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Sistemas Hardware-Software

Aula 07 – Loops

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Instruções condicionais

Lembrando que: `cmp` é igual a `sub`, `test` é igual a `and`
resultado não é armazenado.

		`cmp a,b`	`test a,b`
`je`	“Equal”	`b == a`	`b&a == 0`
`jne`	“Not equal”	`b != a`	`b&a != 0`
`js`	“Sign” (negative)	`b-a < 0`	`b&a < 0`
`jns`	(non-negative)	`b-a >=0`	`b&a >= 0`
`jg`	“Greater”	`b > a`	`b&a > 0`
`jge`	“Greater or equal”	`b >= a`	`b&a >= 0`
`jl`	“Less”	`b < a`	`b&a < 0`
`jle`	”Less or equal”	`b <= a`	`b&a <= 0`
`ja`	“Above” (unsigned >)	`b > a`	`b&a > 0U`
`jb`	“Below” (unsigned <)	`b < a`	`b&a < 0U`

```
cmp 5, (p)
je:  *p == 5 .
jne: *p != 5 .
jg:  *p >  5 .
jl:  *p <  5 .
```

```
test a, a
je:   a == 0 .
jne:  a != 0 .
jg:   a >  0 .
jl:   a <  0 .
```

```
test a, 0x1
je:   a_LSB == 0.
jne:  a_LSB == 1.
```

O par de comandos **if-goto<=>gotoC**

O par de comandos if-goto é equivalente às instruções
cmp/**test** seguidas de um **jump** condicional

```
cmp 0x4, %rdi
jle label
(bloco 1)
label:
...
```

```
if (a <= 4) {
        goto label;
}
(bloco1)
label:
. . .
```

Vamos chamar código **C** que use somente `if-goto` de **gotoC**!

Exemplo – setas e comparação

```
Dump of assembler code for function funcao:
   0x0000000000001149 <+0>:     endbr64
   0x000000000000114d <+4>:     mov    %edi,%eax
   0x000000000000114f <+6>:     mov    $0x0,%edx
   0x0000000000001154 <+11>:    jmp    0x115b <funcao+18>
   0x0000000000001156 <+13>:    add    %edi,%edx
   0x0000000000001158 <+15>:    add    $0x1,%eax
   0x000000000000115b <+18>:    cmp    %esi,%eax
   0x000000000000115d <+20>:    jle    0x1156 <funcao+13>
   0x000000000000115f <+22>:    mov    %edx,%eax
   0x0000000000001161 <+24>:    ret
End of assembler dump.
```

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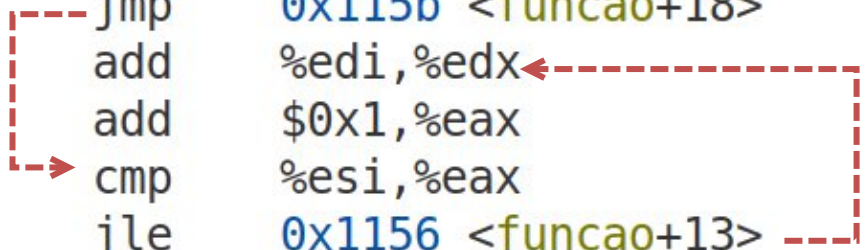
   0x000000000000115f <+22>:    mov    %edx,%eax
   0x0000000000001161 <+24>:    ret
End of assembler dump.
```



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   0x000000000000115f <+22>:    mov    %edx,%eax
   0x0000000000001161 <+24>:    ret
End of assembler dump.
```

→ **sempre pula**

Versão if-goto

```
int funcao(int edi, int esi) {
    int edx = 0;
    int eax = edi;
    goto compara;
    faz_algo:
        edx += edi;
        eax += 1;
    compara:
    if (eax-esi <= 0) {
        goto faz_algo;
    }
    return edx;
}
```

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Exemplo – setas e comparação

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   0x0000000000001149 <+0>:     endbr64
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End of assembler dump.
```

→ **sempre pula**

Versão if-goto

```
int funcao(int edi, int esi) {
    int edx = 0;
    int eax = edi;
    goto compara;
    faz_algo:
        edx += edi;
        eax += 1;
    compara:
    if (eax-esi <= 0) {
        goto faz_algo;
    }
    return edx;
}
```

Versão legível

```
int funcao(int a, int b) {
    int res = 0;
    int i = a;
    while (i <= b) {
        res += a;
        i += 1;
    }
    return res;
}
```

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while

While version

```
while (Test)
  Body
```

Goto Version

```
  goto test;
loop:
  Body
test:
  if (Test)
    goto loop;
done:
```

while

```
long foo_while(long n) {
  long sum = 0;

  while (n > 0) {
    sum += n;
    n--;
  }

  sum *= sum;
  return sum;
}
```

```
long foo_while_gotoC(long n) {
  long sum = 0;

  goto test;

loop:
  sum += n;
  n--;

test:
  if (n > 0)
    goto loop;

  sum *= sum;
  return sum;
}
```

while

```
long foo_while_gotoC(long n) {
  long sum = 0;

  goto test;

loop:
  sum += n;
  n--;

test:
  if (n > 0)
    goto loop;

  sum *= sum;
  return sum;
}
```

```
0000000000000044 <foo_while_gotoC>:
  44:   mov    $0x0,%eax
  49:   jmp    52 <foo_while_gotoC+0xe>
  4b:   add    %rdi,%rax
  4e:   sub    $0x1,%rdi
  52:   test   %rdi,%rdi
  55:   jg     4b <foo_while_gotoC+0x7>
  57:   imul   %rax,%rax
  5b:   retq
```

while

