Channel coding
part 2

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OUTLINE:

- ❖ convolution code
- ➢ encoder for convolution code
- -state diagram
- -code tree
- - trellis
- ➢ decoding of convolution codes
- - Viterbi algorithm

Convolution coding is a popular error-correcting coding method used to improve the reliability of communication system.

Convolutional codes are commonly specified by three parameters: **(*n*,*k*,*m*)**:

n = number of output bits

k = number of input bits

m = number of memory registers

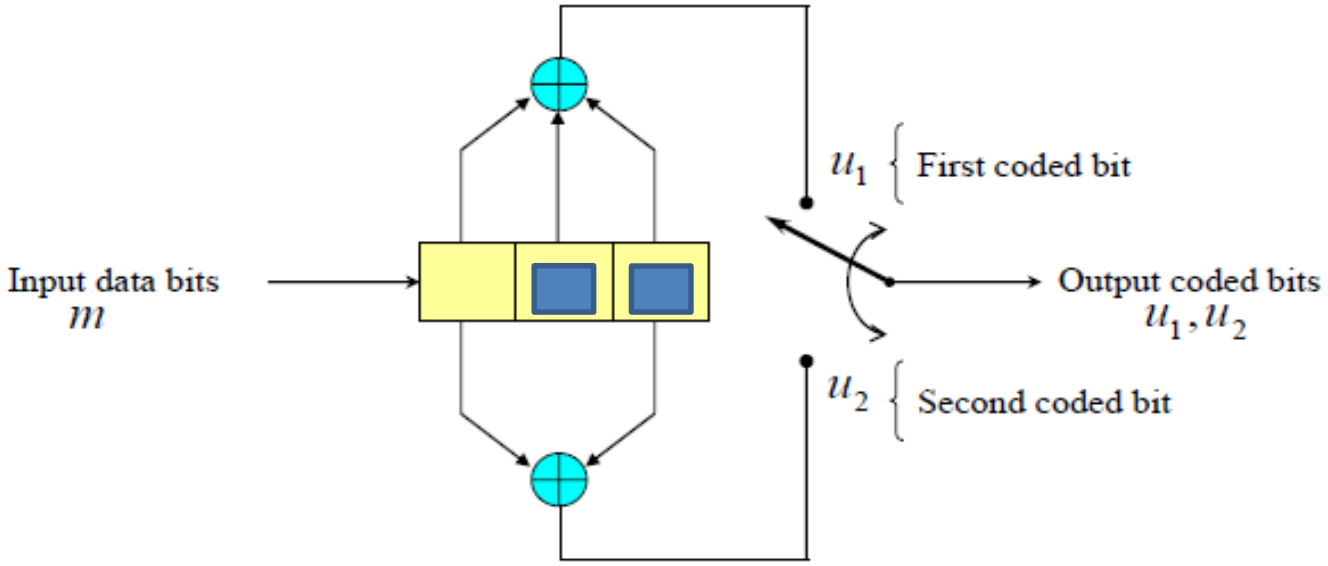
Registers (or delay elements) is capable of holding one bit (0 or 1) and each having one input and one output, The output of each register is always the same as the input was one unit of time earlier.

The quantity ***k/n*** is called as **code rate**. It is a measure of the efficiency of the code.

The quantity L is called the **constraint length** of the code.

It represents the number of bits in the encoder memory that affect the generation of the *n* output bits, L = k (m-1)

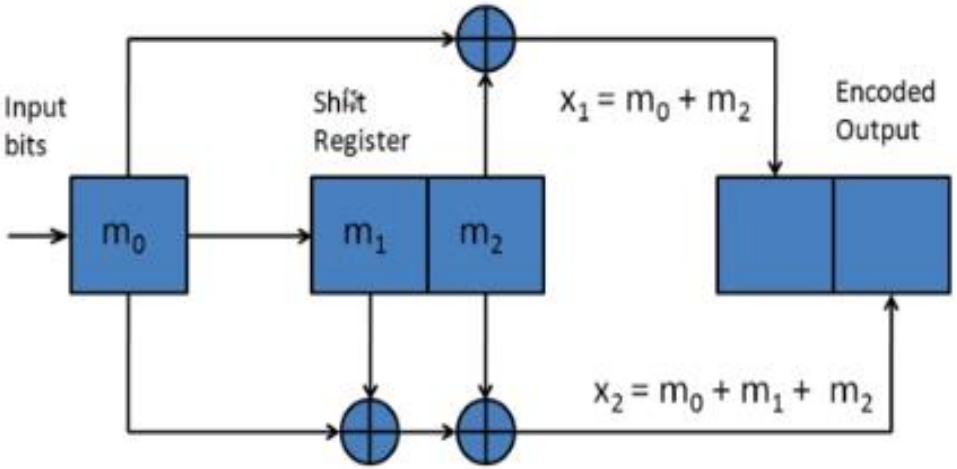
➢ encoder for convolution code

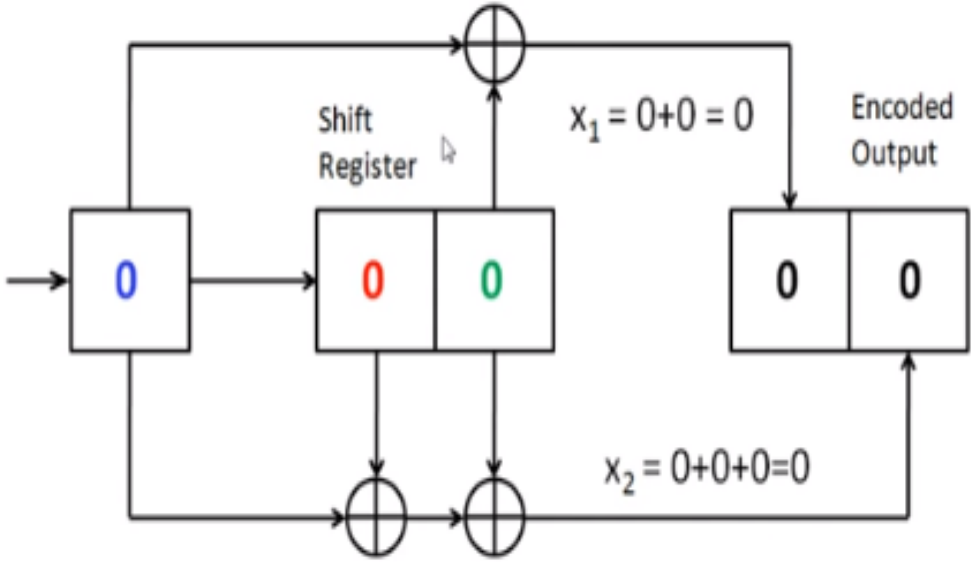


n = number of output bits
k = number of input bits
m = number of memory registers

constraint length of the code L = k (m-1)

The no of bit in the shaded register are called state of code and are defined by
No. of states = 2^L

