

Sistemas Hardware-Software

Aula 07 – Loops

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O par de comandos **if-goto**

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`:

```
0x000000000000001149 <+0>:      endbr64
0x00000000000000114d <+4>:      mov     %edi,%eax
0x00000000000000114f <+6>:      mov     $0x0,%edx
0x000000000000001154 <+11>:     jmp     0x115b <funcao+18>
0x000000000000001156 <+13>:     add     %edi,%edx
0x000000000000001158 <+15>:     add     $0x1,%eax
0x00000000000000115b <+18>:     cmp     %esi,%eax
0x00000000000000115d <+20>:     jle     0x1156 <funcao+13>
0x00000000000000115f <+22>:     mov     %edx,%eax
0x000000000000001161 <+24>:     ret
```

End of assembler dump.

Exemplo – setas e comparação

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```
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0x000000000000001154 <+11>:     jmp     0x115b <funcao+18>
0x000000000000001156 <+13>:     add     %edi,%edx ←-----
0x000000000000001158 <+15>:     add     $0x1,%eax
0x00000000000000115b <+18>:     cmp     %esi,%eax
0x00000000000000115d <+20>:     jle     0x1156 <funcao+13> -----
0x00000000000000115f <+22>:     mov     %edx,%eax
0x000000000000001161 <+24>:     ret
```

End of assembler dump.

Exemplo – setas e comparação

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```
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0x000000000000014d <+4>:      mov     %edi,%eax
0x000000000000014f <+6>:      mov     $0x0,%edx
0x0000000000000154 <+11>:     - jmp     0x115b <funcao+18> → sempre pula
0x0000000000000156 <+13>:     add     %edi,%edx ←-----
0x0000000000000158 <+15>:     add     $0x1,%eax
0x000000000000015b <+18>:     -> cmp     %esi,%eax -----
0x000000000000015d <+20>:     jle     0x1156 <funcao+13> -
0x000000000000015f <+22>:     mov     %edx,%eax
0x0000000000000161 <+24>:     ret
```

End of assembler dump.

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;
}
```


Exemplo – setas e comparação

Dump of assembler code for function `funcao`:

```
0x0000000000000149 <+0>:      endbr64
0x000000000000014d <+4>:      mov     %edi,%eax
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0x0000000000000154 <+11>:     - jmp     0x115b <funcao+18> → sempre pula
0x0000000000000156 <+13>:     add     %edi,%edx ←-----
0x0000000000000158 <+15>:     add     $0x1,%eax
0x000000000000015b <+18>:     - cmp     %esi,%eax
0x000000000000015d <+20>:     jle     0x1156 <funcao+13> -----
0x000000000000015f <+22>:     mov     %edx,%eax
0x0000000000000161 <+24>:     ret
```

End of assembler dump.

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;
}
```

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_goto_1(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_goto_1(long n) {  
    long sum = 0;
```

```
    goto test;
```

```
loop:
```

```
    sum += n;
```

```
    n--;
```

```
test:
```

```
    if (n > 0)
```

```
        goto loop;
```

```
    sum *= sum;
```

```
    return sum;
```

```
}
```

```
000000000000000044 <foo_while_goto_1>:
```

```
44:    mov    $0x0,%eax
```

```
49:    jmp    52 <foo_while_goto_1+0xe>
```

```
4b:    add    %rdi,%rax
```

```
4e:    sub    $0x1,%rdi
```

```
52:    test   %rdi,%rdi
```

```
55:    jg     4b <foo_while_goto_1+0x7>
```

```
57:    imul   %rax,%rax
```

```
5b:    retq
```

while

```
long foo_while_goto_1(long n){ 000000000000000044 <foo_while_goto_1>:
    long sum = 0;              44:    mov    $0x0,%eax
    goto test;                 49:    jmp    52 <foo_while_goto_1+0xe>
loop:    sum += n;              4b:    add    %rdi,%rax
        n--;                  4e:    sub    $0x1,%rdi
test:    if (n > 0)             52:    test   %rdi,%rdi
        goto loop;            55:    jg     4b <foo_while_goto_1+0x7>
    sum *= sum;                57:    imul   %rax,%rax
    return sum;                5b:    retq
}
```

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

```
00000000000000002c <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

```
0000000000000000a0 <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.

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)

Exercício 1

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
```

Exercício 1 – setas e comparação

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
```

```
graph TD
    0x066f --> 0x676
    0x0679 --> 0x671
    0x0671 --> 0x0676
```

Registrador	tipo	identificador
%edi	int	a
%eax	int	res

Exercício 1 – setas e comparação

Dump of assembler code for function soma_2n:

```
0x066a <+0>:      mov     $0x1,%eax
0x066f <+5>:      -jmp     0x676 <soma_2n+12> → sempre pula
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
```

Registrador	tipo	identificador
%edi	int	a
%eax	int	res

Expressão

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

$a - 1 > 0$
 $a > 1$

Exercício 1 – versão if-goto

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
```

```
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;
}
```


Exercício 1 – 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
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;
}
```

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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