Vježbe za MI

1. N=5 simbola

$p(m_1)=0.3$

$p(m_2)=0.26$

$p(m_3)=0.2$

$p(m_4)=0.15$

$p(m_5)=0.09$

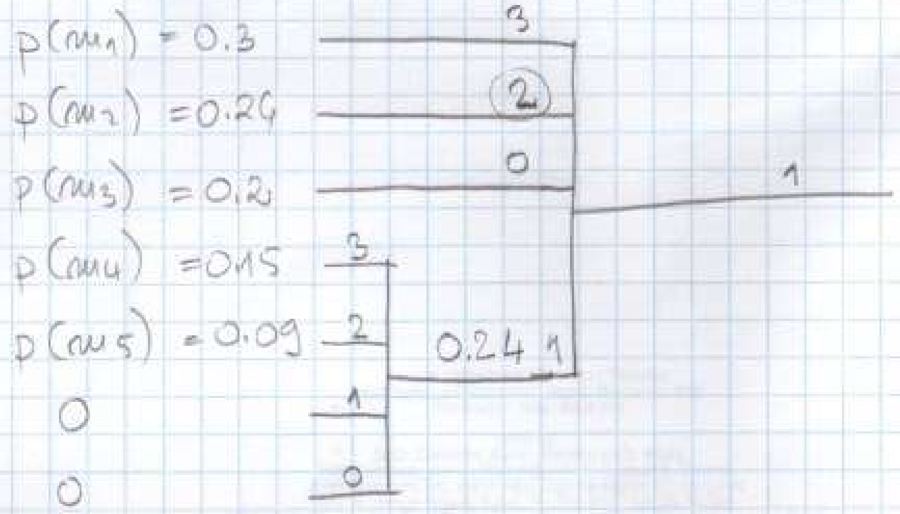
B=4

Huffmanovo kodiranje

+ provjera : $k=\left\lceil \frac{N-1}{B-1} \right\rceil = \left\lceil \frac{5-1}{4-1} \right\rceil = \left\lceil \frac{4}{3} \right\rceil = 2$

$N' = (B-1)\cdot k+1 = 3\cdot 2+1 = 7$

$5 \neq 7$ tj. $N \neq N'$ => dodajem $(N'-N)=\underline{\underline{2}}$ simbola



$m_1=3$

$\boxed{m_2=2} \longrightarrow$ 22222 niz simbola

$m_3=0$

m_4-13

$m_5=12$

Količina informacije $I(p)-?$

$p = m_2 \cdot m_2 \cdot m_2 \cdot m_2 \cdot m_2$

$I(p) = \log_2 \left[p(m_2)^5 \right] = 9.717$ bit/simbol

3. zadatak N=10 simbola

aaaaaaaaaaa* PZK = ?

PP : (POMAK, DULJINA, SLJED_SIM)

①]aaaaaaaaaaa* (0, 0, *)

② [a]aaaaaaaa[a]a * (1, 8, a)

pomakni bp za 1, uzmi 8

③ aaaaaaaaaa[a]* (0, 0, *)

=> PZK = 9 bita

6. zadatak

$$[p(y_j|x_i)] = \begin{array}{c|ccc} & y_0 & y_1 & y_2 \\ x_0 & 1/2 & 1/3 & 1/6 \\ x_1 & 1/6 & 1/2 & 1/3 \\ x_2 & 1/3 & 1/6 & 1/2 \end{array}$$

* simetrični kanal

$n = 3$

$C = \log_2 n - H(\vec{r}) = 1.5849 - 1.4591 = 0.12575$ bit/simbol

$$H(\vec{r}) = -\sum_{i=1}^{3} p_i \log_2 p_i =$$

$$= \frac{1}{2}\log_2 2 + \frac{1}{3}\log_2 3 + \frac{1}{6}\log_2 6 = 0.5 + 0.52832 + +0.4308$$

Quation editor

$t = 1\ h$

m – F. alg.

$p(M_i) - \frac{f_i}{x}$

$\bar{L}$ – srednja duljina poruke

$$p_i(\underbrace{N_{0i} + N_{1i}}_{N_i})$$

N_i – duljina kodne riječi

$p(0) + p(1) = 1$

br. jedinica u poruci

$$p(0) = \frac{\sum_{i=1}^{n} p_i N_{0i}}{\bar{L}} \quad p(1) = \frac{\sum_{i=1}^{n} p_i N_{1i}}{\bar{L}}$$

* naši binarni simboli

* bitovi kao znamenke (ne bitovi inf.)

