Formalni postupci u oblikovanju računalnih sustava

ZADACI

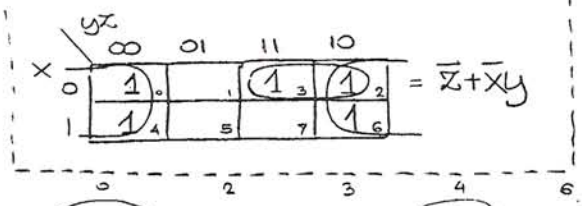
Samo je jedan Mali Ivica!

12.06.2000. god.

1) $f = m0 + m2 + m3 + m4 + m6$

	x	y	z	f
m_0	0	0	0	1
m_1	0	0	1	0
m_2	0	1	0	1
m_3	0	1	1	1
m_4	1	0	0	1
m_5	1	0	1	0
m_6	1	1	0	1
m_7	1	1	1	0

OVO KASNIJE BRIŠI!:



$f = \bar{x}\bar{y}\bar{z} + \bar{x}y\bar{z} + \bar{x}yz + x\bar{y}\bar{z} + xy\bar{z} = \bar{y}\bar{z}(x+\bar{x}) + \bar{x}y(z+\bar{z}) + xy\bar{z} =$

$= \bar{y}\bar{z} + \bar{x}y + xy\bar{z}$ (+ dodajem $\bar{x}y\bar{z}$) =

$= \bar{y}\bar{z} + \bar{x}y + xy\bar{z} + \bar{x}y\bar{z} = \bar{y}\bar{z} + \bar{x}y + y\bar{z}(x+\bar{x}) = \bar{y}\bar{z} + \bar{x}y + y\bar{z} =$

$= \bar{z}(y+\bar{y}) + \bar{x}y = \bar{x}y + \bar{z}$ //

8) a) $Q = \{3,5,8\}$
b) $Q1 = \{prim\}$

a)

Q	y_1	y_2	f(Q)
3	0	0	1
5	0	1	1
8	1	0	1
	1	1	∅

b)

	y_1	y_2	f(Q1)	
0	0	0	1	
1	0	1	1	
2	1	0	0	→ 8 nije prim
3	1	1	∅	

a) $f_S(Q) = \bar{y}_1\bar{y}_2 + \bar{y}_1 y_2 + y_1\bar{y}_2 = (+\bar{y}_1\bar{y}_2) =$

$= \bar{y}_1(y_2+\bar{y}_2) + \bar{y}_2(y_1+\bar{y}_1) = \bar{y}_1 + \bar{y}_2$ //

b) $f_S(Q_1) = \bar{y}_1\bar{y}_2 + 1y_2 = \bar{y}_1(y_2+\bar{y}_2) = \bar{y}_1$

9) a) $\Gamma \vdash_L \omega$ Formula ω je log. pravilima izvedena iz skupa form. Γ
b) $\Gamma \models \omega$ Formula ω je logička posljedica skupa formula Γ

10) Kripke struktura je uređena trojka $M = (S, R, L)$, gdje su:
S → skup mogućih stanja
R → skup relacija među stanjima : $R \subseteq S \times S$
L → funkcija označavanja $L: S \to 2^{AP}$
[AP je broj atoma]

11) $AG(p \to AX\, AG(\neg q \vee A[\neg t\, U\, t]))$
AG – always generally
AX – always next
AU – always until

"Uvijek je zadovoljeno sljedeće:
Ako je p istinit, onda za svako sljedeće stanje uvijek vrijedi da je q lažan ili da je t uvijek lažan dok t ne postane istinit."

OSTALE ZDTKE JOŠ NISMO RADILI!

Samo je jedan Mali Ivica!

7.11.2000. god.

1) $f = m0 + m1 + m3 + m4 + m6 + m7$

	yz \ x	00	01	11	10
	0	1 0	1 1	1 3	2
	1	1 4	5	1 7	1 6

$= \bar{y}\bar{z} + \bar{x}z + xy$ //

	xyz	f
0	000	1
1	001	1
2	010	0
3	011	1
4	100	1
5	101	0
6	110	1
7	111	1

0 1 3 4 6 7

$f = \underbrace{\bar{x}\bar{y}\bar{z}} + \underbrace{\bar{x}\bar{y}z} + \underbrace{\bar{x}yz} + \underbrace{x\bar{y}\bar{z}} + \underbrace{xy\bar{z}} + \underbrace{xyz} = \bar{y}\bar{z}(x+\bar{x}) + \bar{x}z(y+\bar{y}) + xy(z+\bar{z}) =$

