



Universiteit Antwerpen  
| Faculteit Wetenschappen

# Computersystemen en -architectuur

Introductie MIPS

**Tim Apers**

[tim.apers@uantwerpen.be](mailto:tim.apers@uantwerpen.be)

Academiejaar 2022 – 2023

# Instructies

- Bepalen wat een programma doet
- Worden één voor één uitgevoerd
- Arithmetic: optellen, delen, and, or, bitshifts, etc.
- Load/Store: lezen/schrijven naar geheugen
- Conditional: if-statements, loops, etc.
- Voorbeeld:
  - `li $t1, 12` # Register \$t1 bevat nu de waarde 12
  - `addi $t0, $t1, 2` #  $\$t0 = \$t1 + 2$
  - Register \$t0 bevat nu de waarde 14

# Registers

Naam	Nummer	Betekenis
\$zero	0	Altijd gelijk aan 0
\$at	1	Gereserveerd (niet gebruiken)
\$v0 – \$v1	2 – 3	Functie return waarde
\$a0 – \$a3	4 – 7	Functie argumenten
\$t0 – \$t9	8 – 15, 24 – 25	Temporary registers
\$s0 – \$s7	16 – 23	Saved registers
\$k0 – \$k1	26 – 27	Kernel Registers
\$gp	28	Pointer naar global data
\$sp	29	Stack pointer
\$fp	30	Frame pointer
\$ra	31	Return adres
\$f0 – \$f31		Floating point registers

# Labels

- Groeperen van instructies
- Vergelijkbaar met de naam van een functie (zie Python, C++)
- Maakt “jumps” en “branches” mogelijk

```
1 # add.asm: A program that computes the sum of 1 and 2
2 # leaving the result in register $t0.
3 # Registers used:
4 # t0 : used to hold the result
5 # t1 : used to hold the constant 1
6
7 main:                # start execution at main
8     li $t1, 1         # load value 1 into $t1
9     j add             # jump to label 'add'
10    addi $t0, $t1, 1    # $t0 = $t1 + 1
11 add:
12    addi $t0, $t1, 2    # $t0 = $t1 + 2
13 # end of add.asm
```

# System calls

- Request aan besturingssysteem
- Functionaliteiten: input, output, memory, exit
- Hoe?
  1. Plaats code in register \$v0
  2. Roep `syscall` instructie op

# System calls

Naam	Code in \$v0	Argumenten	Return register
print_int	1	\$a0	
print_float	2	\$f12	
print_double	3	\$f12	
print_string	4	\$a0	
read_int	5		\$v0
read_float	6		\$f0
read_double	7		\$f0
read_string	8	\$a0 (geheugen adres) \$a1 (lengte)	
sbrk	9	\$a0 (lengte)	\$v0 adres
exit	10		

# System calls

## Voorbeeld

```
1 # add.asm: A program that computes the sum of 1 and 2
2 # Printing the result
3 # Registers used:
4 # t0 : used to hold the result
5 # t1 : used to hold the constant 1
6 main:
7     li    $t1, 1      # load 1 into $t1
8     addi  $t0, $t1, 2 # $t0 = $t1 + 2
9
10    move  $a0, $t0     # set result to $a0
11    li    $v0, 1       # load code for print_int
12    syscall
13 exit:
14    li    $v0, 10      # load code for exit
15    syscall
16 # end of add.asm
```

# Geheugen

- Maakt het mogelijk om variabelen en data mee te geven in een script
- Data-gedeelte voorafgegaan door directive `.data`
- Voorbeelden:
  - `.ascii "abc":` string
  - `.asciiz "abc":` string gevolgd door zero-byte (zie theorielessen)
  - `.byte 5:` 8-bit integer
  - `.half -3:` 16-bit integer
  - `.word 3200:` 32-bit integer
  - `.space 20:` lege ruimte, 20-bytes groot
- Gebruik `lw` en `sw` instructies om data op te slaan en op te roepen
- Gebruik `la` om het adres te bekomen
- Instructie-gedeelte voorafgegaan door directive `.text`



# Geheugen

## Voorbeeld 1

```
1 # helloworld.asm: A "Hello World" program.
2 # Registers used:
3 # $v0 : syscall parameter and return value
4 # $a0 : syscall parameter: the string to print
5     .data
6 hello_msg: .asciiz "Hello World!\n"
7
8     .text
9 main:
10     la $a0, hello_msg    # load the addr of hello_msg in $a0
11     li $v0, 4            # load code for print_string
12     syscall
13 exit:
14     li $v0, 10          # load code for exit
15     syscall
```