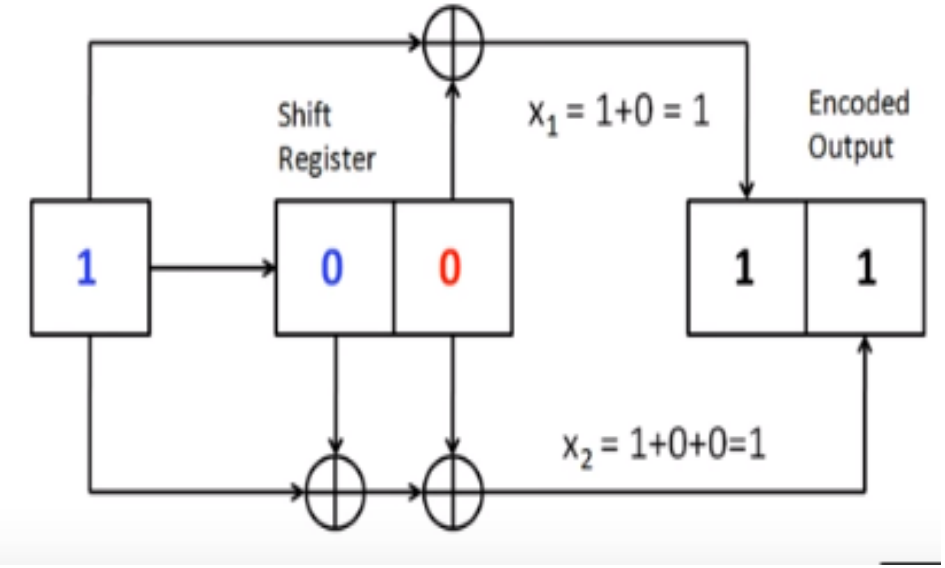




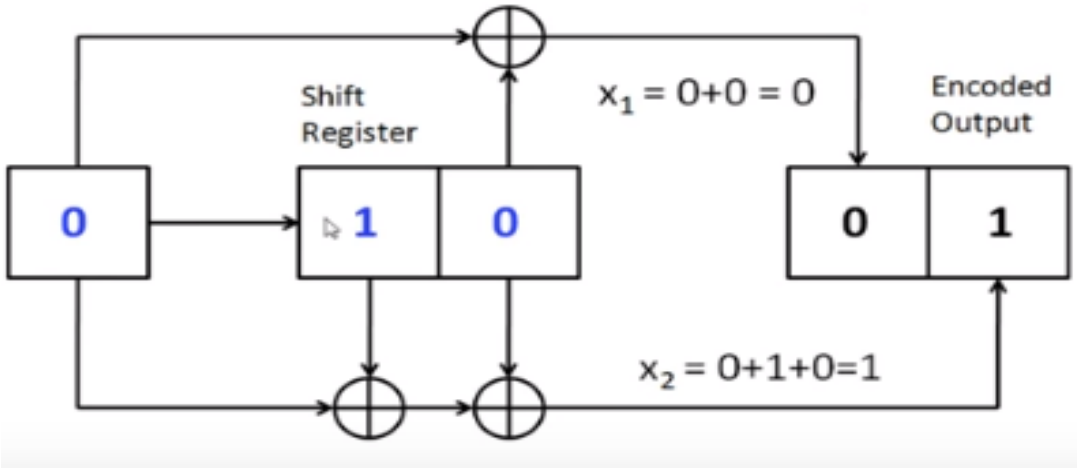
Initially the value in the shift register is [0 0].

Suppose the first incoming bit is 0, then m0 = 0, m1=0 and m2 =0, hence x1 = 0 and x2 = 0

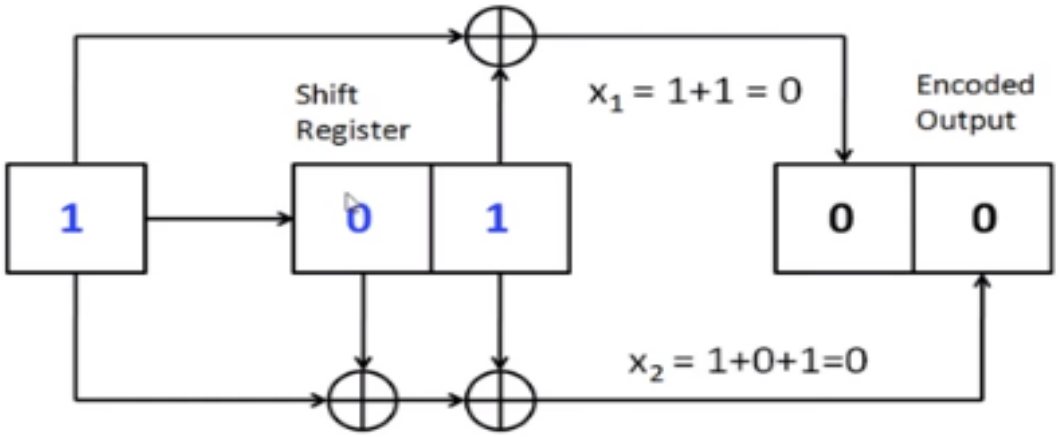
Suppose next incoming bit is 1, then m0=1, m1=0 and m2=0



Suppose next incoming bit is 0, then m0=0, m1=1 and m2=0

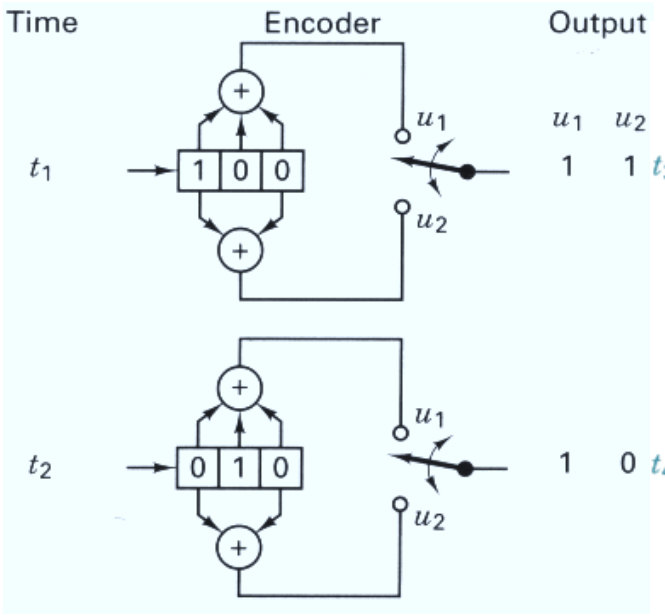


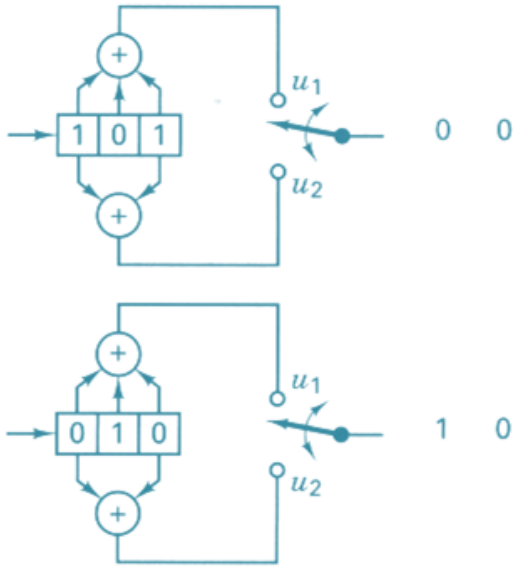
Suppose next incoming bit is 1, then m0=1, m1=0 and m2=1

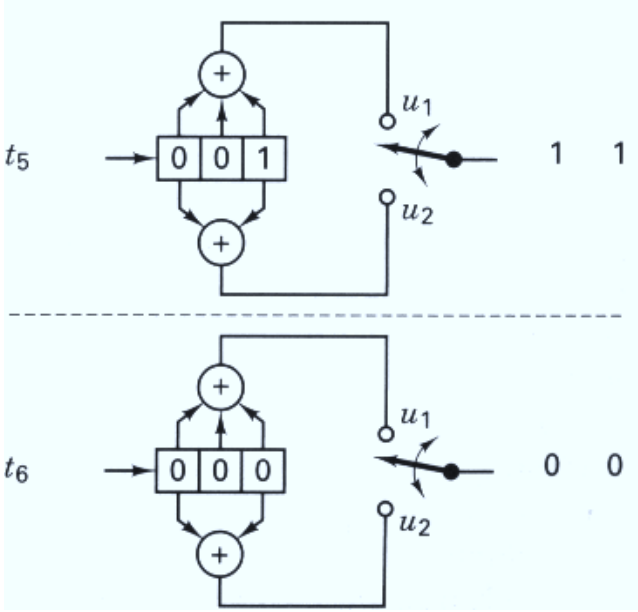


The encoded bits are

Information bit	Encoded bits
0	00
1	11
0	01
1	00







rate $\frac{1}{2}$.

Output sequence: 11 10 00 10 11

2 zeros are in putted at times t_4 and t_5 to flush the register and thus ensure that the tail end of the message is shifted the full length of the register.

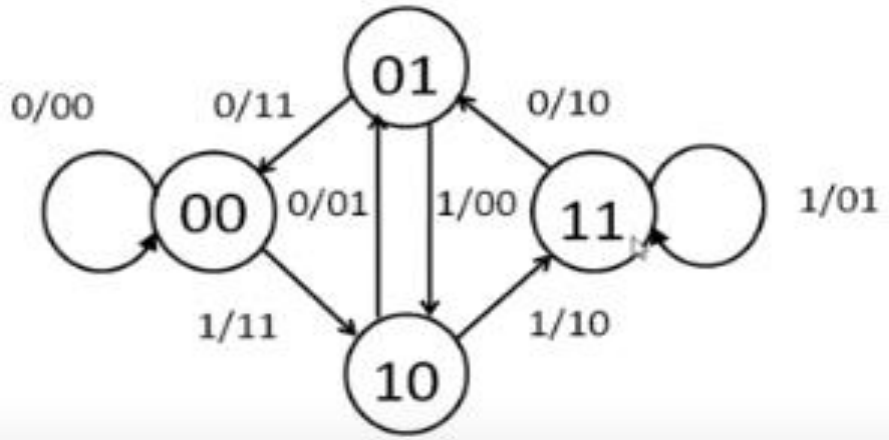
zero input is shown at time t_6, for the reader to verify that the flushing is completed at time t_5. Thus, a new message can be entered at time t_6.