$= \bar{y}\bar{z} + \bar{x}z + xy$ //

2)

a b	c d	f
0 0	0 0	1
0 0	0 1	0
0 0	1 0	0
0 0	1 1	0
0 1	0 0	0
0 1	0 1	1
0 1	1 0	0
0 1	1 1	0
1 0	0 0	0
1 0	0 1	0
1 0	1 0	1
1 0	1 1	0
1 1	0 0	0
1 1	0 1	0
1 1	1 0	0
1 1	1 1	1

ab \ cd	00	01	11	10
00	1 0	1	3	2
01	4	1 5	7	6
11	12	13	1 15	14
10	8	9	11	1 10

a) $f = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{a}\bar{b}\bar{c}d + a\bar{b}c\bar{d} + abcd$ //

b) kasnije

3) Prioritet operatora u CTL formulama:
$(\neg, AG, EG, AF, EF, AX, EX)$, $\wedge$, $\vee$, $(\Rightarrow, AU, EU)$

jednak prior. jednak prior.

4) a) $AG(q \Rightarrow EG\, r)$ ok!
b) $E[A[p1\, U\, p2]\, U\, p3]$ ok!
c) $F[r\, U\, q]$ ※ F nije operator CTL logike
d) $EF\, E[r\, U\, q]$ ok!

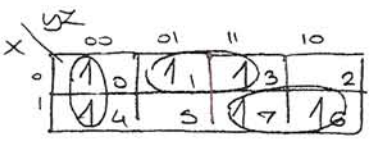
Samo je jedan Mali Ivica!

20.08.2000

1) $f = m0 + m1 + m3 + m4 + m6 + m7$

xyz	f
0	1
1	1
2	0
3	1
4	1
5	0
6	1
7	1

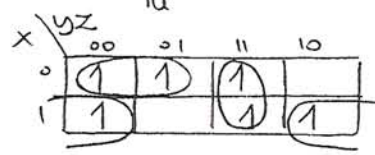
a)



$\bar{y}\bar{z} + \bar{x}z + xy$ //

ili

b)



$x\bar{z} + \bar{x}\bar{y} + yz$ //

9) $M, s \models (\varphi \Rightarrow \omega)$

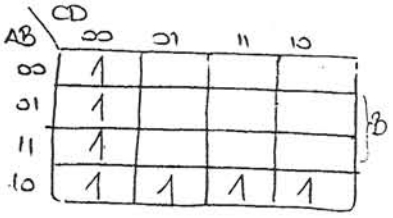
"U modelu M, za stanje $s \in S$ vrijedi:
ako je φ istinita formula (u CTL-log), onda je istinita i ω."

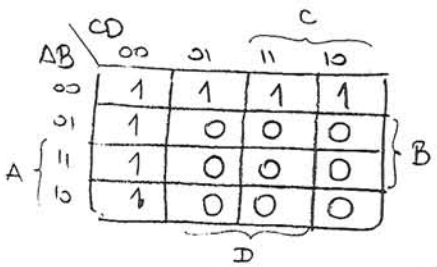
10) a) $AG(q \Rightarrow EG\,r)$ ok!
b) $E[A[p1 U p2] U p3]$ ok!
c) $F[r U q]$ ✗
d) $EF\,E[r U q]$ ok!

Samo je jedan Mali Ivica!

12.07.2000

1) $AB' + C'D' \stackrel{?}{=} (BD+BC+AD+AC)'$ ← stavljam 0 umjesto 1





$\overline{AB} + \overline{CD}$

NIJE!

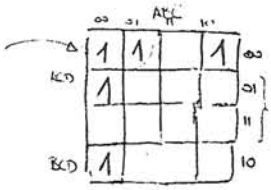
$\overline{BD+BC+AD+AC} = \overline{BD}\cdot\overline{BC}\cdot\overline{AD}\cdot\overline{AC} = (\bar{B}+\bar{D})(\bar{B}+\bar{C})(\bar{A}+\bar{D})(\bar{A}+\bar{C}) =$

$= (\bar{A}\bar{B}+\bar{B}\bar{C}+\bar{A}\bar{D}+\bar{C}\bar{D})(\bar{A}\bar{B}+\bar{B}\bar{D}+\bar{A}\bar{C}+\bar{C}\bar{D}) =$

$= \underbrace{\bar{A}\bar{B}+\bar{A}\bar{B}\bar{D}}_{1001} + \underbrace{\bar{A}\bar{B}\bar{C}}_{1100} + \underbrace{\bar{A}\bar{B}\bar{C}\bar{D}}_{1000} + \underbrace{\bar{B}\bar{C}\bar{D}}_{0\,0\,0} + \underbrace{\bar{A}\bar{C}\bar{D}}_{1\,0\,0} + \bar{C}\bar{D} =$