M poruka

N_1 $\quad N_1 = M_{01} + M_{11} \quad P_1 = \frac{N_1}{M}$

N_2

N_3

ravnomjerni bin. kod → duljine kodnih riječi su JEDNAKE! $L_1 = L_2 = \ldots = L$

IMPLEMENTACIJA KODERA CIKLIČNOG KODA

$g(x) \rightarrow G$

$h(x) \rightarrow H$

$$\boxed{h(x) \cdot g(x) = x^n + 1}$$

ciklička provjera zalihosti

$$G = [I \mid A] \rightarrow C = [d \mid \underbrace{CRC}]$$

→ dG → $[I/A]$

→ metoda ostatka

$$r(x) = CRC = OST \frac{d(x) \cdot x^{n-k}}{g(x)}$$

$c(x) \longrightarrow c'(x)$

$S[c'(x)] =$

vektor pogreške

$$S[c'(x)] = \frac{x^{n-k} \quad c'(x)}{g(x)} = S[e(x)]$$

$$\boxed{c'(x) = c(x) + e(x)}$$

primljena = poslana + pogreška

1. Dan je ciklički kod [7,4] sa gen. polinomom $g(x) = x^3 + x + 1$.

a) je li $c(x) = x^5 + x^4 + x^3 + x$ kodna riječ (pripada li danom kodu?)

b) odr. kodnu riječ koja je poslana $c(x)$, ako je primljeno $c'(x) = x^4 + x + 1$

Zad. riješiti koristeći matricu provjere pariteta, a potom provjeru napraviti računajući maticu provjere pariteta H.

a)

$$[s(x)] = \frac{x^{n-k} c(x)}{g(x)} = \frac{x^3(x^5 + x^4 + x^3 + x)}{x^3 + x + 1}$$

$\cancel{x^8} + x^7 \cancel{+ x^6} + x^4 : (x^3 + x + 1) = x^5 + x^4$

$\cancel{x^8} \cancel{+ x^6} + x^5$

$\cancel{x^7} \cancel{+ x^5} + \cancel{x^4}$

$\cancel{x^7} + \cancel{x^5} \cancel{+ x^4}$

0

b) $H = ?$

↓ $H(x)$

$h(x) \cdot g(x) = x^7 + 1$

$$h(x) = \frac{x^7 + 1}{g(x)} = \frac{x^7 + 1}{x^3 + x + 1}$$

$\cancel{x^7} + 1 : (x^3 + x + 1) = x^4 + x^2 + x + 1$

$\cancel{x^7} + x^5 + x^4$

$\cancel{x^5} + x^4 + 1$

$\cancel{x^5} + x^3 + x^2$

$\cancel{x^4} + x^3 + \cancel{x^2} + 1$

$\cancel{x^4} + \cancel{x^2} + x$

$\cancel{x^3} + \cancel{x} + \cancel{1}$

$\cancel{x^3} + \cancel{x} + \cancel{1}$

0

$\Rightarrow h(x) = x^4 + x^2 + x + 1$

$\Rightarrow h = [1\,0\,1\,1\,1]$

pogreška na 1. mjestu

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

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

$s(c') - c'H^T$

$c' = 0010011$

$c'(x) = x^4 + x + 1$

$$s(c') = c'H^T = [0\,0\,1\,0\,0\,1\,1] \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} =$$

