Linguagem de máquina do MIPS

- O formato dos campos das instruções estão no documento: MIPS Reference Data Card.pdf
- O código assembly para conferência no MARS: exemplo5_pag85_c_tabela.asm

```
# Assembly para a instrução while (save[i] == k) i += 1;

            .data                   # 0x10010000
save:       .word 0, 0, 1, 1        # vetor save[]={0, 0, 1, 1};

            .text                   # 0x00400000
            .globl main             # declara que main é um símbolo global

main:       add  $s3, $zero, $zero  # registrador $s3 recebe 0 + 0 (i = 0)
            add  $s5, $zero, $zero  # registrador $s5 recebe 0 + 0 (k = 0)
Loop:       sll    $t1, $s3, 2      # registrador temporário $t1 = 4 * i
            la     $s6,save         # carrega o endereço do rotulo save (endereço base array) para o registrador $s6
            add  $t1, $t1, $s6      # $t1 = endereço de save[i]
            lw     $t0, 0($t1)      # registrador temporário $t0 = save[i]
            bne    $t0, $s5, Exit   # vá para Exite se save[i] <> k
            addi  $s3, $s3, 1       # i = i + 1
            j Loop                  # vá para Loop
Exit:       nop
```

R Op (6 bits)	Rs (5 bits)	Rt (5 bits)	Rd (5 bits)	Shamt (5 bits)	Funct (6 bits)
I Op	Rs	Rt	Endereço (16 bits)		
J Op	Endereço (26 bits)				

0x00400000
main: add $s3,$zero,$zero (add $19,$0,$0)

R[rd] = R[rs] + R[rt] (0/20 hex)

0x00	0	0	19	0	(0x20)
0 0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 0 0 1 1	0 0 0 0 0	1 0 0 0 0 0
0	0	0	0	9	8	2	0

0x00400004
add $s5, $zero, $zero (add $21,$0,$0)

R[rt] = R[rs] + SignExtImm (8 hex)

0x00	0	0	21	0	(0x20)
0 0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 0 1 0 1	0 0 0 0 0	1 0 0 0 0 0
0	0	0	0	A	8	2	0

0x00400008
loop: sll $t1, $s3, 2 (sll $9,$19,0x00000002)

R[rd] = R[rt] << shamt (0/00 hex)

0x0	0	19	9	2	(0x00)
0 0 0 0 0 0	0 0 0 0 0	1 0 0 1 1	0 1 0 0 1	0 0 0 1 0	0 0 0 0 0 0
0	0	1	3	4	8	8	0

0x0040000c
la $s6,save (lui $1,0x00001001)

R[rt] = {imm, 16'b0} (F hex)

0x0F	0	1			0x1001
0 0 1 1 1 1	0 0 0 0 0	0 0 0 0 1	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1		
3	C	0	1	1	0	0	1

0x00400010
ori $22,$1,0x00000000

R[rt] = R[rs] | ZeroExtImm (D hex)

0x0D	1	22			0x0000
0 0 1 1 0 1	0 0 0 0 1	1 0 1 1 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		
3	4	3	6	0	0	0	0

0x00400014 add $t1,$t1,$s6 (add $9,$9,$22)																R[rd] = R[rs] + R[rt] (0/20 hex)														
0x00						9					22					9										(0x20)					
0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
0				1				3				6				4				8				2				0			
0x00400018 lw $t0, 0($t1) (lw $8,0x00000000($9))																R[rt] = M[R[rs]+SignExtImm] (23 hex)														
0x23						9					8															0x0000					
1	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8				D				2				8				0				0				0				0			
R[rt] = M[R[rs]+SignExtImm] R[8] = M[R[9]+0x0000.0000]																															
0x0040001c bne $t0, $s5, Exit (bne $8,$21,0x00000002)																if(R[rs]!=R[rt]) PC=PC+4+BranchAddr (0x05)														
0x05						8					21															0x0002					
0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1				5				1				5				0				0				0				2			
0x0002 extendido sinal de 16 bits para 32 bits = 0x0000.0002 0x0000.0002 << 2 = 0x0000.0008 bytes PC = (PC+4) +BranchAddr PC = 0x00400020 + 0x00000008 = 0x00400028 (Exit: nop)																															
0x00400020 addi $s3, $s3, 1 (addi $19,$19,0x00000001)																R[rt] = R[rs] + SignExtImm (0x08)														
0x08						19					19															0x0001					
0	0	1	0	0	0	1	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2				2				7				3				0				0				0				1			
0x00400024 j Loop (j 0x00400008) end. bytes 0x00400008 / 4 = 0x00100002 words																PC=JumpAddr (0x02)														
0x02																										0x0100002					
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0				8				1				0				0				0				2							
0x0100002 << 2 = 0x0400008																															
				0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
				0				4				0				0				0				0				8			
PC+4= 0x00400028																															
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
0				0				4				0				0				0				2				8			
PC = 4 Bits mais significativos (PC+4= 0x00400028) concatenados 28 bits 0x0400008 = 0x00400008																															
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0				0				4				0				0				0				8							
0x00400028																0x00000000															

