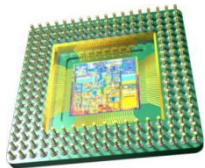


# Sistemas de Microprocessadores (DEEC)

## Arquitectura de Computadores (DEI)



### *Aulas de Laboratório*



# Etapas de Compilação

**código fonte**

```
void main() {  
    int a=1,b=2,c;  
  
    c=a+b;  
}
```

**main.c**

**Pré-  
Processamento**

**código fonte  
pré-processado**

**Compilação**

**código  
Assembly**

**main.s**

**Assembling**

**gcc main.c -o main**

**.c , .s** : ficheiro ASCII (editável)  
**.o , .exe** : ficheiro binário (não editável)

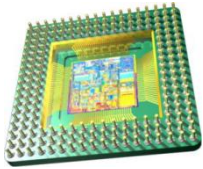
**main.exe**

**código executável**

**Linking**

**main.o**

**código objecto**



# Etapas de compilação: Pré-Processam.

```
void main() {  
    int a=1,b=2,c;  
  
    c=a+b;  
}
```

**main.c**

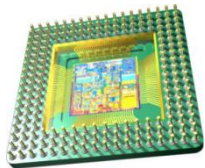
As linguagens de alto nível  
são independentes da  
arquitetura e do SO.

Pré-processamento

gcc -E main.c

```
# 1 "main.c"  
# 1 "<built-in>"  
# 1 "<command-line>"  
# 1 "main.c"  
void main()  
{  
    int a=1, b=2, c;  
    c=a+b;  
}
```

Pré-processamento de directivas  
de compilação (ex. `#include`,  
`#define`, etc.).



# Etapas de compilação: Compilação

```
void main(){  
    int a=1,b=2,c;  
  
    c=a+b;  
}
```

**main.c**

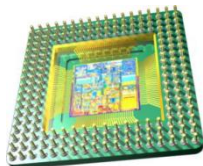
As linguagens de alto nível são independentes da arquitectura e do SO.

Compilação  
gcc -S main.c

```
.file      1 "main.c"  
.section   .mdebug.abi32  
.previous  
.abicalls  
.text  
.align     2  
.globl     main  
.ent       main  
.type      main, @function  
main:  
.frame     $fp, 32, $31  
.mask      0x40000000,-8  
.fmask     0x00000000,0  
.set       noreorder  
.set       nomacro  
addiu      $sp,$sp,-32  
sw         $fp,24($sp)  
move       $fp,$sp  
li         $2,1  
sw         $2,16($fp)      #0x1  
li         $2,2  
sw         $2,12($fp)      #0x2  
lw         $3,16($fp)  
lw         $2,12($fp)  
nop  
addu       $2,$3,$2  
sw         $2,8($fp)  
move       $sp,$fp  
lw         $fp,24($sp)  
addiu      $sp,$sp,32  
j          $31  
nop  
  
.set       macro  
.set       reorder  
.end       main  
.ident     "GCC: (GNU) 4.1.2 20061115"
```

**main.s**

A linguagem Assembly depende da arquitectura do computador (ex. MIPS).



# Etapas de compilação: Assembling

```
.file "main.c"
.text
.globl main
.type main, @function
main:
.LFB0:
.cfi_startproc
pushq %rbp
.cfi_def_cfa_offset 16
movq %rsp, %rbp
.cfi_offset 6, -16
.cfi_def_cfa_register 6
movl -8(%rbp), %eax
movl -4(%rbp), %edx
leal (%rdx,%rax), %eax
movl %eax, -12(%rbp)
leave
ret
.cfi_endproc
.LFE0:
.size      main, .-main
.ident     "GCC: (Ubuntu 4.4.3-4ubuntu5)"
.section .note.GNU-stack,"",@progbits
```

**main.s**

A linguagem Assembly  
depende da arquitectura do  
computador (ex. MIPS).

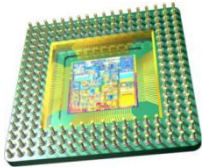
Assembling

gcc main.s -o main

```
00000000 fc 31 c0 8e c0 8e d8 8e d0 bc 00 7c 89 e6 bf 00
00000010 06 b9 00 01 f3 a5 89 fd b1 08 f3 ab fe 45 f2 e9
00000020 00 8a f6 46 bb 20 75 08 84 d2 78 07 80 4e bb 40
00000030 8a 56 ba 88 56 00 e8 fc 00 52 bb c2 07 31 d2 88
00000040 6f fc 0f a3 56 bb 73 19 8a 07 bf 87 07 b1 03 f2
00000050 ae 74 0e b1 0b f2 ae 83 c7 09 8a 0d 01 cf e8 c5
00000060 00 42 80 c3 10 73 d8 58 2c 7f 3a 06 75 04 72 05
00000070 48 74 0d 30 c0 04 b0 88 46 b8 bf b2 07 e8 a6 00
00000080 be 7b 07 e8 b2 00 8a 56 b9 4e e8 8e 00 eb 05 b0
00000090 07 e8 b0 00 30 e4 cd 1a 89 d7 03 7e bc b4 01 cd
000000a0 16 75 0d 30 e4 cd 1a 39 fa 72 f2 8a 46 b9 eb 16
000000b0 30 e4 cd 16 88 e0 3c 1c 74 f1 2c 3b 3c 04 76 06
000000c0 2c c7 3c 04 77 c9 98 0f a3 46 0c 73 c2 88 46 b9
000000d0 be 00 08 8a 14 89 f3 3c 04 9c 74 0a c0 e0 04 05
000000e0 be 07 93 c6 07 80 53 f6 46 bb 40 75 08 bb 00 06
000000f0 b4 03 e8 59 00 5e 9d 75 06 8a 56 b8 80 ea 30 bb
00000100 00 7c b4 02 e8 47 00 72 86 81 bf fe 01 55 aa 0f
00000110 85 7c ff be 85 07 e8 19 00 ff e3 b0 46 e8 24 00
00000120 b0 31 00 d0 eb 17 0f ab 56 0c be 78 07 e8 eb ff
00000130 89 fe e8 03 00 be 85 07 ac a8 80 75 05 e8 04 00
00000140 eb f6 24 7f 53 bb 07 00 b4 0e cd 10 5b c3 8a 74
00000150 01 8b 4c 02 b0 01 56 89 e7 f6 46 bb 80 74 13 66
00000160 6a 00 66 ff 74 08 06 53 6a 01 6a 10 89 e6 48 80
00000170 cc 40 cd 13 89 fc 5e c3 20 20 a0 0a 44 65 66 61
00000180 75 6c 74 3a a0 0d 8a 00 05 0f 01 06 07 0b 0c 0e
00000190 83 a5 a6 a9 0d 0c 0b 0a 09 08 0a 0e 11 10 01 3f
000001a0 bf 44 4f d3 4c 69 6e 75 f8 46 72 65 65 42 53 c4
000001b0 66 bb 44 72 69 76 65 20 00 00 80 8f b6 00 00 00
000001c0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

**main**

Programa executável: cada  
instrução em código máquina (ex.  
código de 32 bits no MIPS).



# Compilação Incremental

