**Projektni zadatak iz Sistemskog Softvera**

## ***Zadatak II* – Interpretativni emulator**

### Opis rešenja:

Realizovani program

### Prevođenje

Program se prevodi pomoću GNU Make alata izvršavanjem komande *make* u kontekstu korenog direktorijuma projekta.

### Testovi

# **EQU**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .extern d, data\_out  .global b, \_start  .equ a, d - '0'  .equ b, '2'  .equ sym0, a + b – d #sym0 = 2  .equ sym1, a + b - d + c # addr(c) + 2  .section text  \_start:  mov $b, data\_out # write ’2’ to terminal  mov $0, %r0  mov sym1(%r0), data\_out # write mem[addr(c) + 2] to terminal (’b’)  jmp \*sym\_quit(%pc) # quit the program  .section data  c:  .word 'a'  .word 'b'  .section end  .equ sym\_quit, quit  quit:  halt  .end | .extern \_start  .global data\_in, data\_out  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  iret  \_terminal:  iret  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/equ/text.o ./tests/equ/ivt\_tab.o -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  2b  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Instrukcije (2B)**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .global \_start  .extern data\_out  .section text  \_start:  push char\_b  push char\_a  call write\_func  pop var  pop var  xchg char\_a, char\_b  push char\_b  push char\_a  call write\_func  pop var  pop var  mov $0, var  call write\_out  add $1, var  call write\_out  sub $-1, var  call write\_out  mul $4, var  call write\_out  div $2, var  call write\_out  not $0xfff8, var  call write\_out  and $9, var  call write\_out  or $6, var  call write\_out  xor $0xe, var  call write\_out  shr var, $2  call write\_out  shl $1, var  call write\_out  halt  .equ char\_a\_offs, 2  .equ char\_b\_offs, 4  write\_func:  mov char\_a\_offs(%sp), data\_out # write ’a’ from stack to output  mov char\_b\_offs(%sp), data\_out # write ’b’ from stack to output  mov $0xA, data\_out # write ’\n’ to output  ret  write\_out:  add $'0', var  mov var, data\_out  mov $0xA, data\_out  sub $'0', var  ret  var:  .word 0  char\_a:  .word 'a'  char\_b:  .word 'b'  .end | .extern \_start  .global data\_in, data\_out  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  iret  \_terminal:  iret  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/instructions/text.o ./tests/instructions/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  ab // rezultat poziva fje write sa parametrima (prenetim preko steka) a i b  ba // rezultat operacije xchg char\_a, char\_b  0 // mov $0, var  1 // add $1, var  2 // sub $-1, var  8 // mul $4, var  4 // div $2, var  7 // not 0xfff8, var  1 // and $9, var  7 // or $6, var  9 // xor $0xe, var  2 // shr var, $2  4 // shl $1, var  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Instrukcije (1B)**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .global \_start  .extern data\_out  .section text  \_start:  push char\_b  push char\_a  call write\_func  pop var  pop var  xchgb char\_a, char\_b  push char\_b  push char\_a  call write\_func  pop var  pop var  movb $0, var  call write\_out  addb $1, var  call write\_out  subb $-1, var  call write\_out  mulb $4, var  call write\_out  divb $2, var  call write\_out  notb $0xf8, var  call write\_out  andb $9, var  call write\_out  orb $6, var  call write\_out  xorb $0xe, var  call write\_out  shrb var, $2  call write\_out  shlb $1, var  call write\_out  halt  .equ char\_a\_offs, 2  .equ char\_b\_offs, 4  write\_func:  movb char\_a\_offs(%sp), data\_out  movb char\_b\_offs(%sp), data\_out  movb $0xA, data\_out  ret  write\_out:  addb $'0', var  movb var, data\_out  movb $0xA, data\_out  subb $'0', var  ret  var:  .word 0  char\_a:  .byte 'a'  char\_b:  .byte 'b'  .end | .extern \_start  .global data\_in, data\_out  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  iret  \_terminal:  iret  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/instructions\_byte/text.o ./tests/instructions\_byte/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  ab // rezultat poziva fje write sa parametrima (prenetim preko steka) a i b  ba // rezultat operacije xchgb char\_a, char\_b  0 // movb $0, var  1 // addb $1, var  2 // subb $-1, var  8 // mulb $4, var  4 // divb $2, var  7 // notb 0xfff8, var  1 // andb $9, var  7 // orb $6, var  9 // xorb $0xe, var  2 // shrb var, $2  4 // shlb $1, var  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Prekidna rutina pri nailasku na nekorektnu instrukciju**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .global \_start  .section text  \_start:  div $0, \_start  .end | .extern \_start  .global data\_in, data\_out  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  mov $0, %r0  loop:  mov msg(%r0), data\_out  add $1, %r0  cmp msg(%r0), $0  jne loop  halt  quit:  halt  \_timer:  iret  \_terminal:  iret  .section ivt\_tab.data  msg:  .byte 'i'  .byte 'n'  .byte 'v'  .byte 'a'  .byte 'l'  .byte 'i'  .byte 'd'  .byte ' '  .byte 'i'  .byte 'n'  .byte 's'  .byte 't'  .byte 'r'  .byte 'u'  .byte 'c'  .byte 't'  .byte 'i'  .byte 'o'  .byte 'n'  .byte 0xa  .byte 0  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/interrupt\_invalid\_ins/text.o ./tests/interrupt\_invalid\_ins/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  invalid instruction  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Prekida rutina terminala**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .global \_start  .section text  \_start:  jmp \_start  .end | .extern \_start  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  iret  .equ diff, 'a' - 'A'  \_terminal:  mov data\_in, %r0  mov %r0, data\_out  cmp %r0, $'a'  jgt exit  cmp $'z', %r0  jgt exit  cmp $'q', %r0  jeq quit  sub $diff, data\_out  exit:  iret  quit:  halt  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/interrupt\_terminal/text.o ./tests/interrupt\_terminal/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  // Prekidna rutina čita ulazni malo slovo a na izlaz šalje njega i  // odgovarajuće veliko slovo, procesor se zaustavlja kada pročita ulazni karakter ‘q’  tTeEsStTiIrRaAnNjJeE pPrRoOgGrRaAmMaAq  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Prekidna rutina tajmera**