$= \bar{A}\bar{B}(1+\bar{D}) + \bar{A}\bar{B}(1+\bar{C}) + \bar{A}\bar{B}(1+\bar{C}\bar{D}) + \bar{C}\bar{D}(\bar{B}+1) + \bar{C}\bar{D}(\bar{A}+1) = \bar{A}\bar{B}+\bar{C}\bar{D}$

(1 1 1 1 1)



Zaključak: $\overline{AB}+\overline{CD} \neq \overline{AB}+\overline{CD}$

6) $p \vdash_L q \neq p \Leftrightarrow q$

7) "Iz svakog stanja moguće je doći do početnog stanja"
AF(poč.stanje)

8) a) EF[r U q] ✗
b) AG AF r ok!
c) A¬G¬p ✗
d) A[p1 U A[p2 U p3] ok!

Samo je jedan Mali Ivica!

20.09.2000

Samo je jedan Mali Ivica!

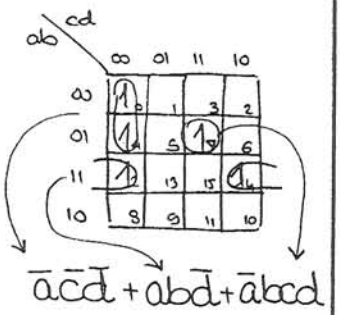
1) $f = m_0 + m_4 + m_7 + m_{12} + m_{14}$

$f = \underset{0}{\bar{a}\bar{b}\bar{c}\bar{d}} + \underset{4}{\bar{a}b\bar{c}\bar{d}} + \underset{7}{\bar{a}bcd} + \underset{12}{ab\bar{c}\bar{d}} + \underset{14}{abc\bar{d}} =$

$= \bar{a}\bar{c}\bar{d}(b+\bar{b}) + \bar{a}bcd + a\bar{b}\bar{d}(c+\bar{c}) =$

$= \bar{a}\bar{c}\bar{d} + \bar{a}bcd + a\bar{b}\bar{d}$ //

	abcd	
0	0000	1
1		0
2		0
3		0
4	0100	1
5		0
6		0
7	0111	1
8		0
9		0
10		0
11		0
12	1100	1
13		0
14	1110	1
15		



8) $M, s \models \varphi$ "Formula φ (u CTL-logici) je istinita u modelu M, s!"

Pojednostavljenje je u tome što pri provjeri modela provjeravamo SAMO ZADOVOLJIVOST, ne i log. posljedicu, tj. bitno nam je samo je li formula φ istinita u jednom modelu M, s.

9) a) $A\neg G(q \Rightarrow E G r)$ ✗
b) $E[A[p_1 U p_2] U p_3]$ OK!
c) $EF[r U q]$ ✗ (zbog F)
d) $EF\,E[r U q]$ OK!

23.06.2000.

1) $f = m0 + m1 + m2 + m3 + m4 + m6 + m7$

a \ bc	00	01	11	10
0	1 0	1 1	1 3	1 2
1	1 4	5	1 7	1 6

$f = \bar{a}\bar{b}\bar{c} + \bar{a}\bar{b}c + \bar{a}b\bar{c} + \bar{a}bc + a\bar{b}\bar{c} + abc + abc$ =

$= \bar{a}\bar{b}(\bar{c}+c) + \bar{a}b(\bar{c}+c) + \bar{b}\bar{c}(a+\bar{a}) + ab(c+\bar{c}) + b\bar{c}(a+\bar{a})$

$= \bar{a}\bar{b} + \bar{a}b + \bar{b}\bar{c} + ab + b\bar{c} = \bar{a}(\bar{b}+b) + b(a+\bar{a}) + \bar{c}(b+\bar{b})$

$= \bar{a} + b + \bar{c}$ //

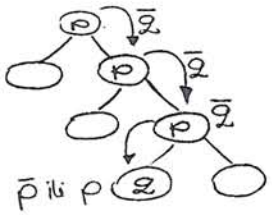
4) $f * g = x_i [f(x_1, .., 1, .., x_n) * g(x_1, .., 1, .., x_n)] + \bar{x}_i [f(x_1, .., 0, .. x_n) * g(x_1, 0., x_n)]$

8) φ u predikatnoj logici

$\models \varphi$ → oznaka tautologije, tj. formula φ je istinita za ∀model

Ne vrijedi 8, jer istinitost φ ovisi o interpretaciji njenih varijabli...