Encoder Representations

➢ State Diagram Representation

- In the state diagram, the state information of the encoder is shown in the circles. Each new input information bit causes a transition from one state to another.
- Contents of the right most (m-1) shift register stages define the states of the encoder. The transition of an encoder from one state to another, as caused by input bits, is depicted in the state diagram.
- The path information between the states, denoted as x/**c**, represents input information bit x and output encoded bits **c**.
- It is customary to begin convolutional encoding from the all zero state.

Input bit	Present State		New State			Output
m_0	m_1	m_2		$x_1=m_0+m_2$	$x_2=m_0+m_1+m_2$	v
0	0	0	00	0+0=0	0+0+0=0	00
1	0	0	10	1+0=1	1+0+0=1	11
0	0	1	00	0+1=1	0+0+1=1	11
1	0	1	10	1+1=0	1+0+1=0	00
0	1	0	01	0+0=0	0+1+0=1	01
1	1	0	11	1+0=1	1+1+0	10
0	1	1	01	0+1=1	0+1+1=0	10
1	1	1	11	1+1=0	1+1+1=1	01



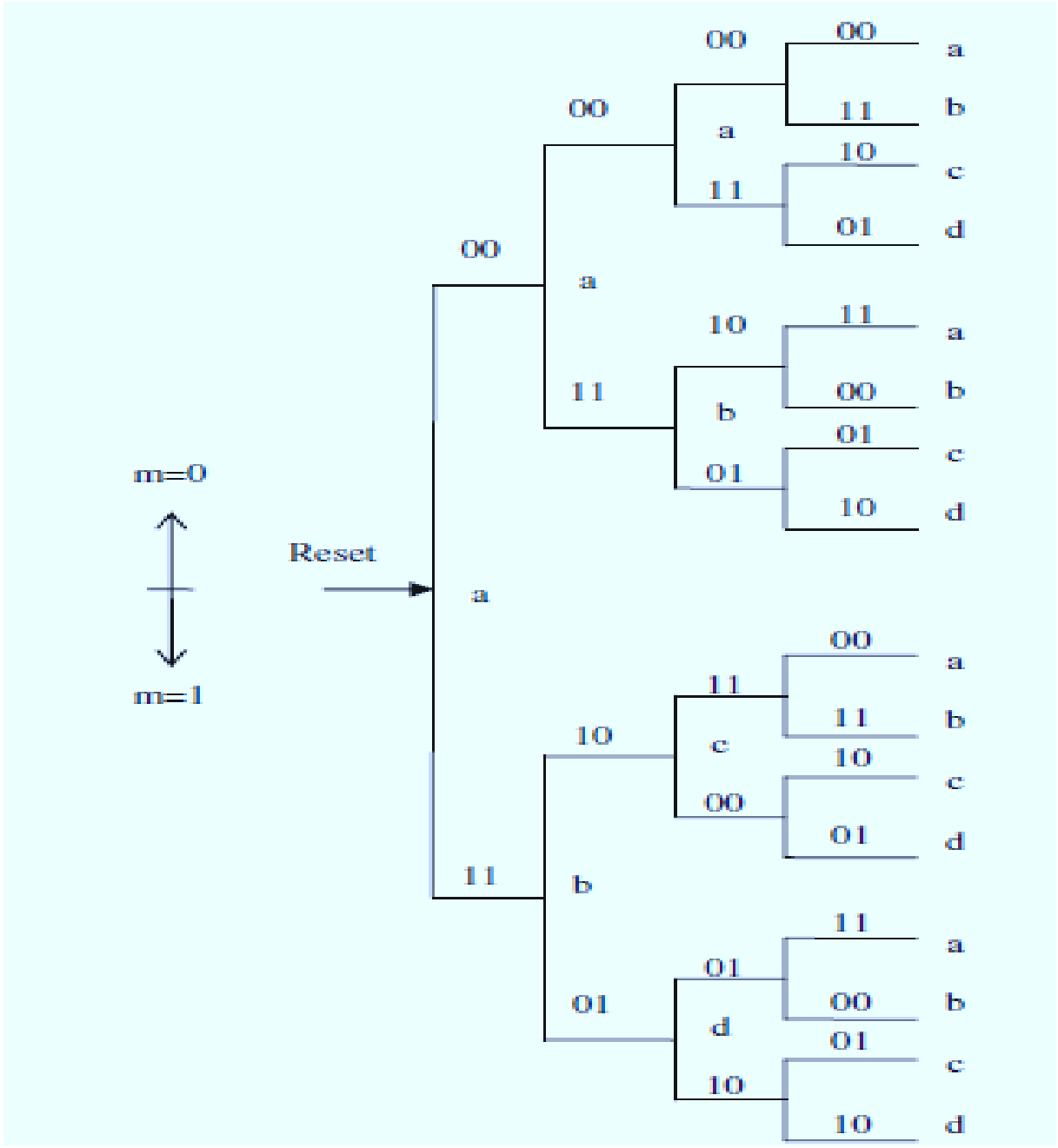
Present State	Input bit	New State
00	0	00
00	1	10
01	0	00
01	1	10
10	0	01
10	1	11
11	0	01
11	1	11

➢ Tree Diagram Representation

- The tree diagram representation shows all possible information and encoded sequences for the convolutional encoder.
- In the tree diagram, a solid line represents input information bit 0 and a dashed line represents input information bit 1.
- The corresponding output encoded bits are shown on the branches of the tree.
- An input information sequence defines a specific path through the tree diagram from left to right

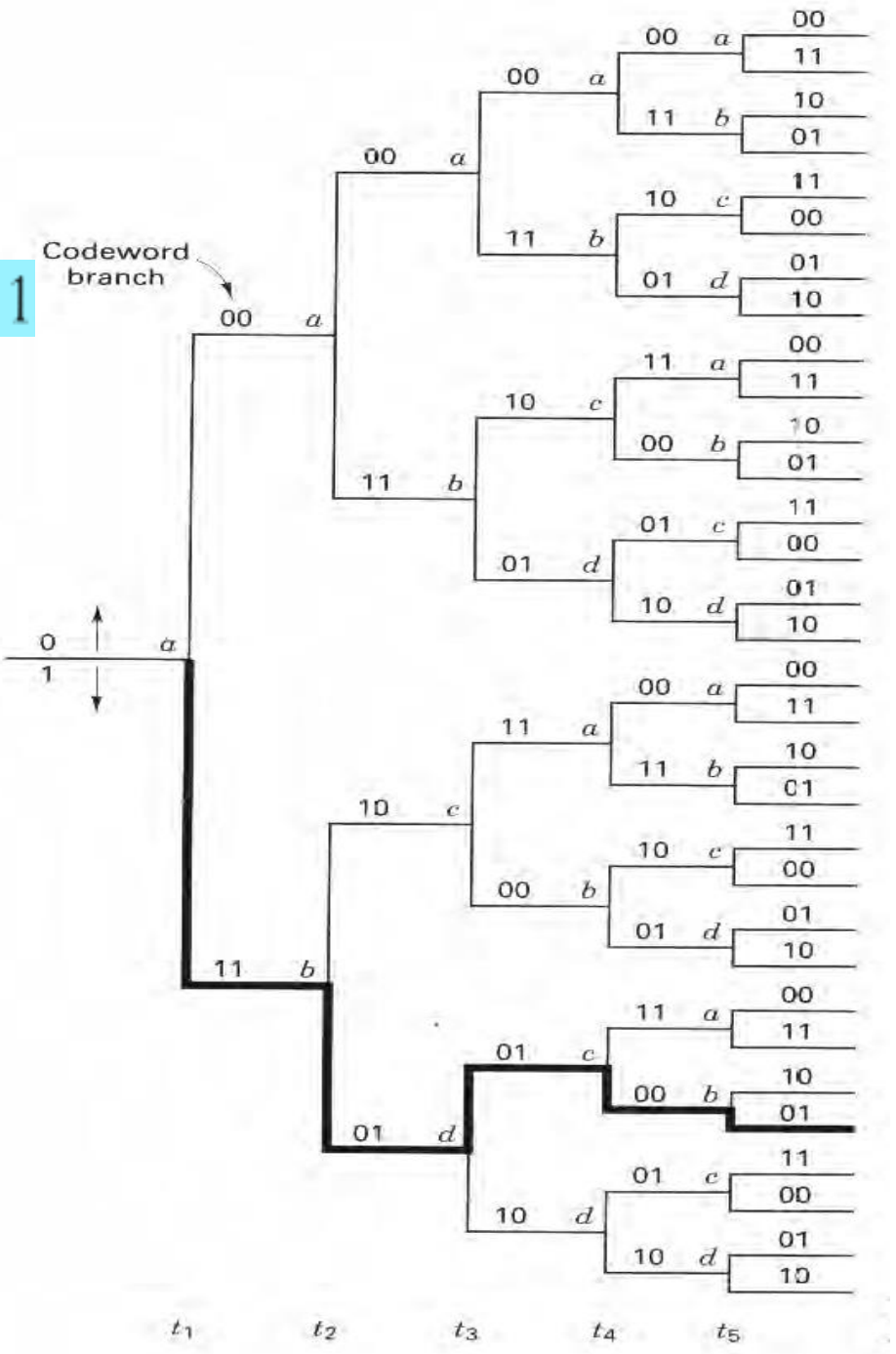
The code tree starts at node ‘a’ if input message bit is m=1, then path of the tree goes down towards node ‘b’ and output is ‘11’. Otherwise, if the input is m=0 at node ‘a’, then path of the tree goes upward towards node ‘a’ and output is ‘00’. Similarly, depending upon the input message bit, the path of the tree goes upward or downward