# Geheugen

## Voorbeeld 2

```
1 # loadandstore.asm: Demonstrate load and store instructions
2 # by implementing c = a + b
3 .data
4 var_a: .word -5      # variable a
5 var_b: .word 8       # variable b
6 var_c: .word 0       # variable c
7
8 .text
9 main:
10     lw $t1, var_a     # load a in $t1
11     lw $t2, var_b     # load b in $t2
12     add $t0, $t1, $t2  # add a and b
13     sw $t0, var_c     # store sum into c
14
15
16 exit:
17     li $v0, 10        # load code for exit
18     syscall
```

# Conditionele instructies

```
1 # conditional.asm
2 # c = max(a, b)
3     .data
4 var_a: .word 8      # variable a
5 var_b: .word 14     # variable b
6 var_c: .word 0      # variable c
7
8     .text
9 main:
10     lw $t1, var_a    # load a in $t1
11     lw $t2, var_b    # load b in $t2
12
13     #conditional: if a > b
14     bgt $t1, $t2, t1_greater # branch if $t1 > $t2
15     sw $t2, var_c    # store b into c
16     j endif          # jump to endif
17 t1_greater:
18     sw $t1, var_c    # store a into c
19 endif:
20     li $v0, 10      # load code for exit
21     syscall
```

# Loops

```
1 # loop.asm
2 # c = a x b
3     .data
4 var_a:  .word 8      # variable a
5 var_b:  .word 5      # variable b
6 var_c:  .word 0      # variable c
7
8     .text
9 main:
10     lw $t1, var_a    # load a in $t1
11     lw $t2, var_b    # load b in $t2
12
13     #loop: add a to result, do this b times
14     li $t0, 0        # loop register
15     li $t3, 0        # result register
16 loop:
17     bge $t0, $t2, endloop    # end loop if loop register >= b
18     add $t3, $t3, $t1        # add a to result
19     addi $t0, $t0, 1         # increase loop register
20     j loop                   # jump to loop
21 endloop:
22     sw $t3, var_c           # store result into c
```

# MARS Simulator

/home/kasper/Desktop/MARS/add.asm - MARS 4.5

File Edit Run Settings Tools Help

add.asm

```
1 # add.asm: A program that computes the sum of 1 and 2
2 # Printing the result
3 # Registers used:
4 # t0 : used to hold the result
5 # t1 : used to hold the constant 1
6 main:
7     li    $t1, 1          # load 1 into $t1
8     addi  $t0, $t1, 2     # $t0 = $t1 + 2
9
10    move  $a0, $t0         # set result to $a0
11    li    $v0, 1           # load code for print_int
12    syscall
13
14    exit:
15    li    $v0, 10          # load code for exit
16    syscall
17 # end of add.asm
```