9) $\exists [p U q]$



"Postoji staza u kojoj za svako stanje staze vrijedi da je p istinito i q lažno do stanja u kojem q postane istinito. Pritom nije rečeno ostaje li p istinit u tom stanju, ili postaje lažan.

10) $\forall s_0 \in S_0, M, s \models \varphi$

Za svako početno stanje modela, vrijedi da je formula φ istinita za taj model.

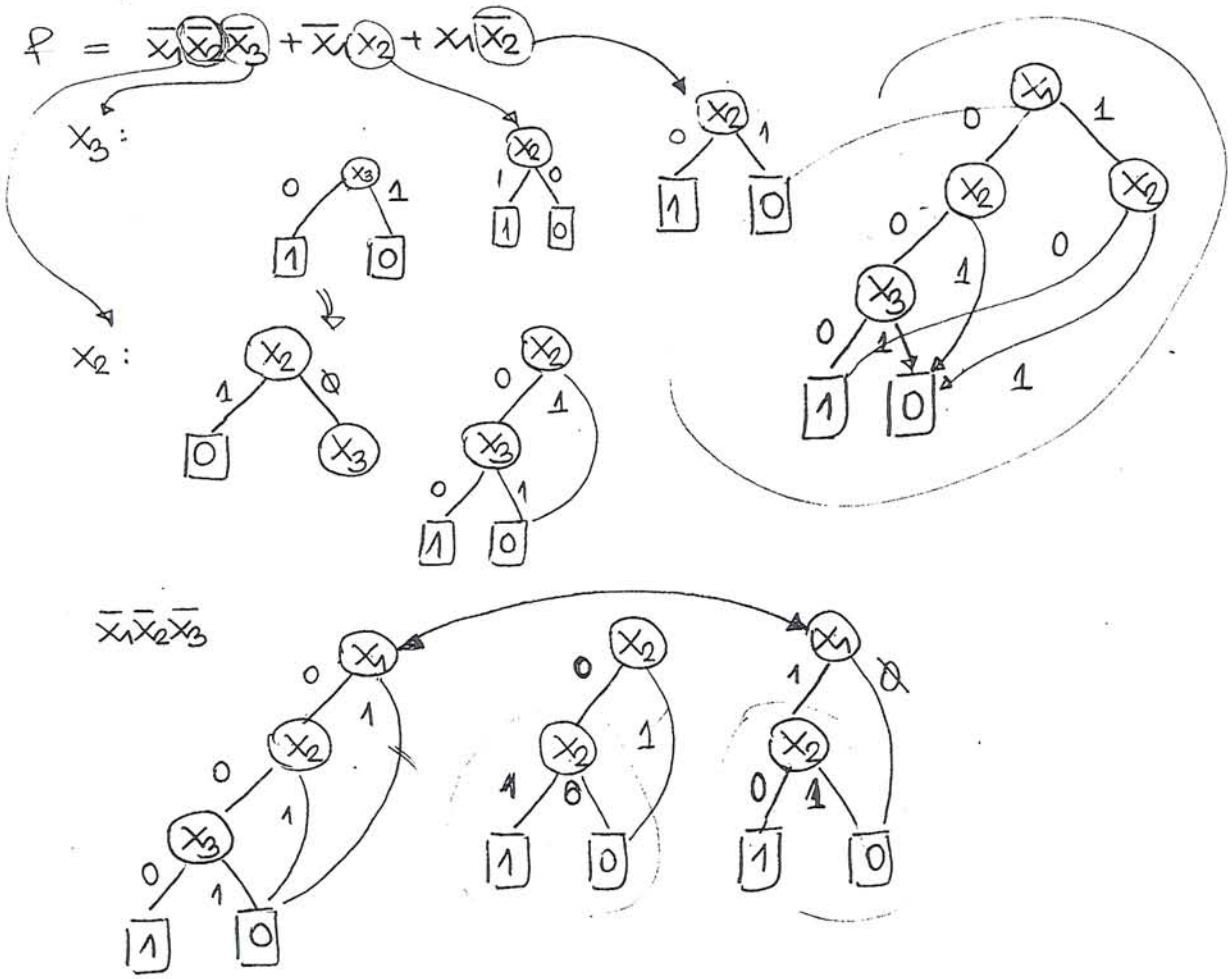
11) a) $A[p U EF\,t]$ ok!