$= [1\,0\,0]$

$c' = [1010011]$

$$s[c'(x)] = \frac{x^{n-k} \cdot c'(x)}{g(x)} = s[e(x)]$$

$s[c'(x)] = x^7 + x^4 + x^3 \ : (x^3 + x + 1) =$

$$\cancel{x^7} + \cancel{x^4} + x^3 : (x^3 + x + 1) = x^4 + x^2$$

$$\underline{\cancel{x^7} + x^5 + \cancel{x^4}}$$

$$\cancel{x^5} + \cancel{x^3}$$

$$\underline{\cancel{x^5} + \cancel{x^3} + x^2}$$

$$\boxed{x^2}$$

sindrom vektora pogreške

$s[e(x)]$

$e(x)$	$s[e(x)]$
—	0 0 0
1	$x+1$
x	
x^2	
⋮	
x^4 →	x^2 ← $s[e(x)]$

$$S[e(x)] = \frac{x^3}{x^3+x+1}$$

$$x^3 : (x^3+x+1) = 1$$

$$\frac{x^3+x+1}{\boxed{x+1}}$$

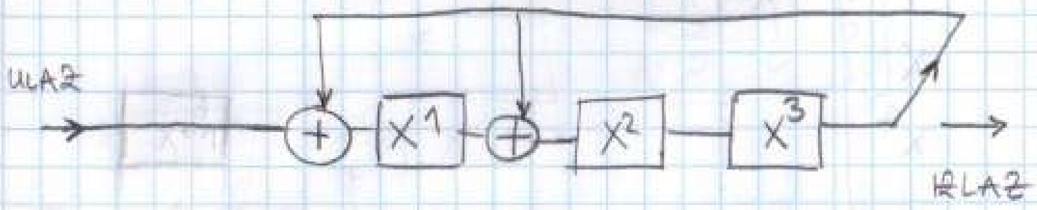
$c'(x) = c(x) + e(x)$

$c(x) = c'(x) + e(x) = (x^4+x+1) + x^6 =$

$= x^6 + x^4 + x + 1$

$c(x) = [1\ 0\ 1\ 0\ 0\ 1\ 1]$

$g(x) = x^3+x+1 = 1+x+x^3$



 - pomični registri

⊕ - modulo 2 zbrajalo

1) opća shema

2) popunjavanje sa brojčanima

PARALELNA IZVEDBA

17.12.2012. god.

5. i 6. DOMAĆA ZADAĆA

prof. Ilić

27. zzv.

Hammingov koder $[n,k] = [7,4]$

*uporaba parnog pariteta

$p = 0{,}004$

$X = [1010 \mid 101 \ldots]$

$$\begin{array}{ccc} X & & C \\ 1010 & \rightarrow & \underset{p_1\ p_2\ x_1\ p_3\ x_2\ x_3\ x_4}{1\ 0\ 1\ 1\ 0\ 1\ 0} \end{array}$$

za ispravno kodiranje:

$$P_{Hamm} = \binom{7}{0} \overset{\text{nema pogreške}}{p^0} (1-p)^7 + \binom{7}{1} \overset{\text{jedna greška}}{p^1} (1-p)^6 = 0{,}9997$$

$[n,k] = [5,4]$

* PARNI PARITET:

$$\begin{array}{ccc} X & & C \\ \underset{\text{poruka}}{1\ 0\ 1\ 0} & \longrightarrow & 1\ 0\ 1\ 0\ 0 \end{array}$$

$$P_{PAR} = \binom{5}{0} p^0 (1-p)^5 = 0{,}98$$

$$\Delta P = P_{Hamm} - P_{PAR} = 0{,}0197 \approx 2\%$$

RAD IZ ISPITNOG ROKA 6.9.2012. god.

22. zzv. linearni binarni ciklični kod K

↳ zbrajanjem 2 kodne riječi dobiva se riječ tog koda!

$[n,k] = [?, 11]$

$$\left.\begin{matrix} [0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0] \\ [1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1] \end{matrix}\right\} \text{2 kodne riječi}$$

i)

$$R(K) = \frac{k}{n} (\leq 1) = \frac{11}{15} = 0{,}733$$

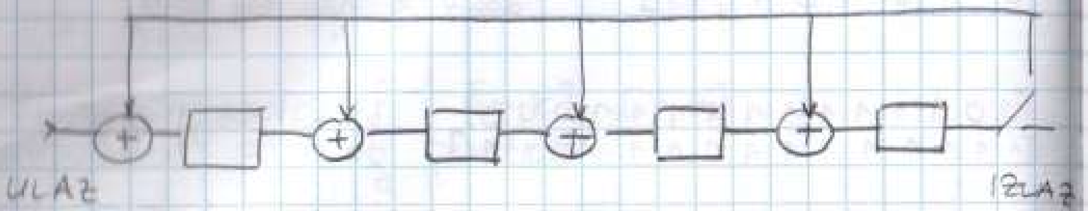
ii) $g(x) = ?$

$$\begin{array}{r} 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1 \\ +\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0 \\ \hline 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1 \end{array}$$

$S = [0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1]$

$p(x) = x^4 + x^3 + x^2 + x + 1$

iii)



iv) $d = [\,0\,0\,0\,0\,0\,0\,0\,0\,1\,1\,1\,] \rightarrow d(x) = x^2+x+1$

$$r(x) = \text{ost}\left[\frac{d(x)\cdot x^{n-k}}{g(x)}\right] = \text{ost}\left[\frac{(x^2+x+1)\cdot x^4}{x^4+x^3+x^2+x+1}\right]$$

$$\cancel{x^6}+\cancel{x^5}+\cancel{x^4} : (x^4+x^3+x^2+x+1) = x^2$$

$$\underline{\cancel{x^6}\;\cancel{+x^5}\;\cancel{+x^4}\;+x^3+x^2}$$

$$x^3+x^2$$

$r(x) = x^3+x^2 \qquad r = [1\,1\,0\,0]$

v) $0\,0\,0\,1\,0\,0\,0\,1\,0\,0\,0 \quad , k^{\perp}$

$H \rightarrow h(x)$

$p(x)\,h(x) = x^n+1$

$k^{\perp}$: $h(x) = (x^{15}+1) : (x^4+x^3+x^2+x+1) =$

$= x^{11}+x^{10}+x^6+x^5+x+1$

$r = n-k$

$k = n-r = 15-11 = 4$

$[n^{\perp}, k^{\perp}] = [15, 4]$

$d = [0\,0\,0\,1] \qquad d(x) = 1$

$$r = \text{ost}\left(\frac{d(x)\cdot x^{n-k}}{h(x)}\right) = \text{ost}\left(\frac{x^{11}}{x^{11}+x^{10}+x^6+x^5+x+1}\right) =$$