m_2	m_1	State
0	0	a
0	1	b
1	0	c
1	1	d


m=0
m=1
Reset
00
11
10
01
a
b
c
d

input sequence 1 1 0 1 1

output codeword sequence 1 1 0 1 0 1 0 0 0 1



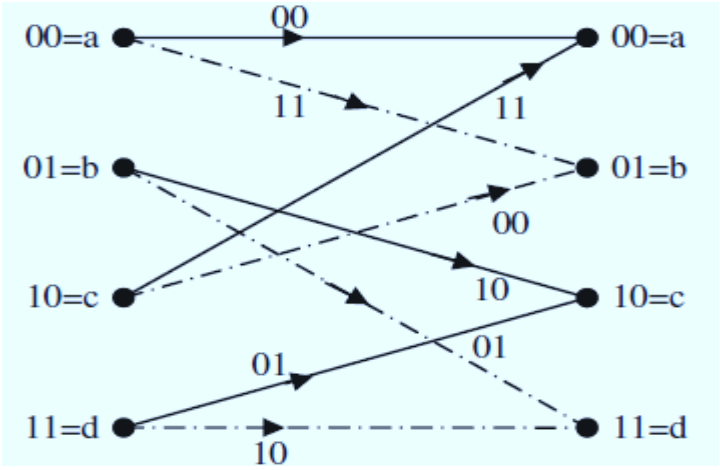
➢ Trellis Diagram Representation

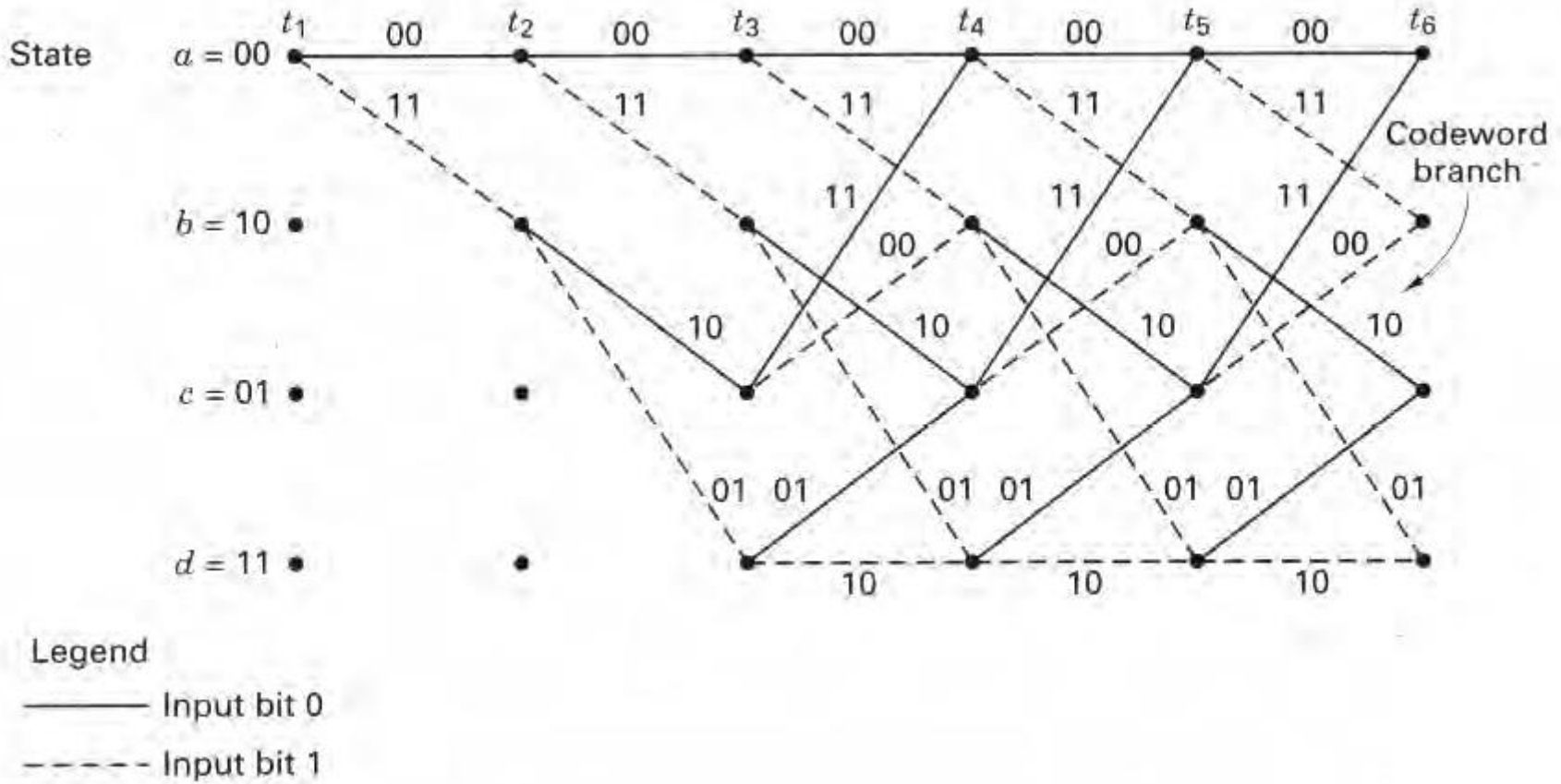
- The trellis diagram is basically a redrawing of the state diagram. It shows all possible state transitions at each time step.
- The trellis diagram is drawn by lining up all the possible states (2^L) in the vertical axis. Then we connect each state to the next state by the allowable codeword for that state.
- There are only two choices possible at each state. These are determined by the arrival of either a 0 or a 1 bit.

Steps to construct trellis diagram

- It starts from scratch (all 0's in the SR, i.e., state a) and makes transitions corresponding to each input data digit.
- These transitions are denoted by a solid line for the next data digit 0 and by a dashed line for the next data digit 1.
- Thus when the first input digit is 0, the encoder output is 00 (solid line)
- When the input digit is 1, the encoder output is 11 (dashed line).
- We continue this way for the second input digit and so on as depicted in Figure that follows.