b) $AEF\,t$ ✗

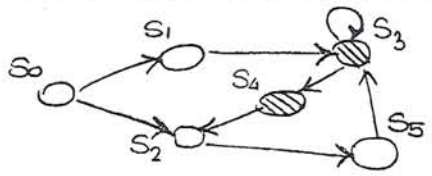
c) $FG\,t$ ✗

d) $AF[(r U q) \wedge (p U t)]$ ✗

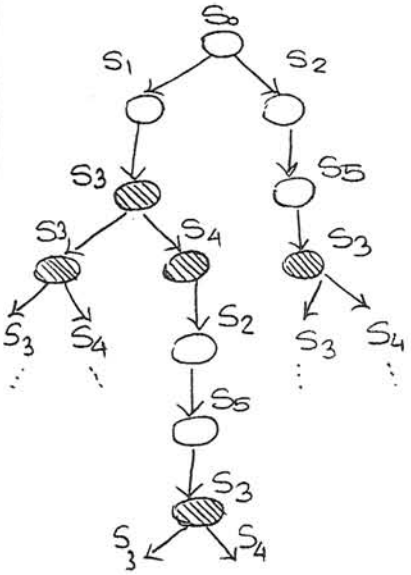
Samo je jedan Mali Ivica!



Samo je jedan Mali Ivica!



Kripke struktura s poč. stanjem S_0



$AG(white \oplus black) \equiv$

$\equiv AG(w \wedge \neg b \vee \neg w \wedge b)$

$\neg EG\, white$

$\neg E(white\, U\, (black \wedge AX(AG\, white)))$

$\downarrow$

ne $\exists$put so samo 1 crnom kuglom!

Samo je jedan Mali Ivica!

ITE-algoritam:

$\emptyset$	$\emptyset$	ite(f,g,0)
AND(f,g)	$f \cdot g = fg + \bar{f} \cdot 0$	ite(f,ḡ,0)
f>g	$f \cdot \bar{g} = f\bar{g} + \bar{f} \cdot 0$	ite(f,1,0)
f	$f = f \cdot 1 + \bar{f} \cdot 0$	ite(f̄,g,0) = ite(f,0,g) BOLJE
f<g	$f \cdot g = f \cdot g + \bar{f} \cdot 0$	ite(g,1,0)
g	$g = g \cdot 1 + \bar{g} \cdot 0$	ite(f,ḡ,g)
XOR(f,g)	$f \oplus g = f\bar{g} + \bar{f}g$	ite(f,1,g)
OR(f,g)	$f + g = f \cdot 1 + \bar{f} \cdot g$	ite(f̄,ḡ,0) = ite(f,0,g) BOLJE
NOR(f,g)	$\overline{f+g} = \bar{f} \cdot \bar{g} + f \cdot 0$	ite(f,g,g)
XNOR(f,g)	$f \oplus g = \bar{f}\bar{g} + f \cdot g$	ite(g,1,0) = ite(g,0,1) BOLJE
NOT(g)	$\bar{g} = 1 \cdot \bar{g} + 0 \cdot g$	ite(f,1,ḡ)
f≥g	$f + \bar{g} = f \cdot 1 + \bar{f}\bar{g}$	ite(f̄,1,0) = ite(f,0,1)
NOT(f)	$\bar{f} = \bar{f} \cdot 1 + f \cdot 0$	ite(f̄,1,g) = ite(f,g,0)
f≤g	$\bar{f} + g = \bar{f} \cdot 1 + f \cdot g$	ite(f̄,1,ḡ) = ite(f,ḡ,1)
NAND(f,g)	$\overline{fg} = \bar{f} + \bar{g} = \bar{f} \cdot 1 + f \cdot \bar{g}$	
1	1	

$ite(f,g,h) = fg + \bar{f}h$

v → vršna varijabla od f,g,h

$$ite(f,g,h) = v(fg+\bar{f}h)_v + \bar{v}(fg+\bar{f}h)_{\bar{v}} =$$
$$= \textcircled{v}(f_v g_v + \bar{f}_v h_v) + \textcircled{\bar{v}}(f_{\bar{v}} g_{\bar{v}} + \bar{f}_{\bar{v}} h_{\bar{v}}) =$$
$$= ite(v, ite(f_v, g_v, h_v), ite(f_{\bar{v}}, g_{\bar{v}}, h_{\bar{v}})) =$$
$$= (v, t, e) = R$$