$= x^{10}+x^6+x^5+x+1$

$r = [\,1\,0\,0\,0\,1\,1\,0\,0\,0\,1\,1\,]$

29. ZZV.

binarni ciklični blok kod $K[15,7]$

$g(x) = x^8 + x^7 + x^6 + x^4 + 1$

$\left.\begin{matrix} n = 15 \\ k = 7 \end{matrix}\right\} n - k = 8 = r$ broj zaštitnih bitova

i) $R(k) - ?$

$R(k) = \frac{k}{n}$ - inf. bitova / - ukupni br. bitova

$R(k) = 0,9947$

ii) $(x^{15} + 1) = g(x) \cdot h(x)$

$\Rightarrow h(x) = \frac{x^{15}+1}{g(x)}$ ALI, BEZ OSTATKA!

$(\cancel{x^{15}} + 1) : (x^8 + x^7 + x^6 + x^4 + 1) = x^7 + x^6 \ldots + 1$

$\cancel{x^{15}} + x^{14} + x^{13} + x^{11} + x^7$

$\vdots$

0

$\Rightarrow g(x)$ je generirajući polinom !

iii) $d(x) = x^4 + x + 1$

$c(x) = d(x)\, x^r + r(x)$

$r(x) = \frac{d(x) \cdot x^r}{g(x)} = \frac{x^{12} + x^9 + x^8}{x^8 + x^7 + x^6 + x^4 + 1} =$

$=$

$(x^{12} + x^9 + x^8) : (x^8 + x^7 + x^6 + x^4 + 1)$

$\vdots$

$x^{12} + x^9 + x^8$ } ostatak $\rightarrow r(x)$

$c(x) = d(x) \cdot r^r + r(x) = x^{12} + x^9 + x^8 + x^7 + x^4 + x^3$

$c = [\,0\,0\,0\,1\,0\,0\,1\,1\,1\,0\,0\,1\,1\,0\,0\,0\,]$

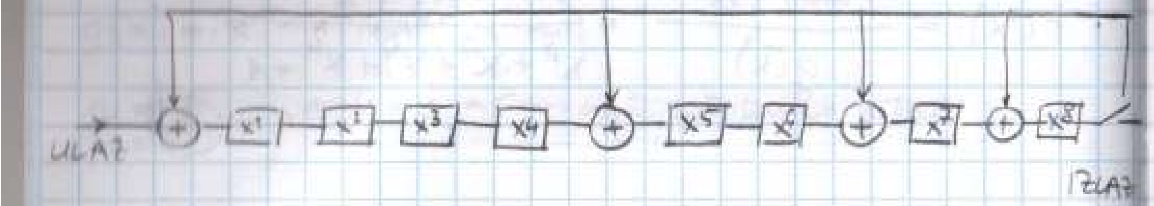
iv) $c(x) = x^{14} + x^5 + x + 1$

$S[c(x)] = \frac{x^{n-k}\, c(x)}{g(x)} = \frac{x^8 \cdot (x^{14} + x^5 + x + 1)}{x^8 + x^7 + x^6 + x^4 + 1}$

ostatak dijeljenja: $x^6 + x^4 + x^2 + x$

$\Rightarrow S \neq 0$ nije kodna riječ tog koda!

v) skica cikličnog koda:



23. ZZU.

ii) $S(y) = y H^T$

H^T ? pogađa se!

$$\underset{[8\times3]}{\overset{S(y)}{\begin{bmatrix} 0&0&0\\ 1&1&0\\ 1&0&1\\ 1&0&0\\ 0&1&0\\ 0&0&1\\ 0&1&1\\ 1&1&1 \end{bmatrix}}} = \underset{[8\times5]}{\overset{y}{\begin{bmatrix} 0&0&0&0&0\\ 0&0&0&0&1\\ 0&0&0&1&0\\ 0&0&1&0&0\\ 0&1&0&0&0\\ 1&0&0&0&0\\ 0&0&0&1&1\\ 1&0&0&0&1 \end{bmatrix}}} \underset{[5\times3]}{\begin{bmatrix} 0&0&1\\ 0&1&0\\ 1&0&0\\ 1&0&1\\ 1&1&0 \end{bmatrix}}$$