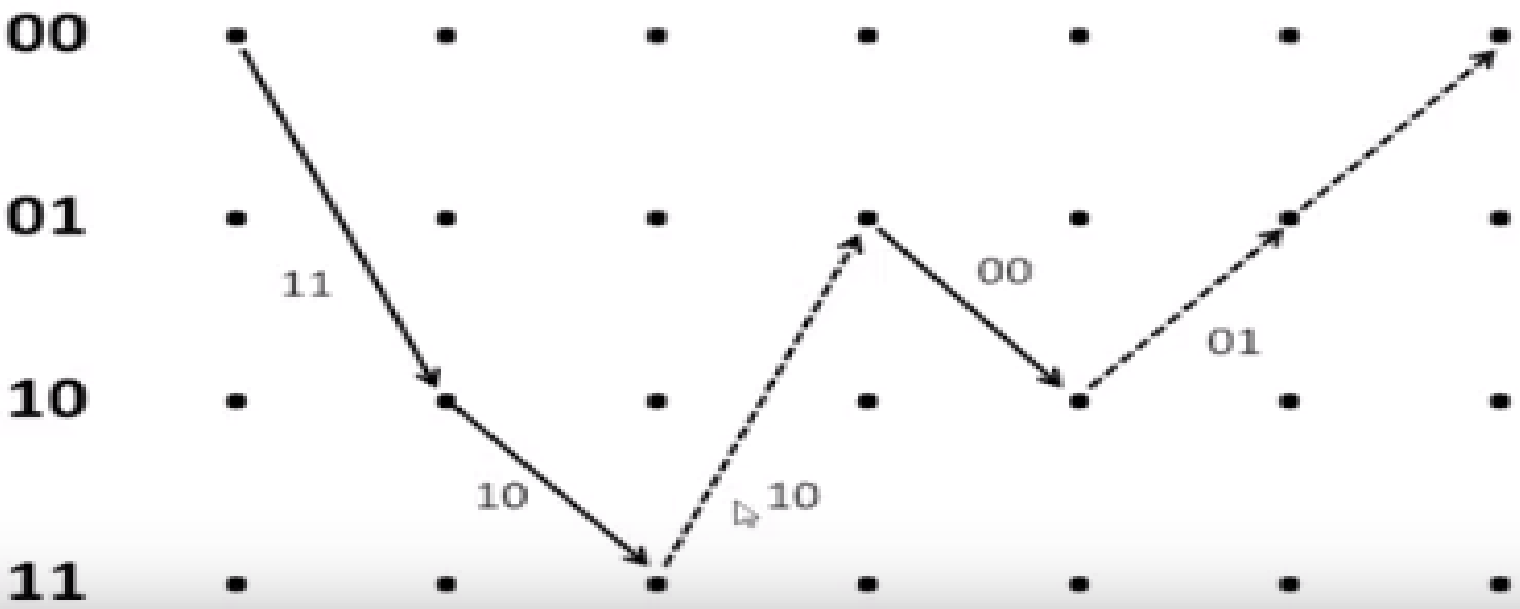
m_2	m_1	State
0	0	a
0	1	b
1	0	c
1	1	d





Example: Suppose input bits stream is u = (1101). Encode using Trellis code.

Two 0s are added to return the encoder to its zero state.



Hence the encoded output is

(1 1 0 1 0 0) = (11 10 10 00 01 11)

Decoding of convolutional codes

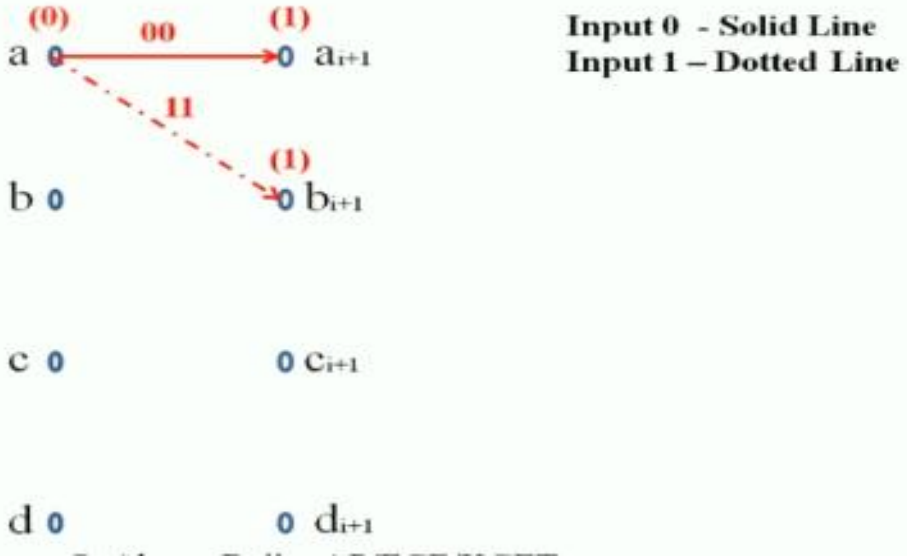
- - Viterbi algorithm

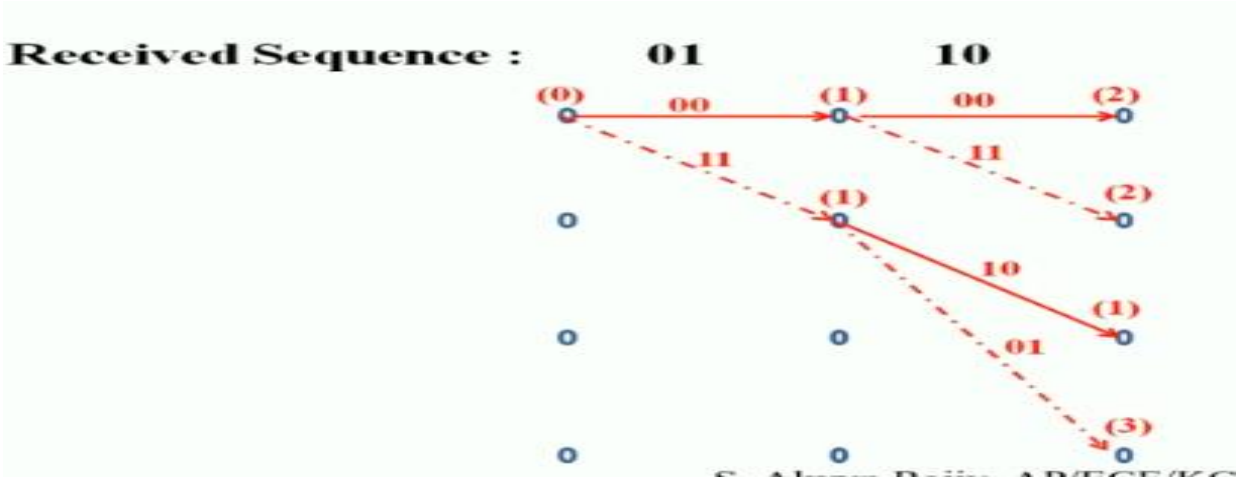
- The Viterbi decoder examines the entire received sequence of a given length.
- It works on maximum likelihood decoding rule which tried to reduce the error between the detected sequence and the original transmitted sequence.
- Trellis diagram is constructed for a system based on the received sequence the path is straight and the trellis level by level.
- If a condition raises in such a way that there is no path for the corresponding sequence then the viterbi decoding helps to detect the best path based on the subsequent sequence