TERM_CASES → (1,f,g), (0,g,f), (f,1,0), (f,f,f) } = f

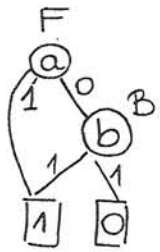
```
ITE_ALG (f,g,h){
    rez, term_case = TERM_CASE (f,g,h)
    if (term_case) return rez;
    rez, comp_table = COMP_TABLE_HASH_ENTRY (f,g,h)
    if (comp_table) return rez;

    v = TOP_VAR (f,g,h)
    t = ITE_ALG (fv, gv, hv)
    e = ITE_ALG (fv̄, gv̄, hv̄)

    if (t=e) return t;

UMEĆEM U COMP_T [ R = FIND_OR_ADD_UNIQUE_TABLE(v,t,e);
                  INSERT_COMP_T ((f,g,h), R)

    return R;
}
```

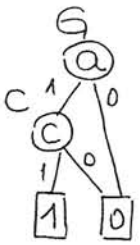
	COMP_TAB.	UNIQUE_T
ključ	(f,g,h)	(v,t,e)

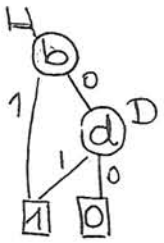
Samo je jedan Mali Ivica!

$F = a+b$
$G = ac$
$H = b+d$

$F_a = 1$ $\quad F_{\bar{a}} = b$ $\qquad G_a = c$ $\quad G_{\bar{a}} = \emptyset$ $\qquad H_a = b+d = H_{\bar{a}} = H$ $\quad H_b = 1$ $\quad H_{\bar{b}} = d$







Kako naći $I = ite(F,G,H)$?

$I = ite(F,G,H) = a(F_a G_a + \bar{F}_a H_a) + \bar{a}(F_{\bar{a}} G_{\bar{a}} + \bar{F}_{\bar{a}} H_{\bar{a}})$

$= ite(a, ite(F_a, G_a, H_a), ite(F_{\bar{a}}, G_{\bar{a}}, H_{\bar{a}}))$ =

$= (a, ite(F_a, G_a, H_a); ite(F_{\bar{a}}, G_{\bar{a}}, H_{\bar{a}}))$

$= (a, ite(1, C, H), ite(B, \emptyset, H))$ =

$= (a, C, (B\cdot\emptyset + \bar{B}\cdot H))$ = → vanjska var. = b

$= (a, C, (b, ite(B_b, \emptyset_b, H_b), ite(B_{\bar{b}}, \emptyset_{\bar{b}}, H_{\bar{b}}))$ =

$= (a, C, (b, ite(1, \emptyset, 1), ite(\emptyset, \emptyset, D))$ =

$= (a, C, (b, \emptyset, D)) = (a, C, J)$

$J \equiv$ ovoga nema pa ga treba izgraditi

$J = b\cdot\emptyset + \bar{b}\cdot D$ →

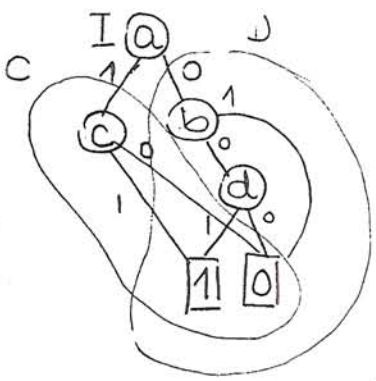
$a(C) + \bar{a}(b\emptyset + \bar{b}d)$

$I = ac + \bar{a}\bar{b}d$

Konačno:

$I = aC + \bar{a}J$

≡>



CHECH:

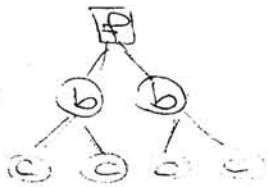
$I = ite(F,G,H) = (a+b)ac + \overline{(a+b)}\cdot(b+d) =$

$= ac + \bar{a}\bar{b}(b+d) = ac + \bar{a}\bar{b}d$ //

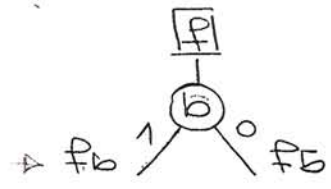
Samo je jedan Mali Ivica!