ili: $c \to c' = c + e$

$$s(c') = c'H^T = (c+e)H^T = \overset{0}{\cancel{cH^T}} + eH^T = eH^T$$

$$S = eH^T \;/\cdot e^{-1}$$

$$\underbrace{e^{-1}}_{1} S = H^T \Rightarrow \boxed{H^T = S}$$

$$H = \left[\begin{array}{cc|ccc} 0&0&1&1&1\\ 0&1&0&0&1\\ 1&0&0&1&0 \end{array}\right]$$

zamjene stupaca da bi se dobio standardni oblik

$$\left[A^T \,\middle|\, I\right]$$

$$H = \left[\begin{array}{cc|ccc} 1&1&1&0&0\\ 1&0&0&1&0\\ 0&1&0&0&1 \end{array}\right]$$

$$\underbrace{}_{A^T} \quad \underbrace{}_{I}$$

provjera : $\boxed{G \cdot H^T = 0}$

$$G_1 = \left[I \,\middle|\, A\right]$$

$$G_1 = \left[\begin{array}{cc|ccc} 1&0&1&1&0\\ 0&1&1&0&1 \end{array}\right]$$

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

$$H_1 = \left[\begin{array}{cc|ccc} 1&1&1&0&0\\ 1&0&0&1&0\\ 0&1&0&0&1 \end{array}\right]$$

25. zzv.

$n=7$

$c = \overset{6}{1}\,\overset{5}{1}\,\overset{4}{1}\,\overset{3}{1}\,\overset{2}{0}\,\overset{1}{0}\,\overset{0}{0}$

$$(x^7+1)=\overset{g_2(x)}{(x+1)}\overset{g_3(x)}{(x^3+x+1)}\overset{g_4(x)}{(x^3+x^2+1)}$$

1°

$k=n-r=7-0$ ↯

$$h(x)=\frac{x^7+1}{g(x)}$$

$g(x)=1$

$g_2(x)=x+1$

$g_3(x)=x^8+x+1$

$g_4(x)=x^3+x^2+1$

$g_5(x)=x^7+1$

$$(\cancel{x^6}+\cancel{x^5}+x^4+\cancel{x^3}):(x^3+x^2+1)=x^3+x$$
$$\underline{\cancel{x^6}+\cancel{x^5}+\cancel{x^3}}$$
$$\cancel{x^4}$$
$$\underline{\cancel{x^4}+x^3+x}$$
$$x^3+x \qquad //$$

$$(\cancel{x^6}+\cancel{x^5}+x^4+x^3):(x+1)=x^5+x^3$$
$$\underline{\cancel{x^6}+\cancel{x^5}}$$
$$\cancel{x^4}+\cancel{x^3}$$
$$\underline{\cancel{x^4}+\cancel{x^3}}$$
$$0 \qquad ↯$$

26. zzv.

$d_1=[101]$ $c_1=[100101]$

$d_2=[011]$ $c_2=[001011]$

$d_3=[111]$ $c_3=[010110]$

$d_4=[100]$ $c_4=[x\,x\,x\,x\,?\,?]$

$[n,k]=[6,3]$

$$\boxed{d_i\cdot G=c_i}$$

$$G=\begin{bmatrix} g_{11} & g_{12} & g_{13} & g_{14} & g_{15} \\ g_{21} & g_{22} & g_{23} & g_{24} & g_{25} \\ g_{31} & g_{32} & g_{33} & g_{34} & g_{35} \end{bmatrix}$$

$$d_1\cdot G=[101]\cdot G=[\underbrace{g_{11}\oplus g_{31}}\ \underbrace{g_{12}\oplus g_{32}}\cdots g_{16}\oplus g_{36}]=$$

$$=[1\,0\,0\,1\,0\,1]$$

$$G=\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 \end{bmatrix} \Rightarrow c_4=d_4\cdot G$$

$c_4=[101110]$

13. zzv.

$$G = \left[\begin{array}{cccc|cccc} 1&0&0&0&1&1&1&0\\ 0&1&0&0&1&1&0&1\\ 0&0&1&0&1&0&1&1\\ 0&0&0&1&0&1&1&1 \end{array}\right]$$

$$\underbrace{\hphantom{1\,1\,1\,0}}_{A}$$

i)

$G = [I \mid A]$

$H = [A^T \mid I]$

$$\Rightarrow H = \left[\underbrace{\begin{matrix} \downarrow & \downarrow & & \\ 1&1&1&0\\ 1&1&0&1\\ 1&0&1&1\\ 0&1&1&1 \end{matrix}}_{A^T} \middle| \underbrace{\begin{matrix} & & \downarrow & \downarrow \\ 1&0&0&0\\ 0&1&0&0\\ 0&0&1&0\\ 0&0&0&1 \end{matrix}}_{I} \right]$$

PLOTKINOVA NEJEDNAKOST!
$[n, k]$

$d_{min} \leq \frac{\quad}{2^k - 1}$

min Hamm udalj koda: min br stupaca koji se zbroja da bi se dobio nul vektor.