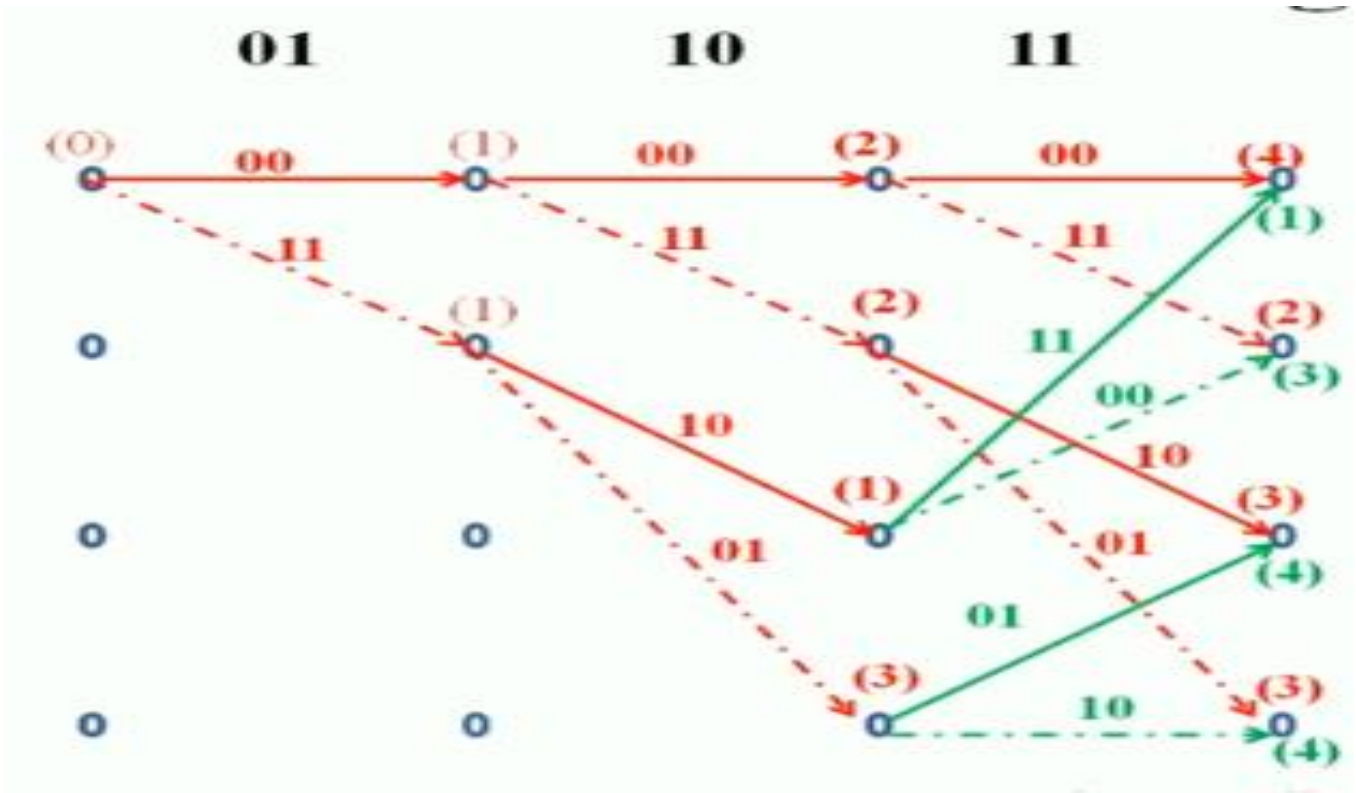
Example

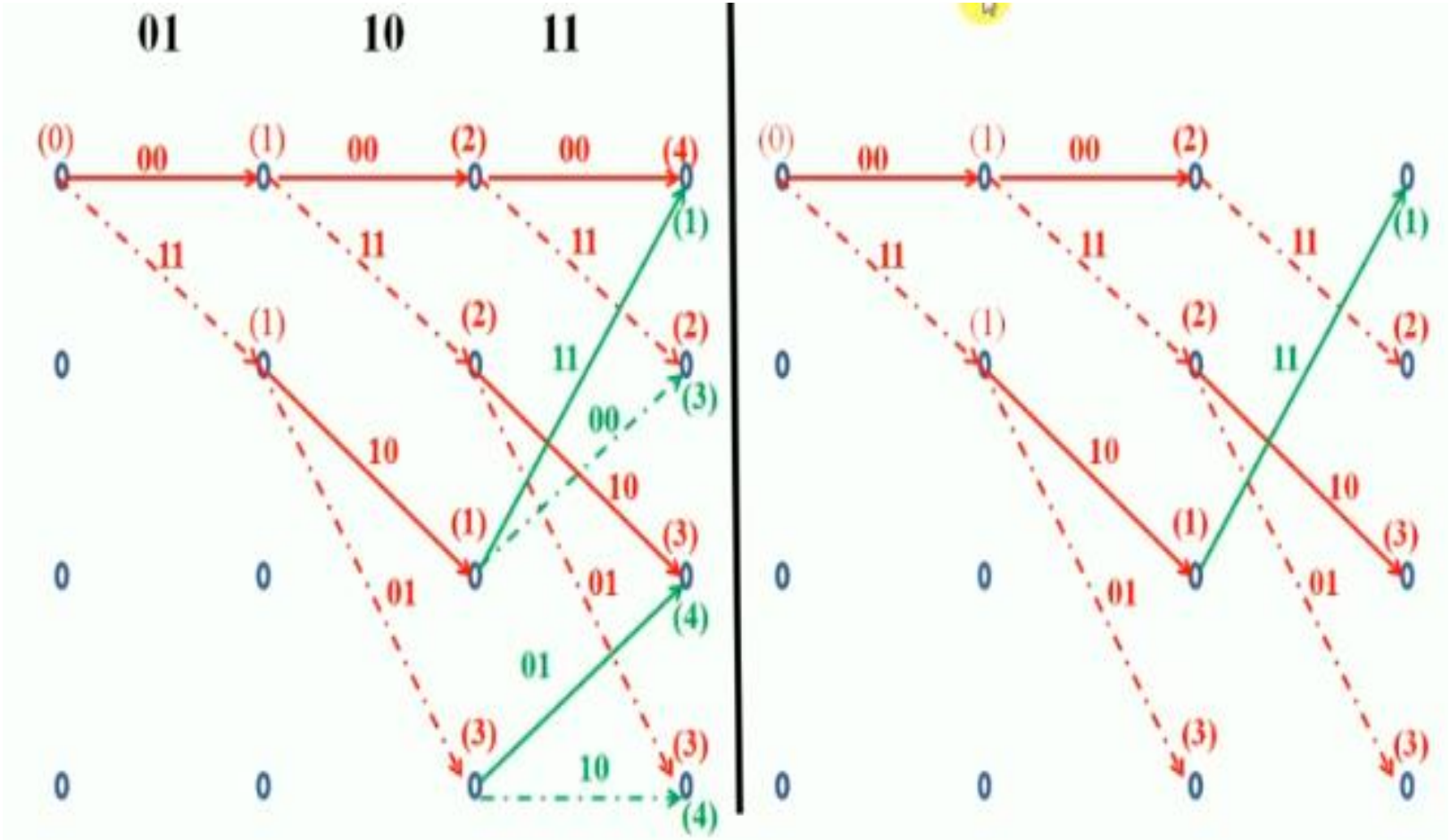
Here we Consider to transmit message sequence 100000 code word in a transmission medium, In this medium some error to be occurs due to several noises. In a receiver side we receive error code word 01 10 11 10 00 00. Find and Correct the error and get original message sequence in a receiver side by using Viterbi Algorithm(Maximum Likelikood decoding).