$f = abc + \bar{b}d + \bar{c}d$

$b \leq c \leq d \leq a$



$\begin{cases} f_b = ac + \bar{c}d \\ f_{\bar{b}} = d + \bar{c}d \end{cases}$



$\begin{cases} f_{bc} = a \\ f_{b\bar{c}} = d \end{cases}$

$f_{\bar{b}}$

$f_{\bar{b}c} = d + d = d + ef\bar{d}$

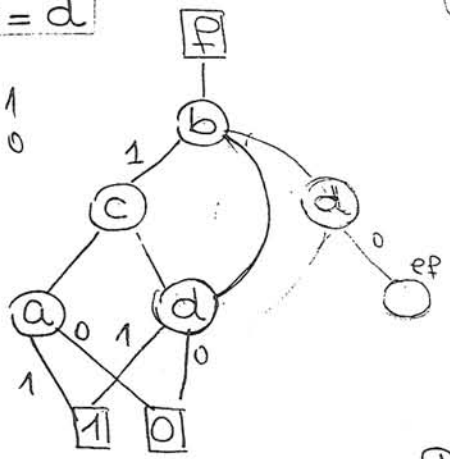
$f_{\bar{b}\bar{c}} = d + d = d + ef\bar{d}$

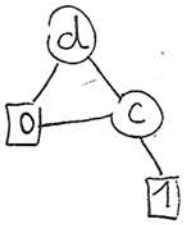
$f_{\bar{b}d} = 1$

$f_{\bar{b}\bar{d}} = ef$

$f_{bca} = 1$

$bc\bar{a} = 0$

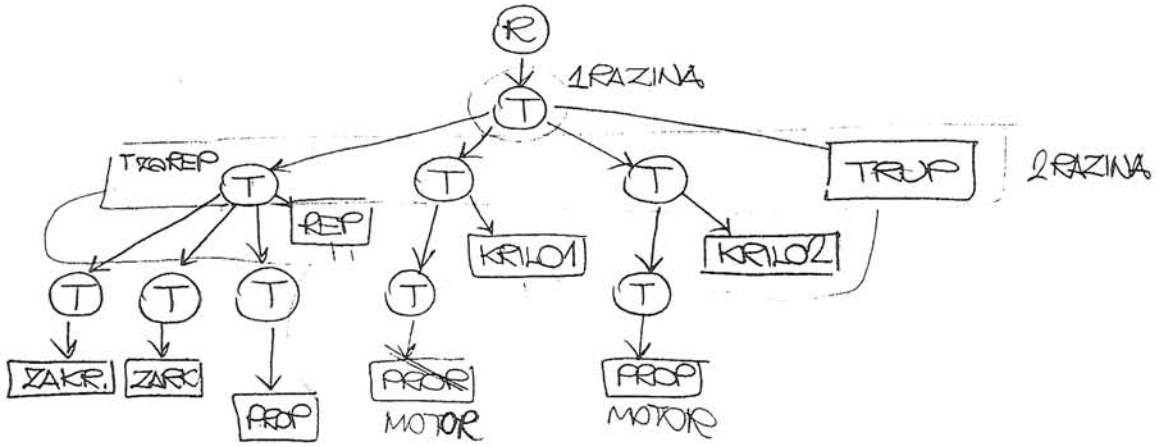




Samo je jedan Mali Ivica!

```
Transform {
    translation   x y z
    rotation      x y z angle
    scale         x y z
    children [...]
```

1.9 0.3 0.4



avion_v1.0.wrl

```
#TRUP
DEF Trup Transform {
    children [
        Transform {
            scale 1.9 0.3 0.4
            children [
                DEF Kugla1 Shape {
                    appearance Appearance {
                        material Material {
                            diffuseColor 1.0 1.0 1.0
                        }
                    }
                    geometry Sphere {}
                }
            ]
        }
```

Samo je jedan Mali Ivica!

Samo je jedan Mali Ivica!

Postavljanje -
- kamere
- predmeta u kompoziciju
- izbor leće i zoom (projekcija)
- veličina slike

Transf. pogleda & modela kreiraju "MODEL VIEW" matricu *
↓
koo-iz lok. koo-sustava
u koo-sustav kamere

* pomak modela } mijenjamo
ili pomak kamere } koo sustav

ROTIRANJE
TRANSLATIRANJE } 3.10.4
SKALIRANJE

PROJEKCIJA ↗ PERSPEKTIVNA (realno)
↘ ORTOGONALNA

↳ glFrustum() --> parametri projekcije
gluLookAt (eyeX, eyeY, eyeZ, cx, cy, cz, upx, upy, upz)
↓
pogled na scenu — točka gledišta — što na liniji gl. — što je gore

PROJEKCIJA } kako će scena biti
TRANSF. U PROZOR } iscrtana na monitoru?
↳ oblik dostupnog dijela ekrana (vel. fotografije)

u pixelima!?