$\underset{\sim\sim\sim}{d(H) = 4}$

ii)

$c' = [1\,1\,1\,1\,1\,0\,0\,x]$

$s(c') = c' \cdot H^T$

$s(c') = c' \cdot H^T = [0\ 1\ 1\ 1{+}x]$

za $x = 0$

$s(c') = [0\,1\,1\,1] \in H$ ⇏ poslana točna riječ (pripada matrici H!)

za $x = 1$

$s(c') = [0\,1\,1\,0] \notin H$ //

24. zzv.

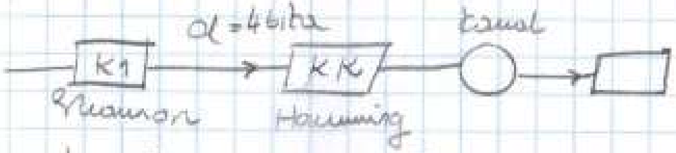
$X = \{x_0, \ldots, x_{15}\}$

$p(x_0) = \ldots = p(x_{15}) = \frac{1}{15}$

$M \leq 2^n$

$16 \leq 2^n \quad , \quad n = 4$

$\underbrace{1001010}1101\ldots$



$c' = [1\,0\,0\,1\,0\,1\,0]$

*provjera greške u kanalu:

$S = c' \cdot H^T$

$s = [1001010] \cdot H^T = [\underbrace{1\,1\,0}]$

greška na 3. mjestu

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

$c = [1011010]$

$d = [1010]$

Vježba : Zaštitno kodiranje

① $[k+1, k]$ **parni paritet**

a) $[4, 3]$ → kodne riječi

0000 ✓
0001 ✗
0010 ✗
0011 ✓
0100 ✗
0101 ✓
0110 ✓
0111 ✗
~~1000 ✗~~

1000 ✗
1001 ✓
1010 ✓
1011 ✗
1100 ✓
1101 ✗
1110 ✗
1111 ✓

Rj :

0000
0011
0101
0110

1001
1010
1100
1111

②

$$[101010] \cdot H^T = 0$$

$$H^T = [A^T | I]$$

$$H = [A | I] = \left[\begin{array}{ccc|ccc} 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 \end{array}\right]$$

$$H^T = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \cdot [illegible]$$

$$[101010] \cdot \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} = [0\ 0\ 0] = 0 \quad ✓$$

b)

$$[x11100] \Rightarrow x = ?$$

$$[x11100] \cdot \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} = 0$$

0

$$\boxed{x = 0}$$

c) $\overset{\text{poslano}}{[0011111]}$ $\overset{\text{primljeno}}{[001101]}$

$$\boxed{S = \text{primljeno} \cdot H^T} =$$

$$= [001101] \cdot \begin{bmatrix} 0 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} =$$

$$= [0\ 1\ 0]$$

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

$G = [6, 3]$

sve kodne riječi u kodu? $c = ?$

$$c = d \cdot G$$

d : kodirana poruka $c = d \cdot G$

$$d: \begin{matrix} [000] \\ [001] \\ [010] \\ [011] \\ [100] \\ [101] \\ [110] \\ [111] \end{matrix}$$

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

$$= \begin{matrix} [000000] \\ [001011] \\ [010011] \\ [011000] \\ [100101] \\ [101110] \\ [1 \\ [1111 \end{matrix}$$

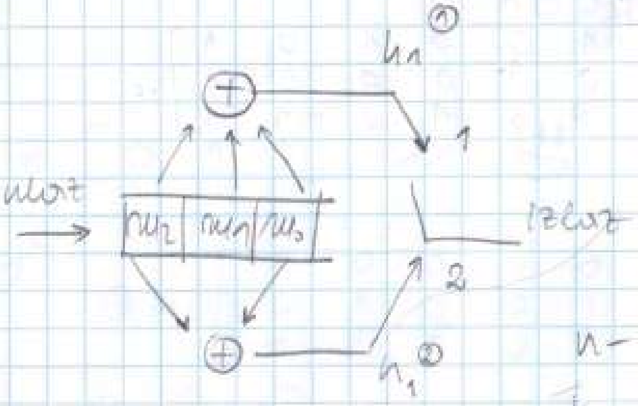
1 puls : 1 bit ulazi ; 2 se generiraju

(2, 1, 3)
(n, k, L) $L = \overset{n}{\cancel{m}} + 1$

veličina por. def. veličinu G

$$\boxed{C = d \cdot G}$$

Pr: Za konv. kod. odr. funkcijske generatore



n – br. izlaza

k – br. ulaza

$l = \overset{\text{broj}}{n} + 1$

l – veličina kodera

$h_1^{①} = [1\ 1\ 1]$

$h_1^{②} = [1\ 0\ 1]$

(2, 1, 3)

$d = \overbrace{[1\ 1\ 1]}^{③}$ c = ?

