Prev year:

Q5 (2020)

(b)

If we check even parity then check sum of received codeword $s=0$, if it is not then error is detect but not fixed. For checking odd parity $s=1$.

Let's take an ex:

$I_1 = (10111)_2$, $I_2 = (111011)_3$

Encoding with even parity:

$P = 1+0+1+1+1 = 0$

Transmitted codeword $c_1 = (101110)_2$

$P = 1+1+1+0+1+1$
$= 1$

Transmitted codeword
$c_2 = (1110111)$

Now if in receiver side,

c_2 is altered as $c_2' = (1010111)_2$

For checking even parity checksum

$s = 1+0+1+0+1+1+1 = 1$

That is parity failures.

For received codeword

$c_1 = (1011110)_2$

For checking even parity checksum

$s = 1+0+1+1+1+0 = 0$ ✓

That indicated parity is not failure.

Thus it works.

Q: 2026

(b) Why do we need convolution codes in error control coding?

① Efficient encoding: convolutional codes are generated using convolutional encoders which efficiently convert input data bits into encoded bits.

② Error detection and correction: It provide robust error detection and correction process.

③ Sequencial processing: It allows continuous encoding and decoding of data streams which is essential for real time ~~data~~ communication.

④ Versatility: It allows making them adaptibility for various communication requirement.

⑤ parallelism: Convolutional encoding and decoding can be parallelized enabling ~~faster~~ processing.

(6) concatenation: Convolutional code can be concatenated with other code to enhance error correction performance.

2020. Q7.4 (c) Write down the properties of Trellis encoded modulation (TEM)

(1) Joint encoding: TEM simultanously encode both data and channel symbol.

(2) Mapping to constelletion: Each block of data bits are mapped to specific point in the modulation constelletion.

(3) State Transition Diagram: TEM encoding represented by trellis diagram. where each state represents a specific combination of encoding symbol and transition between state correspond to change in data.

(4) Viterbi Decoding: Here Decoding is performed by Viterbi Algorithm.

(5) Spectral efficiency: By jointly error control coding and modulation. TCM achieves higher spectral efficiency.

(6) Trade off b/w performance and complexity
It allows trade off b/w performance and complexity by varying the constraint length and code rate.

(2020 Q4 : (a) AWGN চ্যানেল)

2020. Q8 (b)

Q: Advantages of Viterbi Algorithm:

(1) Maximum likelihood Decoding: It finds the most likely transmitted sequence of symbol based on receive data.

(2) Efficiency: It efficiently explores all possible path of trial diagram.

(3) Adaptibility: The algorithm can handle various error pattern and channel condition.

(4) Real-time operation: It operated sequentially and well suited for real time processing.

(5) parallelization: The viterbi algorithm can be parallized. enabling faster decoding.

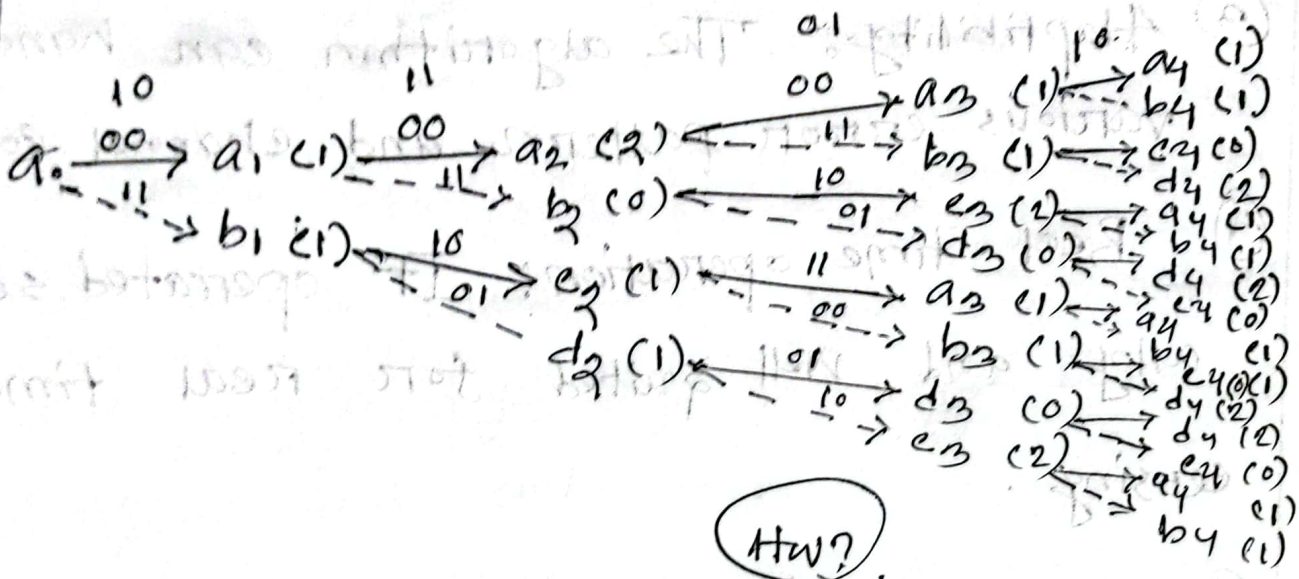
Qs. (a) bit flipping algorithm (video whatsapp) (LDPC)

Qs. (1) (2018) => Whats app.