<table>
<tr><td colspan="16">nop</td><td colspan="16"></td></tr>
<tr><td colspan="6">0x0</td><td colspan="5">0x0</td><td colspan="5">0x0</td><td colspan="5">0x0</td><td colspan="5">0x0</td><td colspan="6">0x0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
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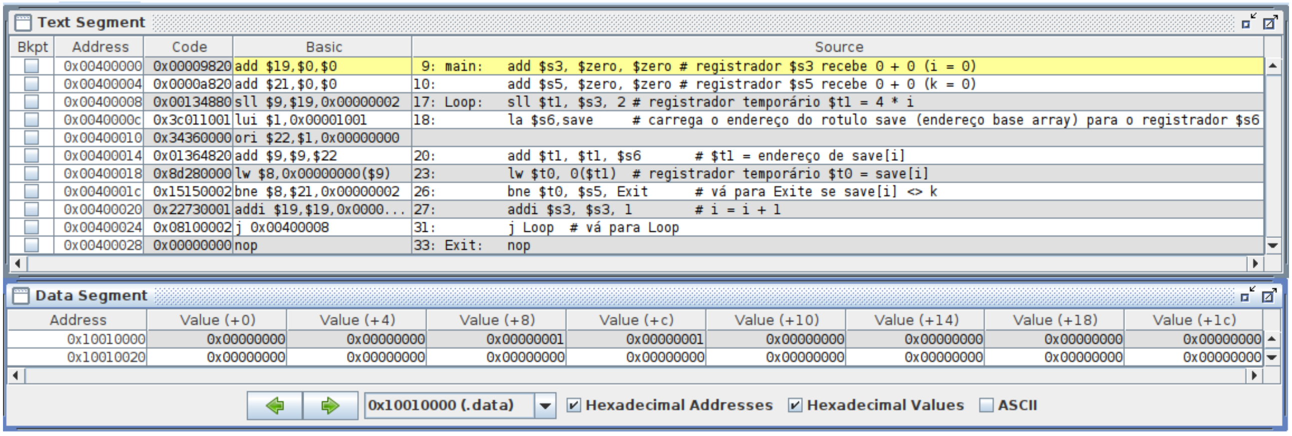

Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x00009820	add $19,$0,$0	9: main: add $s3, $zero, $zero # registrador $s3 recebe 0 + 0 (i = 0)
	0x00400004	0x0000a820	add $21,$0,$0	10: add $s5, $zero, $zero # registrador $s5 recebe 0 + 0 (k = 0)
	0x00400008	0x00134880	sll $9,$19,0x00000002	17: Loop: sll $t1, $s3, 2 # registrador temporário $t1 = 4 * i
	0x0040000c	0x3c011001	lui $1,0x00001001	18: la $s6,save # carrega o endereço do rotulo save (endereço base array) para o registrador $s6
	0x00400010	0x34360000	ori $22,$1,0x00000000	
	0x00400014	0x01364820	add $9,$9,$22	20: add $t1, $t1, $s6 # $t1 = endereço de save[i]
	0x00400018	0x8d280000	lw $8,0x00000000($9)	23: lw $t0, 0($t1) # registrador temporário $t0 = save[i]
	0x0040001c	0x15150002	bne $8,$21,0x00000002	26: bne $t0, $s5, Exit # vá para Exite se save[i] <> k
	0x00400020	0x22730001	addi $19,$19,0x0000...	27: addi $s3, $s3, 1 # i = i + 1
	0x00400024	0x08100002	j 0x00400008	31: j Loop # vá para Loop
	0x00400028	0x00000000	nop	33: Exit: nop

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000000	0x00000000	0x00000001	0x00000001	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000