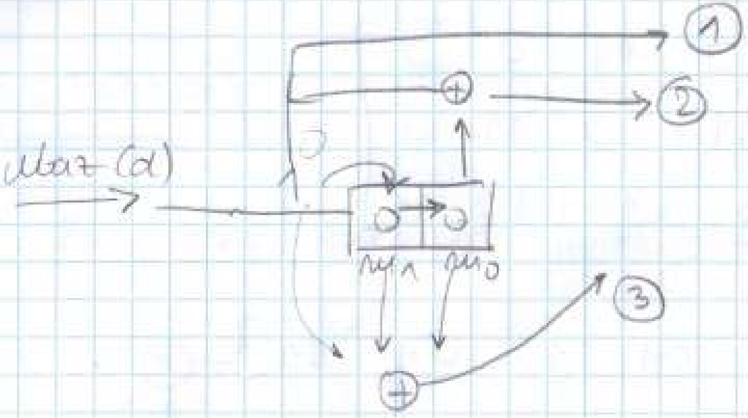
$c = d \cdot G$

$$G = \text{zbog } d!\ ③ \left\{ \begin{bmatrix} G_0 & G_1 & G_2 & 0 & 0 \\ 0 & G_0 & G_1 & G_2 & 0 \\ 0 & 0 & G_0 & G_1 & G_2 \end{bmatrix} \right. =$$

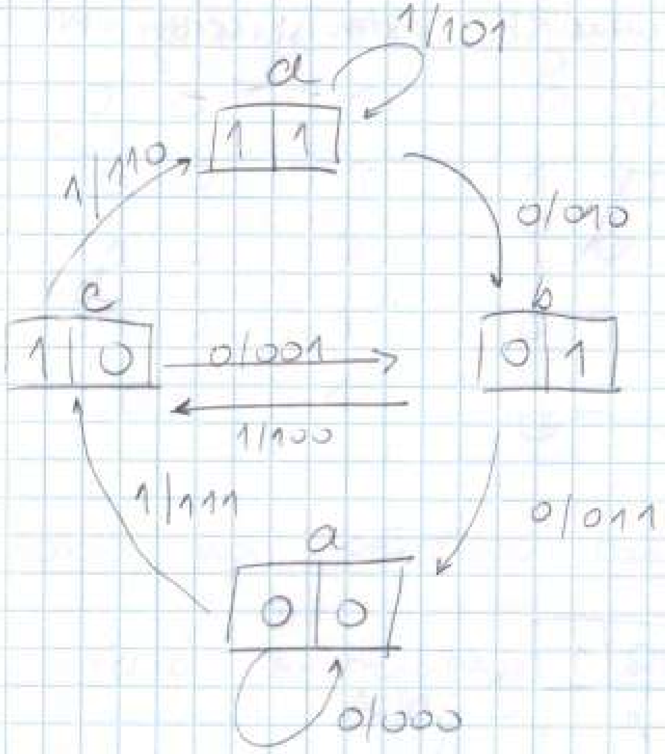
$$= \begin{bmatrix} 11 & 10 & 11 & 0 & 0 \\ 0 & 11 & 10 & 11 & 0 \\ 0 & 0 & 11 & 10 & 11 \end{bmatrix}$$

$c = [11\ \ 01\ \ 10\ \ 01\ \ 11]$

dekoder: patrz na przejściu!



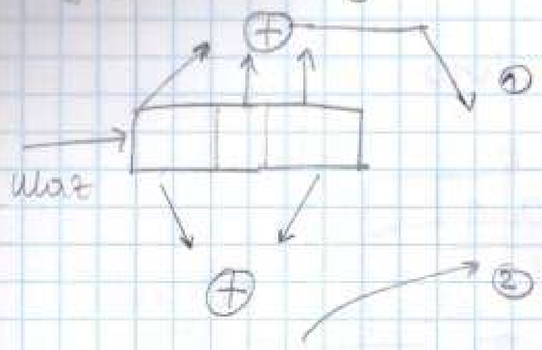
	m1 m2 stany rejestru		wej d	wyj 1¹	2²	2³
a	0	0	0	0	0	0
	0	0	1	1	1	1
c	1	0	0	0	0	1
	0	1	0	0	1	1