```
long foo_while_gotoC(long n){
          long sum = 0;
          goto test;
  loop:   sum += n;
           n--;
  test:   if (n > 0)
               goto loop;
          sum *= sum;
          return sum;
}
```

```
0000000000000044 <foo_while_gotoC>:
  44:    mov    $0x0,%eax
  49:    jmp    52 <foo_while_gotoC+0xe>
  4b:    add    %rdi,%rax
  4e:    sub    $0x1,%rdi
  52:    test   %rdi,%rdi
  55:    jg     4b <foo_while_gotoC+0x7>
  57:    imul   %rax,%rax
  5b:    retq
```

while – Outra variação

While version

```
while (Test)
   Body
```

Goto Version

```
loop:
   if (!Test)
      goto done;

   Body
   goto loop;
done:
```

while – Outra variação

While version

```
while (Test)
   Body
```

Goto Version

```
loop:
   if (!Test)
      goto done;

   Body
   goto loop;
done:
```

Código em C:

```
while ( sum != 0 ) {
    <loop body>
}
```

Assembly

```
loop:   testq %rax, %rax
        je    done
        <loop body code>
        jmp   loop
done:
```

for

For Version

```
for (Init; Test; Update )
    Body
```

for

For Version

```
for (Init; Test; Update )
        Body
```

While Version

```
Init;
while (Test ) {
    Body
    Update;
}
```

for

```
long foo_for(long n) {
  long sum;

  for (sum = 0; n > 0; n--) {
    sum += n;
  }

  sum *= sum;
  return sum;
}
```

```
long foo_while(long n) {
  long sum = 0;

  while (n > 0) {
    sum += n;
    n--;
  }

  sum *= sum;
  return sum;
}
```

for

while

```
000000000000002c <foo_while>:
  2c:    mov    $0x0,%eax
  31:    jmp    3a <foo_while+0xe>
  33:    add    %rdi,%rax
  36:    sub    $0x1,%rdi
  3a:    test   %rdi,%rdi
  3d:    jg     33 <foo_while+0x7>
  3f:    imul   %rax,%rax
  43:    retq
```

for

```
00000000000000a0 <foo_for>:
  a0:    mov    $0x0,%eax
  a5:    jmp    ae <foo_for+0xe>
  a7:    add    %rdi,%rax
  aa:    sub    $0x1,%rdi
  ae:    test   %rdi,%rdi
  b1:    jg     a7 <foo_for+0x7>
  b3:    imul   %rax,%rax
  b7:    retq
```

Atividade prática

Loops (20 minutos)

1. Identificar saltos condicionais em ciclos
2. Reconstruir um loop a partir de um programa com if-goto.

Resposta atividade prática (exercício 1 a 6)

```
Dump of assembler code for function soma_2n:
   0x066a <+0>:     mov    $0x1,%eax
   0x066f <+5>:     jmp    0x676 <soma_2n+12>
   0x0671 <+7>:     shr    %edi
   0x0673 <+9>:     add    $0x1,%eax
   0x0676 <+12>:    cmp    $0x1,%edi
   0x0679 <+15>:    ja     0x671 <soma_2n+7>
   0x067b <+17>:    repz retq
```

Resposta – setas e comparação

```
Dump of assembler code for function soma_2n:
   0x066a <+0>:     mov    $0x1,%eax
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```

Registrador	**tipo**	**identificador**
%edi	int	a
%eax	int	res

Resposta – setas e comparação

```
Dump of assembler code for function soma_2n:
   0x066a <+0>:     mov    $0x1,%eax
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```

→ **sempre pula**

Registrador	**tipo**	**identificador**
%edi	int	a
%eax	int	res

Expressão

```
cmp     $0x1,%edi
ja      0x671 <soma_2n+7>
```

a - 1 > 0
a > 1

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Resposta – versão gotoC

```
Dump of assembler code for function soma_2n:
   0x066a <+0>:     mov    $0x1,%eax
   0x066f <+5>:     jmp    0x676 <soma_2n+12>
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   0x0676 <+12>:    cmp    $0x1,%edi
   0x0679 <+15>:    ja     0x671 <soma_2n+7>
   0x067b <+17>:    repz retq
```

```
int soma_2n(unsigned int a) {
    int res = 1;
    goto verifica;

    faz_algo:
    a = a >> 1;
    res += 1;

    verifica:
    if (a > 1) {
        goto faz_algo;
    }

    return res;
}
```

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Resposta – versão C

```
Dump of assembler code for function soma_2n:
   0x066a <+0>:     mov    $0x1,%eax
   0x066f <+5>:     jmp    0x676 <soma_2n+12>
   0x0671 <+7>:     shr    %edi
   0x0673 <+9>:     add    $0x1,%eax
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   0x067b <+17>:    repz retq
```

```
int soma_2n(unsigned int a) {
    int res = 1;
    goto verifica;

    faz_algo:
    a = a >> 1;
    res += 1;

    verifica:
    if (a > 1) {
        goto faz_algo;
    }

    return res;
}
```

Versão C legível

```
int soma_2n(unsigned int a) {
    int res = 1;
    while (a > 1) {
        a = a/2;
        res++;
    }

    return res;
}
```

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Atividade prática

Loops (para entrega)

1. Reconstruir um loop a partir de um programa com if-goto.
2. Identificar corretamente estruturas de controle aninhadas (loop + condicional)

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