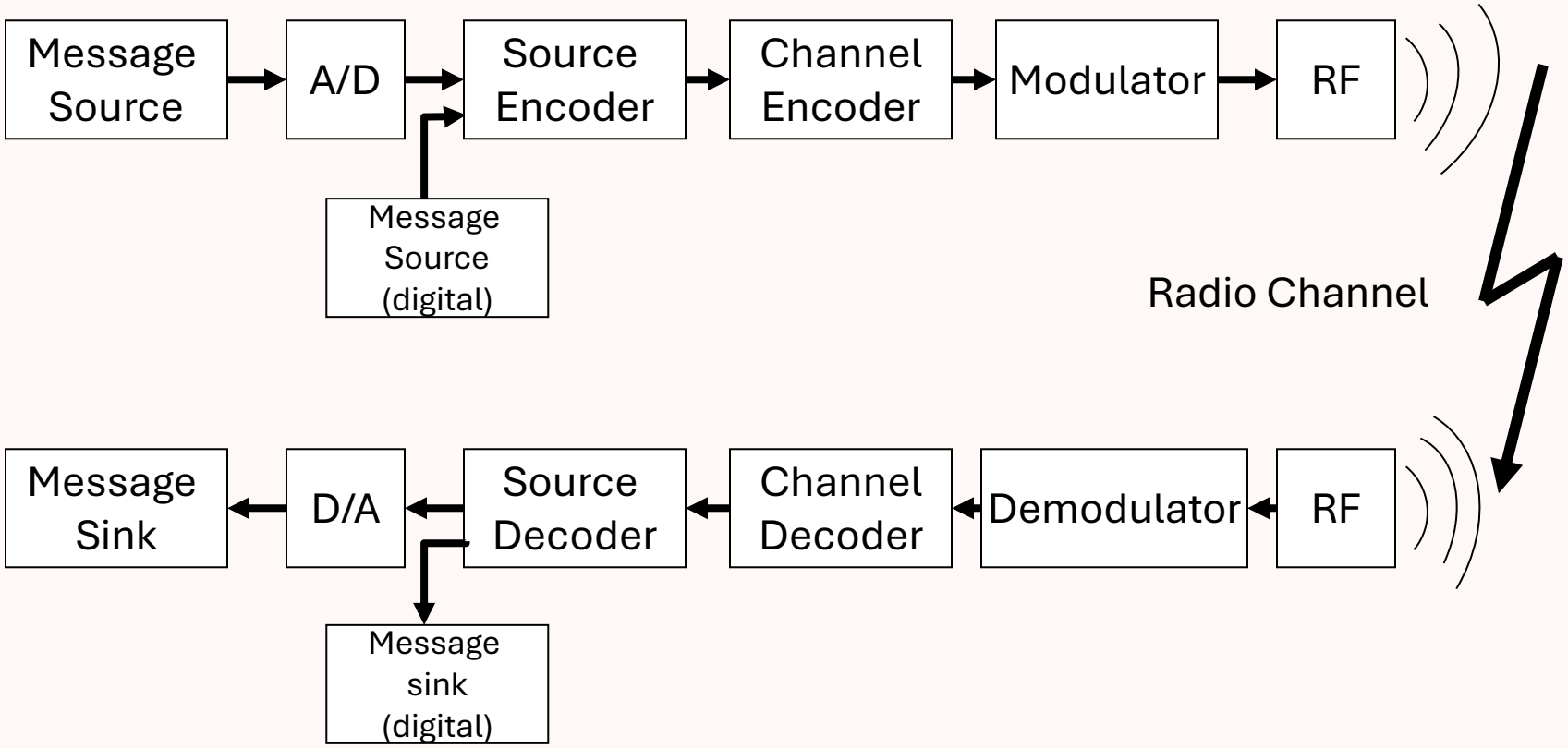
$d_{\min}$ = min distance of a path that diverge and remerge to all 0s

$$t = floor((d_{\min} - 1)/2)$$

Channel Coding for Mobile Communication

Gen.	Channel Coding
2G	Cyclic Codes (FIRE/CRC), (Punctured) Convolutional Codes
3G	Convolutional Codes, Turbo Codes
4G	Tail Biting Convolutional Codes, Turbo Codes
5G	Polar Codes, LDPC Codes




Message Source
A/D
Source Encoder
Channel Encoder
Modulator
RF
Message Source (digital)
Radio Channel
Message Sink
D/A
Source Decoder
Channel Decoder
Demodulator
RF
Message sink (digital)