2017

Q4. (b)

(10 11 01 10 10)



HW?

Hamming code:

(1) (7, 4)

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

4 Identity Mat. For Information.

parity.

For (7,4) S can found directly

$(S_1, S_2, S_3) = (V_1+V_2+V_3+V_5,\ V_2+V_3+V_4+V_6,\ V_1+V_2+V_4+V_7)$

Parity check matrix $H = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$

For (6,3)

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$H = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

For (5,3)

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix}$$

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \end{bmatrix}$$

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Proof

(i) $GH^T = 0$

$G = I_K | P$

$H = P^T | I_{n-K}$

L.H.S $= GH^T$

$= (I_K | P)(P^T | I_{n-K})^T$

$= (I_K | P)\left(\frac{P}{I_{n-K}}\right)$

$= I_K P + P I_{n-K}$

$= P + P = 0$

(ii) $CH^T = 0$

L.H.S $= CH^T$

$= (IG)H^T$

$= I.GH^T$

$= I.0 = 0$

Error syndrom $S = VH^T$

$V = c + e$

Q. show that (4, 3) even parity code is linear.

(0000), (0011), (0101), (1001), (1010), (1100), (0110), (1111).

Now For linearity two codeword generate another new codeword.

$$\begin{array}{r} 1001 \\ 1010 \\ \hline 0011 \end{array}$$

d(2)

w(2)

It is a codeword.

For odd parity:

(0001), (0010), (0100), (1000), (1110), (1101), (1011), (0111)

$$\begin{array}{r} 0010 \\ 0100 \\ \hline (0110) \end{array}$$

→ even parity (✗)

Q35.

(a) For (5, 3) linear code:

$n = 5, \quad K = 3. \quad r = 5 - 3 = 2$

So $I_K = I_3 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$G = I_3 P$

$= \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix}$

Q7. (a)

Given,

$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$

I = 3bit total $I = (000, 001, 010, 011, 100, 101, 110, 111)$

$$c_1 = IG$$

$$= (000) \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

$$= (000000)$$

Samely, $c_2 = (001101)$, $c_3 = (010011)$,

$c_4 = (011110)$, $c_5 = (100190)$

$c_6 = (101011)$, $c_7 = (110101)$

$c_8 = (111000)$

(4)

$$P = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$$

$$P^T = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

$$I_{n-k} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

CamScanner

$H = P^T \mid I_{n-k}$

$$= \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Received code word $Y = 111001$

Error syndrom $S = YH^T$

$$S = [1\ 1\ 1\ 0\ 0\ 1] \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

01243675

$$= 1+0+1+0+0+1,\ 1+1+0,\ 1+1+1$$

$$= (1\ 0\ 1)$$

Syndrom table for (6,3)

Error pattern	syndrom S_1	S_2	S_3	
000000	0	0	0	0
000001	0	0	1	1
000010	0	1	0	2
000100	1	0	0	4
001000	0	1	1	3
010000	1	0	1	5
100000	1	1	0	6

(iii) Here for error syndrom (101), 5bit is error occured

i.e pattern = 010000

Now corrected error

$$V = c + e$$
$$= 111000 + 010000$$
$$= (101000)$$

Q7.

2018

(b) code rate $r = \frac{k}{n}$

$(n, k) = (7, 4)$. $= \frac{4}{7}$

2016

7(c)

Given codeword $c = \{0000, 1011, 0101, 1110\}$

Received codeword $= 1101$

Let

$e = 1000$ now

By $c \oplus e$,

$$\begin{array}{r} 0000 \\ \oplus\ 1000 \\ \hline 1000 \end{array} \qquad \begin{array}{r} 1011 \\ \oplus\ 1000 \\ \hline 0011 \end{array} \qquad \begin{array}{r} 0101 \\ \oplus\ 1000 \\ \hline 1101 \end{array}$$

$$\begin{array}{r} 1110 \\ 1000 \\ \hline 0110 \end{array}$$

So, 0101 is appropriate codeword.