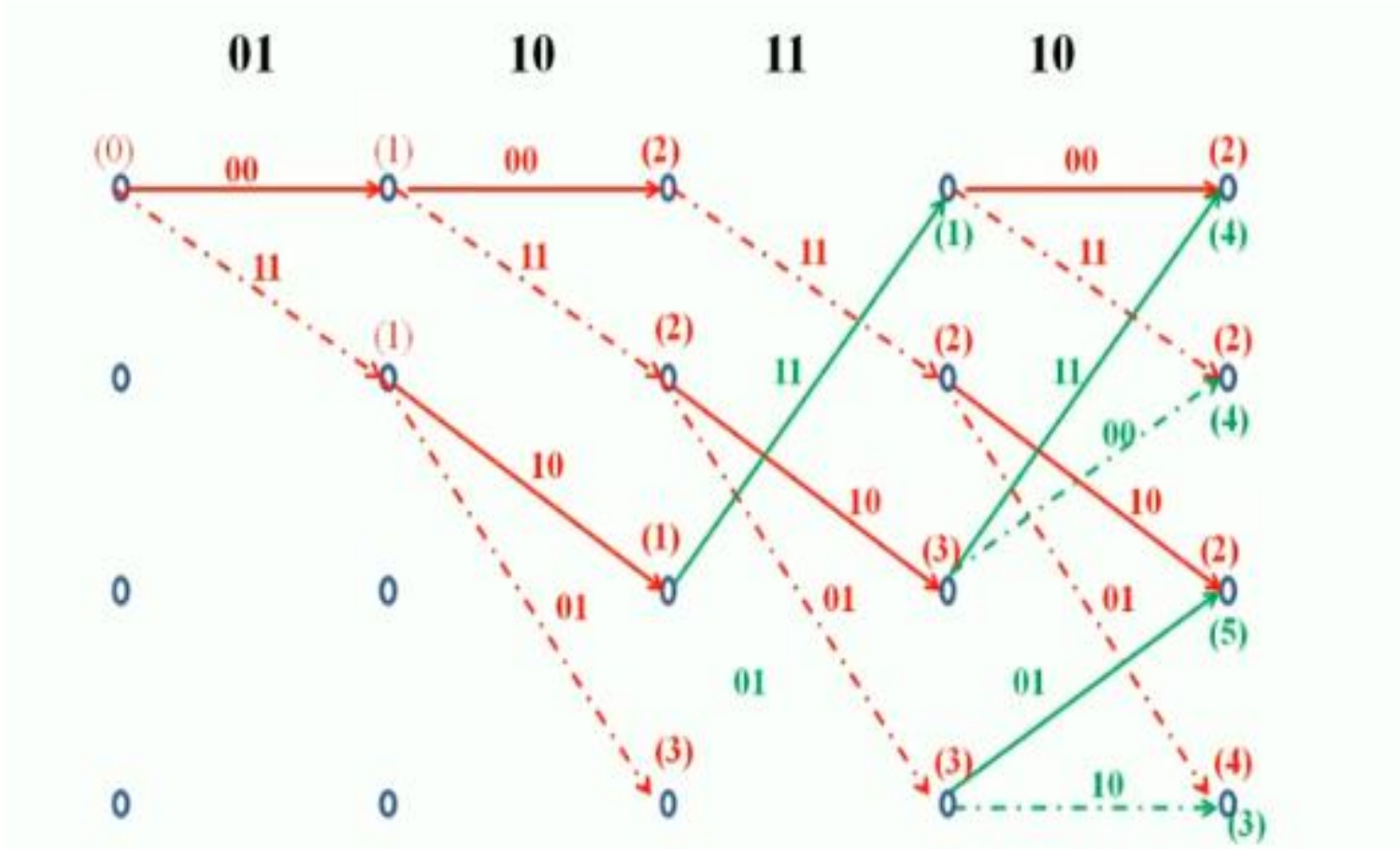
Received Sequence : 01

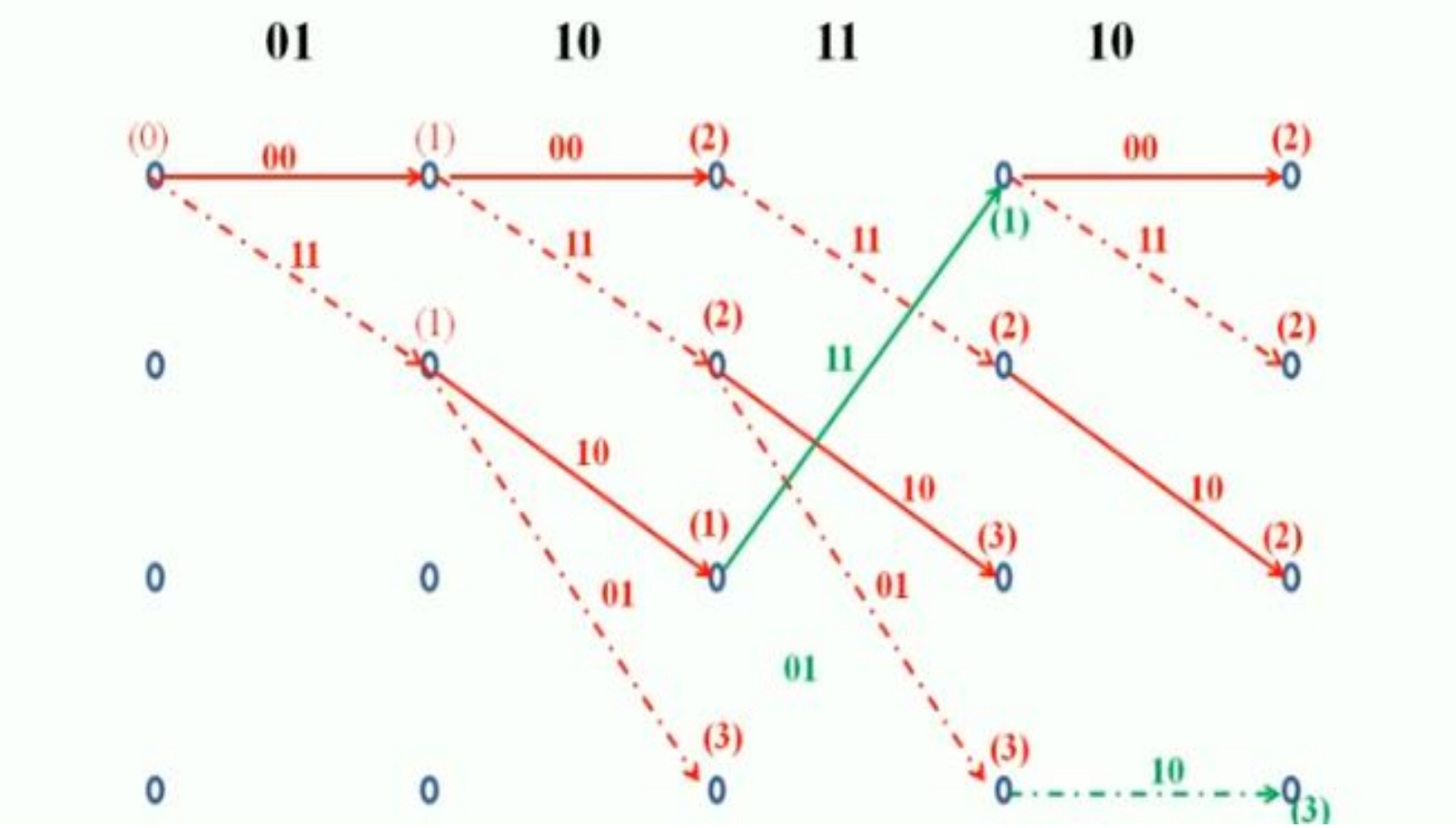


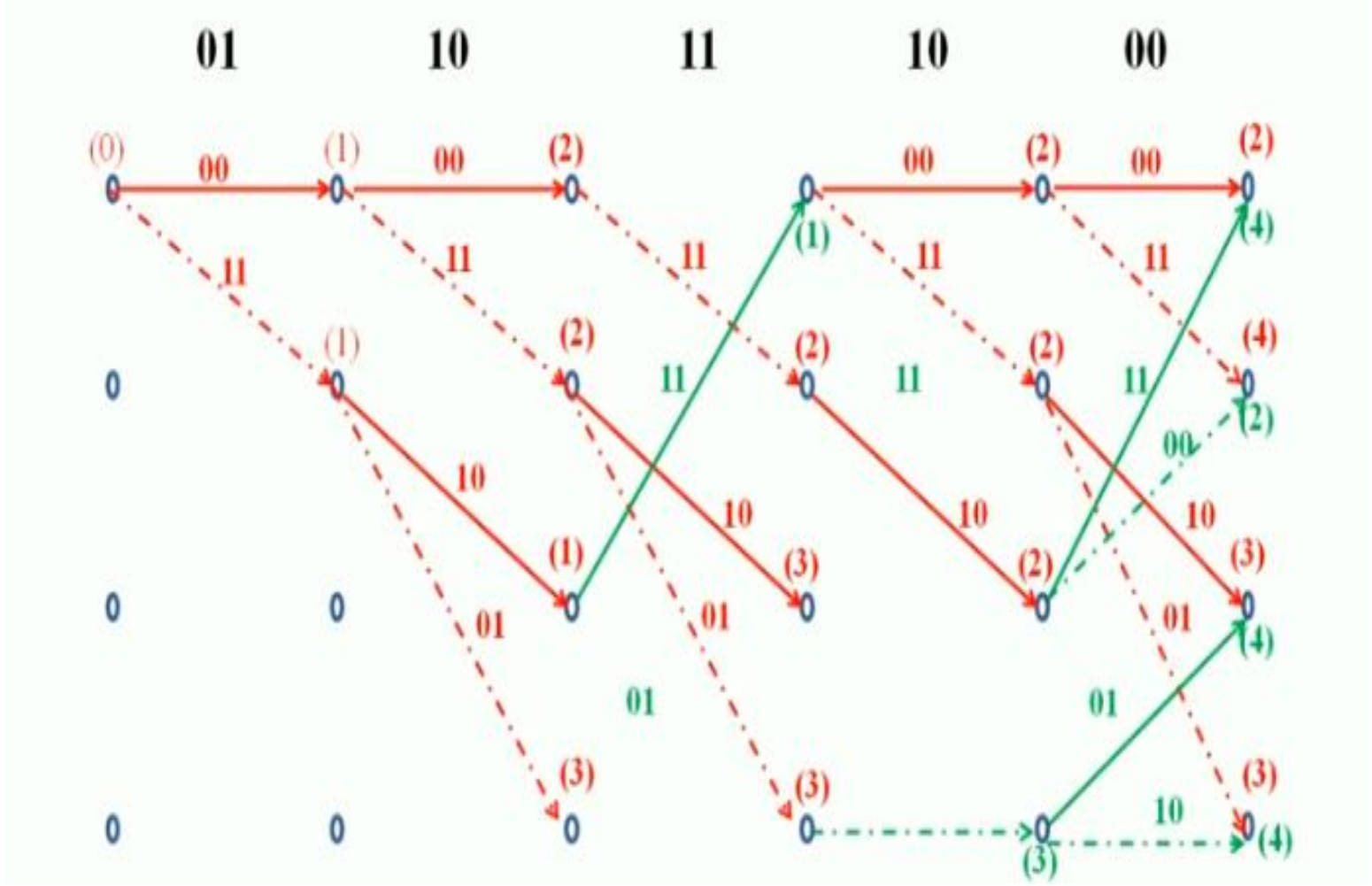

Received Sequence :
01
10
(0)
00
(1)
00
(2)
11
11
(2)
(1)
10
(1)
01
(3)