Line: 1 Column: 1 ☒ Show Line Numbers

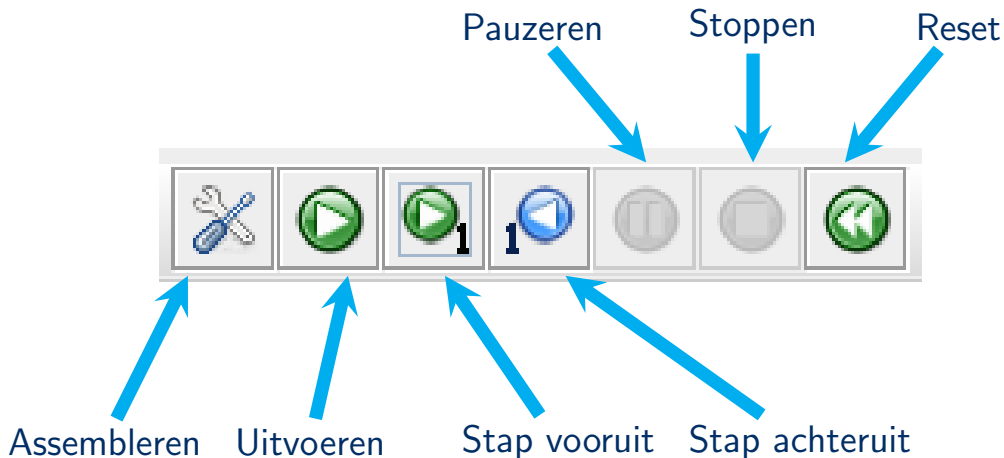
Mars Messages Run I/O

Clear

Registers	Coproc 1	Coproc 0
Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$a3	7	0x00000000
\$t0	8	0x00000000
\$t1	9	0x00000001
\$t2	10	0x00000000
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000000
\$s1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$s7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10008000
\$sp	29	0x7ffffcfc
\$fp	30	0x00000000
\$ra	31	0x00000000
pc		0x00400000
hi		0x00000000
lo		0x00000000

# MARS Simulator

## Toolbar



# MARS Simulator

/home/kasper/Desktop/MARS/add.asm - MARS 4.5

File Edit Run Settings Tools Help

Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x24090001	addiu \$9,\$0,0x0...	7: li \$t1, 1 ...
	0x00400004	0x21280002	addi \$8,\$9,0x0...	8: addi \$t0, \$t1, 2 ...
	0x00400008	0x00082021	addu \$4,\$0,\$8	10: move \$a0, \$t0 #...
	0x0040000c	0x24020001	addiu \$2,\$0,0x0...	11: li \$v0, 1 ...
	0x00400010	0x0000000c	syscall	12: syscall
	0x00400014	0x2402000a	addiu \$2,\$0,0x0...	14: li \$v0, 10 #...
	0x00400018	0x0000000c	syscall	15: syscall

Data Segment

Address	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...

Registers

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x00000000
\$v1	3	0x00000000
\$a0	4	0x00000000
\$a1	5	0x00000000
\$a2	6	0x00000000
\$a3	7	0x00000000
\$t0	8	0x00000000
\$t1	9	0x00000000
\$t2	10	0x00000000
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000000
\$s1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$s7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10000000
\$sp	29	0x7ffffc
\$fp	30	0x00000000
\$ra	31	0x00000000
pc		0x00400000
hi		0x00000000
lo		0x00000000

Mars Messages

Run I/O

Assemble: assembling /home/kasper/Desktop/MARS/add.asm

Assemble: operation completed successfully.

Clear

# MARS Simulator

/home/kasper/Desktop/MARS/add.asm - MARS 4.5

File Edit Run Settings Tools Help

Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x24090001	addiu \$9,\$0,0x0...	7: li \$t1, 1 ...
	0x00400004	0x21280002	addi \$8,\$9,0x0...	8: addi \$t0, \$t1, 2 ...
	0x00400008	0x00082021	addu \$4,\$0,\$8	10: move \$a0, \$t0 #...
	0x0040000c	0x24020001	addiu \$2,\$0,0x0...	11: li \$v0, 1 ...
	0x00400010	0x0000000c	syscall	12: syscall
	0x00400014	0x2402000a	addiu \$2,\$0,0x0...	14: li \$v0, 10 #...
	0x00400018	0x0000000c	syscall	15: syscall

Data Segment

Address	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)	Value (...)
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...
0x100...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...	0x000...

Registers

Name	Number	Value
\$zero	0	0x00000000
\$at	1	0x00000000
\$v0	2	0x0000000a
\$v1	3	0x00000000
\$a0	4	0x00000003
\$a1	5	0x00000000
\$a2	6	0x00000000
\$a3	7	0x00000000
\$t0	8	0x00000003
\$t1	9	0x00000001
\$t2	10	0x00000000
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000000
\$s1	17	0x00000000
\$s2	18	0x00000000
\$s3	19	0x00000000
\$s4	20	0x00000000
\$s5	21	0x00000000
\$s6	22	0x00000000
\$s7	23	0x00000000
\$t8	24	0x00000000
\$t9	25	0x00000000
\$k0	26	0x00000000
\$k1	27	0x00000000
\$gp	28	0x10000000
\$sp	29	0x7fffffc
\$fp	30	0x00000000
\$ra	31	0x00000000
pc		0x0040001c
hi		0x00000000
lo		0x00000000

Mars Messages

3  
-- program is finished running --

Clear



# MIPS Reference sheet

- Overzicht van alle instructies en betekenis
  - Arithmetic, Logic instructions
  - Branch, Jump instructions
  - Memory instructions
- Te vinden op de MSDL-website