```
#include "soma.h"

int main(){
  int a,b,c;

  c=soma(a,b);
  return c;
}
```

**main.c**

```
int soma(int a, int b)
{ return a+b; }
```

**soma.c (+ soma.h)**

Compilação + Assembling  
gcc -c main.c

**main.o**

61

62 00000005 66B802000000  
63 0000000B 66BB01000000  
64 00000011 6601D8

65

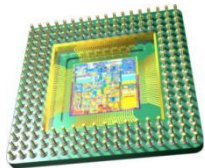
66

Compilação + Assembling  
gcc -c soma.c

**soma.o**

Código objecto/máquina:

- Instruções codificadas em "opcodes";
- Alguns endereços por resolver; só depois de tudo ligado é que sabemos onde fica.



# Etapas de compilação: Linking

main.o

soma.o

Linking

gcc main.o soma.o -o main

código objecto

61

62 00000005 66B802000000

63 0000000B 66BB01000000

64 00000011 6601D8

65

66

```
00000000 fc 31 c0 8e c0 8e d8 8e d0 bc 00 7c 89 e6 bf 00
00000010 06 b9 00 01 f3 a5 89 fd b1 08 f3 ab fe 45 f2 e9
00000020 00 8a f6 46 bb 20 75 08 84 d2 78 07 80 4e bb 40
00000030 8a 56 ba 88 56 00 e8 fc 00 52 bb c2 07 31 d2 88
00000040 6f fc 0f a3 56 bb 73 19 8a 07 bf 87 07 b1 03 f2
00000050 ae 74 0e b1 0b f2 ae 83 c7 09 8a 0d 01 cf e8 c5
00000060 00 42 80 c3 10 73 d8 58 2c 7f 3a 06 75 04 72 05
00000070 48 74 0d 30 c0 04 b0 88 46 b8 bf b2 07 e8 a6 00
00000080 be 7b 07 e8 b2 00 8a 56 b9 4e e8 8e 00 eb 05 b0
00000090 07 e8 b0 00 30 e4 cd 1a 89 d7 03 7e bc b4 01 cd
000000a0 16 75 0d 30 e4 cd 1a 39 fa 72 f2 8a 46 b9 eb 16
000000b0 30 e4 cd 16 88 e0 3c 1c 74 f1 2c 3b 3c 04 76 06
000000c0 2c c7 3c 04 77 c9 98 0f a3 46 0c 73 c2 88 46 b9
000000d0 be 00 08 8a 14 89 f3 3c 04 9c 74 0a c0 e0 04 05
000000e0 be 07 93 c6 07 80 53 f6 46 bb 40 75 08 bb 00 06
000000f0 b4 03 e8 59 00 5e 9d 75 06 8a 56 b8 80 ea 30 bb
00000100 00 7c b4 02 e8 47 00 72 86 81 bf fe 01 55 aa 0f
00000110 85 7c ff be 85 07 e8 19 00 ff e3 b0 46 e8 24 00
00000120 b0 31 00 d0 eb 17 0f ab 56 0c be 78 07 e8 eb ff
00000130 89 fe e8 03 00 be 85 07 ac a8 80 75 05 e8 04 00
00000140 eb f6 24 7f 53 bb 07 00 b4 0e cd 10 5b c3 8a 74
00000150 01 8b 4c 02 b0 01 56 89 e7 f6 46 bb 80 74 13 66
00000160 6a 00 66 ff 74 08 06 53 6a 01 6a 10 89 e6 48 80
00000170 cc 40 cd 13 89 fc 5e c3 20 20 a0 0a 44 65 66 61
00000180 75 6c 74 3a a0 0d 8a 00 05 0f 01 06 07 0b 0c 0e
00000190 83 a5 a6 a9 0d 0c 0b 0a 09 08 0a 0e 11 10 01 3f
000001a0 bf 44 4f d3 4c 69 6e 75 f8 46 72 65 65 42 53 c4
000001b0 66 bb 44 72 69 76 65 20 00 00 80 8f b6 00 00 00
000001c0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

main

Programa executável: cada  
instrução em código máquina (ex.  
código de 32 bits no MIPS).