PROJEKCIJA — glFrustum
T.U.P — gl.Viewport (koo-poč.točka ekrana, širina, visina)
(0, 0, 64, 50)

OPERACIJE S MATRICOM:

glMatrixMode() --> def. GL_PROJECTION
GL_MODEL_VIEW

glLoadIdentity() --> jedinična matrica
glTranslatef()
glRotatef()
glScalef()

glLoadMatrix*() --> s kojom mat. popunjavamo tekuću matricu

void glMultMatrix{fd}(const TYPE *m)

Inicijalizacija prozora:

V glutInitDisplayMode (mode) ↗ 1 sruti / 2 sruti spremnik
↘ RGB boja?
V glutInitWindowSize (šir. visina)
-"- -"- Position (x, y) --> poč. položaj

int -"- CreateWindow (name)
V -"- DisplayFunc (vFunc) — postavljanje → callback f-ja. ∀ iscrtavanje nove slike !

glutReshapeFunc (void (*func)(šir, visina))

Samo je jedan Mali Ivica!

POTREBNO:
→ biblioteka klasa (s3d_259.exe)
raspakirati u proizvoljan dir.
→ shout3d.zip
otvoriti Web3D.jpx projekt!

PREDNOSTI
→ ne zahtjeva poseban preglednik, ni plug in, već Java enabled.
→ Vrijeme kad se učitava VRML zapis, na kon. način se startira player za taj zapis (napisan kao applet)
⇓
MANA ① na rač. sa sporijom vezom start ide sporo!
MANA ② složeni mat. izrazi nisu optimalni u Javi

APPLET (extends java.applet.Applet)
- izvodi se unutar web browsera na klient. rač.
- ne mogu R/W s loc. diska (-)
- nema instalacijske procedure (+)

Ugradnja u HTML: tag <APPLET></APPLET>
atributi CODE (ime klase appl)
CODEBASE (staza do dat. apl.)
WIDTH } applet unutar stranice
HIGHT }

APSOLUTNI URL dat. app: CODEBASE/CODE

tag <PARAM> name/value atributi
Unutar apleta: getParameter

Shout3D: src parametar (adresira ime vrl dat)

```
< APPLET CODEBASE="." CODE="shout3d/Shout3DApplet.class"
  ARCHIVE="..." W H>
  <param name="src" value="avion/avion.wrl">
</APPLET>
```

Shout3DApplet
Shout3DPanel -- logika za rendering. } nasljediti in drugo

U TAGU → 640×480 (WIDTH×HEIGHT)
U metodi Shout3DApplet.initShout3DPanel() 320×240
Panel mora biti < applet ako želimo vidljive komponente

PRISTUP: getNodeByName() klasa Shout3DPanel
Web3DPanel extends Shout3DPanel
Transform SS;
SS = (Transform) getNodeByName("SS");

Samo je jedan Mali Ivica!

Kako ulaz novog konk. utječe na mon. konk.
Ⓑ Razlika ekonom. i rač. troškova
II Bilanca stanja

Ⓐ Bilanca uspjeha
Razlika pros. i gran. troška

I Ⓑ Kako vrijeme utječe na proizvodnju [Trenutačni, kratki i dugi rok]
Što određuje krivulju ~~ponude~~ ponude

Ⓐ Što je krivulja proiz. mogućnosti?
Što uzrokuje neefikasnost (što je neefikasnost)

Samo je jedan Mali Ivica!

$n^2+4n+4=0$

$n_{1,2} = \frac{+4 \pm \sqrt{16-16}}{2} = 2$

$n^2-2n-256=0$

$n_{1,2} = \frac{-2 \pm \sqrt{4+4\cdot 256}}{2} = \frac{-2 \pm 32}{2} = -2 \pm 16$

-18
+14

Samo je jedan Mali Ivica!

1 ~~7~~
2 5
3 Ivan
4 ~~Ana~~ Sanda
5 ~~Sanda~~ Natasa
6 ~~Natasa~~ Ana
7 ~~Ana~~ Jurica
8 SSTBTHW
9 COWM
10 F
11. Gossip

	6 A	5 B	C	D	E
A	∅	3	4	1	∅
B	∅	∅	4	2	∅
C	∅	∅	∅	1	2
D	∅	∅	2	∅	4
E	∅	∅	∅	∅	∅

① ⊗①

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

A→B→C→D→E

② ⊗②

$$\begin{bmatrix} -3 & 0 & 0 & - \\ - & -3 & 0 & - \\ - & - & -1 & 2 \\ - & - & 0 & -1 \\ - & - & - & - \end{bmatrix}$$

A→B→D→E

③ ⊗②

A→C←B→D→E

$$\begin{bmatrix} -3 & 2 & 0 & - \\ - & -1 & 2 & - \\ - & - & -1 & 2 \\ - & - & 0 & -3 \\ - & - & - & - \end{bmatrix}$$

④ KRAJ
ALG

max PUTOK = 5