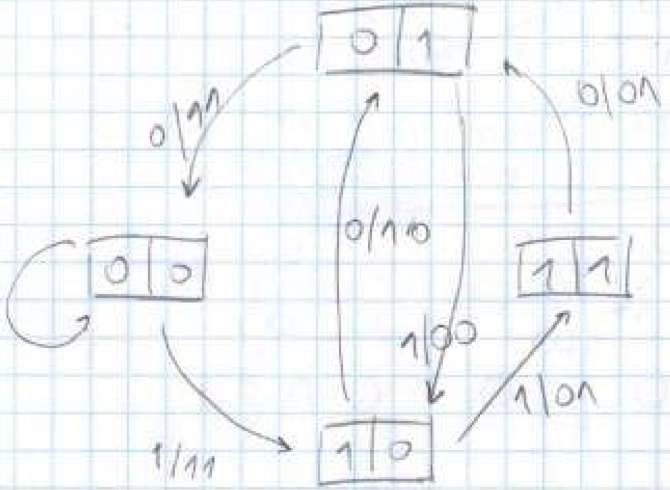


d = [1 0 1]

111 001 100

Za ovaj konvolucijski koder skiciraj dijagram stanja





m1 m2	ulaz	izlaz
0 0	–	0 0
0 0	1	1 1
1 0	0	1 0
1 0	1	0 1
0 1	1	

Koko : na bežičnim kanalima

* sklop za preplitanje bitova

INTERLIBER

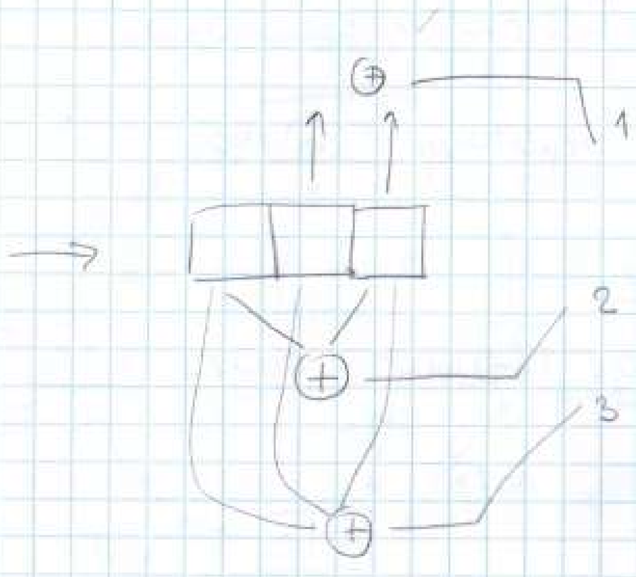
snopovne pogr → sluč. pogr.

Prayer

$h_1^1 = [0 1 1]$

$h_1^2 = [1 0 1]$

$h_1^3 = [1 1 1]$



30. ZZV.

$K = \{0101, 1010, 1100\}$

Odr. sve kodne riječi koda $K^{\perp}$

$$K^{\perp} = \left\{ [y_1\ y_2\ y_3\ y_4] \mid y \in K^{\perp} \cdot X \in K = 0 \right\}$$

$$[y_1\ y_2\ y_3\ y_4] \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} = [0\ 0\ 0] =$$

$$= [y_2 + y_4 \quad y_1 + y_3 \quad y_1 + y_2]$$

$$\left. \begin{array}{l} y_2 + y_4 = 0 \\ y_1 + y_3 = 0 \\ y_1 + y_2 = 0 \end{array} \right\} \Rightarrow \boxed{y_2 = y_4 = y_1 = y_3}$$

Rješenje : $K^{\perp} = \{0000, 1111\}$

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28. ZZV.

$(5, 4, 3)$
$(5, 2, 3)$

$K = \{00000, 11010, 01111, 10101\}$

a) $G = ?$ $H = ?$

* postoji više rješenja

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

$k = \log_2(M) \rightarrow k = 2$

$$G = [\, I_k \mid A \,]$$

$$H = [\, A^T \mid I_{n-k} \,] = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

b) $S(y) = y \cdot H^T$

00000	11010	01111	10101	000
00001	11011	01110	10100	001
00010	11000	01101	10110	010
00100				100
01000	– –	– –	– –	111
10000				101
00011				011
01001				110

c) $p(K) = \sum_{i=0}^{n} N_i\, p_g^{\,i} (1 - p_g)^{n-i}$

$N_0 = 1 \quad N_1 = 5 \quad N_2 = 2$

$$p(K) = p_g^{\,0}(1 - p_g)^5 + 5\, p_g^{\,1}(1 - p_g)^4 + 2 p_g^{\,2}(1 - p_g)^3$$