|  |  |
| --- | --- |
| Kod ulaznog fajla text.o | Kod ulaznog fajla ivt\_tab.o |
| .global \_start  .section text  \_start:  jmp \_start  .end | .extern \_start  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  add $1, cnt  mov cnt, %r0  add $'0', %r0  mov %r0, data\_out  cmp cnt, $9  jne exit  mov $0, cnt  exit:  iret  cnt:  .word 0  \_terminal:  cmp data\_in, $'q'  jeq quit  iret  quit:  halt  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/interrupt\_timer/text.o ./tests/interrupt\_timer/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  // Tajmer broj po broj sekvence 1-9 sve dok se ne pritisne taster ’q’  12345678912345678912  | ~~~~~~ Execution Done ~~~~~~ | | |

# **Prekidna rutina tajmera**

|  |  |
| --- | --- |
| Kod ulaznog fajla text0.o | Kod ulaznog fajla text1.o |
| .extern data\_out, addr3  .global addr2  .section text  out2:  mov $'2', data\_out  jmp \*addr3(%pc)  .section addrsec  addr2:  .word out2  .end | .global \_start  .extern data\_out, addr2  .section text  addr0:  .word out0  out0:  mov $'0', data\_out  jmp \*addr1(%pc)  \_start:  mov $'s', data\_out  jmp \*addr0(%pc)  out1:  mov $'1', data\_out  jmp \*addr2(%pc)  addr1:  .word out1  .end |
| Kod ulaznog fajla text2.o | **Kod ulaznog fajla ivt\_tab.o** |
| .extern data\_out  .global addr3  .section text  out3:  mov $'3', data\_out  halt  .section addrsec  addr3:  .word out3  .end | .extern \_start  .global data\_in, data\_out  .section ivt\_tab  .word \_start  .word \_invalid\_instruction  .word \_timer  .word \_terminal  .section ivt\_tab.text  .equ data\_in, 0xFF00  .equ data\_out, 0xFF02  \_invalid\_instruction:  iret  \_timer:  iret  \_terminal:  iret  .end |
| Izlaz dobijen pokretanjem emulatora komandom:  ./bin/emulator ./tests/linking\_multiple\_files\_rel\_pc/text0.o ./tests/linking\_multiple\_files\_rel\_pc/text1.o ./tests/linking\_multiple\_files\_rel\_pc/text2.o ./tests/linking\_multiple\_files\_rel\_pc/ivt\_tab.o -place=text@0x4000 -place=ivt\_tab@0x0000 | |
| | ~~~ Starting Emulator ~~~ |  s0123  | ~~~~~~ Execution Done ~~~~~~ | | |

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