$e = 1000,$

$V = c + e$

$= 0101 + 1000 = 1101$

Q.

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} \qquad R = [0\,1\,1\,0\,0\,1]$$

is any error occured then fixed it?

Solve:

$S = RH^T$

$$H^T = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \therefore R = [0\,1\,1\,0\,0\,1]$$

$\therefore S = (1\ 0\ 0)$ From syndrom table (6,3)

$e = 0001000$

$\therefore$ actual codeword

$$= \begin{array}{r} 011001 \\ 000100 \\ \hline 010001 \end{array}$$

$(011101)_m$

Video problem:

Q. consider the codeword $c = (110110)$ of $(6,3)$ single error correcting code. Determine $\hat{e}$, the decoders estimate of e, when e injures the error pattern.

(i) $e_1 = (001000)$

(ii) $e_2 = (011011)$

(iii) $e_3 = (000111)$

Solve:

(i) Received codeword

$$v = e + e_1$$

$$= 110110 + 001000$$

$$= (111110)$$

$$S = vH^T = (1\,1\,1\,1\,1\,0)\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= (1\,1\,0)$$

From syndrom table $\hat{e} = 001000$

corrected codeword $\hat{c} = v + \hat{e}$

$$= 111110 + 001000$$

$$= (110110) \text{ ans}$$

$$\begin{array}{r} 110110 \\ 011011 \\ \hline 101101 \end{array}$$

(ii) Received codeword

$$v = e + e_2 = (110110) + (011011)$$

$$= (101101)$$

$$S = VH^T = (1\,0\,1\,1\,0\,1)\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= (0\ 0\ 0)$$ No error

(iii) $V = C + e_3$

$$= \begin{array}{r} 110110 \\ 000111 \\ \hline (110001) \end{array}$$

$$S = VH^T = (1\,1\,0\,0\,0\,1)\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= (1\ 1\ 1)$$

Tread vi: 33 Page:

Q. $G = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$ $u = (1101)$

$c = ?$

Solve:

$c = GU$

$= (1101) \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$

$= (0 \; 0 \; 0 \; 1 \; 1 \; 0 \; 1)$

2017

7. (a)

Given, $G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$ $(6, 3)$

Here,

$c_0 = (000) \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$

$= (000000)$

$$S_1 = (001)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (001011)$$

$$S_2 = (010)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (010110)$$

$$S_3 = (011)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (011101)$$

$$S_4 = (100)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (100101)$$

$$S_5 = (101)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (101110)$$

$$S_6 = (110)\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$$= (110011)$$

~~$S_7 = (111)$~~

$$S_0 = (000)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (000000)$$

$$= (000000)$$

$$S_1 = (001)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (110001)$$

$$S_2 = (010)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (101010)$$

$$S_3 = (011)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (011011)$$

$$S_4 = (100)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (011100)$$

$$S_5 = (101)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (101101)$$

$$S_6 = (110)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (110110)$$

$$S_7 = (111)\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} = (000111)$$

~~7 (d) 2018~~

7 (a) 2017

Standard array:

coset leader			
000000	110001	101010	011011
000001	110000	101011	011010
000010	110010	101000	011111
000100	110100	101110	010011
001000	111001	100010	010111
010000	100001	111010	111011
100000	010000	001010	

000000	111100	101101	110110	000111
001000	111101	101100	110111	000110
010000	111110	101111	110100	000101
100000	111000	$\boxed{101001}$	110010	000011
110000	101100	100101	111110	001111
101000	011100	111101	100110	010111
011000	111100	001101	010110	100011

Now For 101001, coset leader

$= 000100$

$\therefore$ correct code $= 101001 + 000100$

$= (101010)$

2020

Q7. (1)

(iii)

Here, $P = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

$c = \cancel{[c_0\ c_1\ c_2]}$ $m = [m_0\ m_1\ m_2]$

$P \cdot c = MP = [m_0\ m_1\ m_2] \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

m_1 m_2 m_0 001

$P_0 = m_0 + m_2$

$P_1 = m_0 + m_1$ $P_2 = m_1 + m_2$

Weight for Check

Sl No:	m	P	Code Word	Weight
1	000	000	000000	0
2	001	101	001101	3
3	010	011	010011	3
4	011	110	011110	4
5	100	110	100110	3
6	101	011	101011	4
7	110	101	110101	4
8	111	000	111000	3

minimum distance = 3

Number of error can be detected

$d_{min} \geq s+1$

$\Rightarrow 3 \geq s+1$

$\Rightarrow s \leq 2$ i.e 2

Number of error can be corrected

$d_{min} \geq 2t+1$

$\Rightarrow 3 \geq 2t+1$

$\Rightarrow t \leq 1$ i.e 1

2018 ৭ (a) পাটি নদী GF(2)

2015

Q6: (b) $C = \{0000, 1010, 0101, 1111\}$

$c_0 = 0000$, $c_1 = 1010$, $c_2 = 0101$,

$c_3 = 1111$

$c_{11} = c_1 + c_2$

$$\begin{array}{r} 1010 \\ 0101 \\ \hline 1111 \end{array} \Big\} d = 4$$

$= c_3 \quad w = 4$

they are linear codewords.