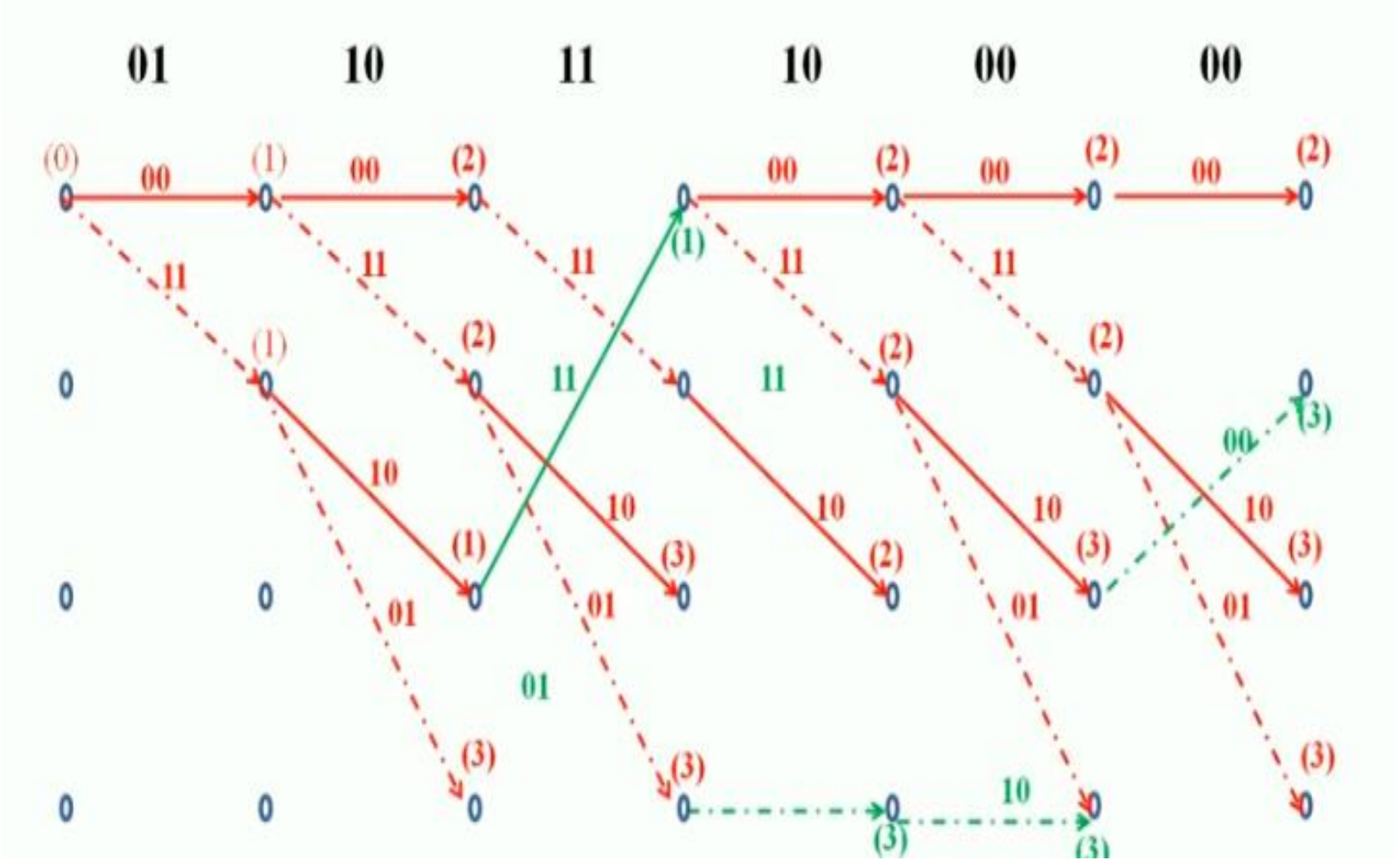

01
10
11
(0)
00
(1)
00
(2)
00
(4)
11
11
11
(1)
(2)
(2)
(3)
11
00
10
10
(1)
(3)
01
01
(4)
01
(3)
(3)
10
(4)


01
10
11
(0)
(1)
(2)
(4)
(1)
(2)
(3)
(1)
(3)
(4)
(3)
(3)
(4)
00
11
10
01

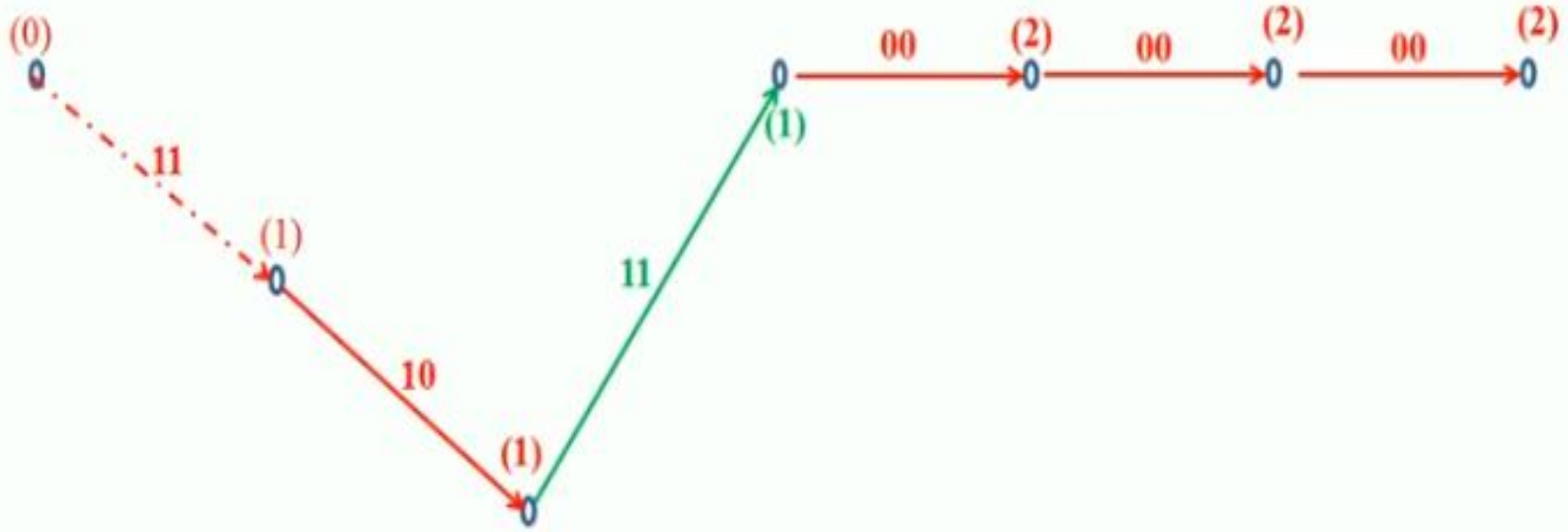

01
10
11
10
(0)
(1)
(2)
(1)
(2)
(1)
(2)
(3)
(1)
(2)
(3)
(4)
(2)
(4)
(2)
(5)
(3)
(4)
(3)
00
11
10
01
00
11
10
01
00
11
10
01
00
11
10
01
10


01
10
11
10
(0)
(1)
(2)
(3)
00
11
10
01
(1)
(2)
(3)
(1)
(2)
(3)
00
11
10
01
(1)
(2)
(3)
00
11
10
(2)
(3)


01
10
11
10
00
(0)
(1)
(2)
(3)
(4)
00
11
10
01


01
10
11
10
00
00
(0)
(1)
(2)
(3)
00
11
10
01

Received Code :	01	10	11	10	00	00
Corrected Code:	11	10	11	00	00	00
Message Sequence:	1	0	0	0	0	0



Thank you