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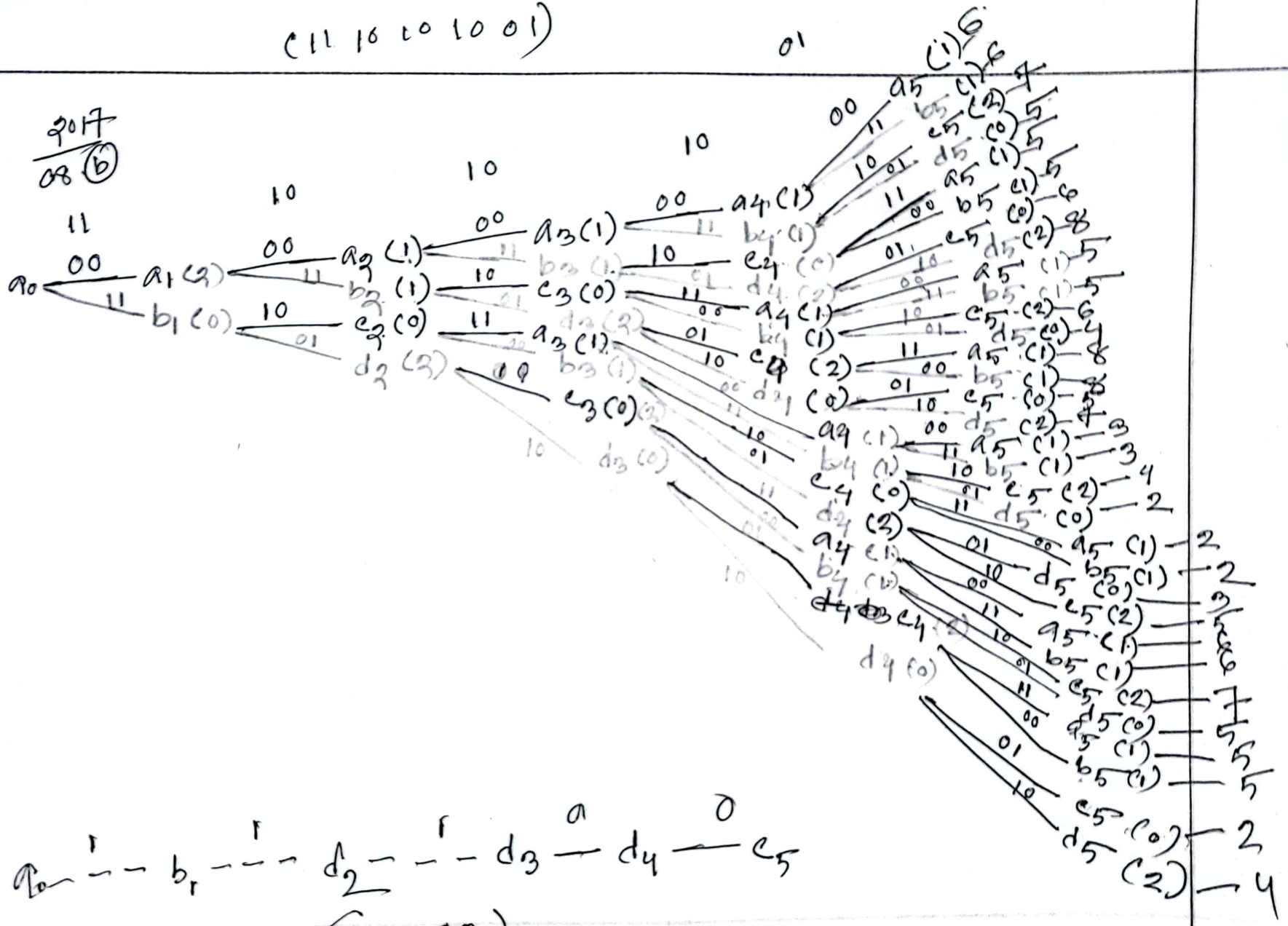
(11 10 10 10 01)

2017
08 (b)



$a_0 \xrightarrow{1} b_1 \xrightarrow{1} d_2 \xrightarrow{1} d_3 \xrightarrow{0} d_4 \xrightarrow{0} c_5$

(1 11 00) → Received codeword.