



Computer Science 50

Introduction to Computer Science I

Harvard College

Week 10

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Underneath the Hood

Software

- :: Pre-Processing
- :: Compiling
- :: Assembling
- :: Linking
- :: Executing

From Source Code to Object Code

source code

```
#include <stdio.h>

int
main(int argc, char *argv[])
{
    printf("hello, world\n");
}
```

compile

assembly code

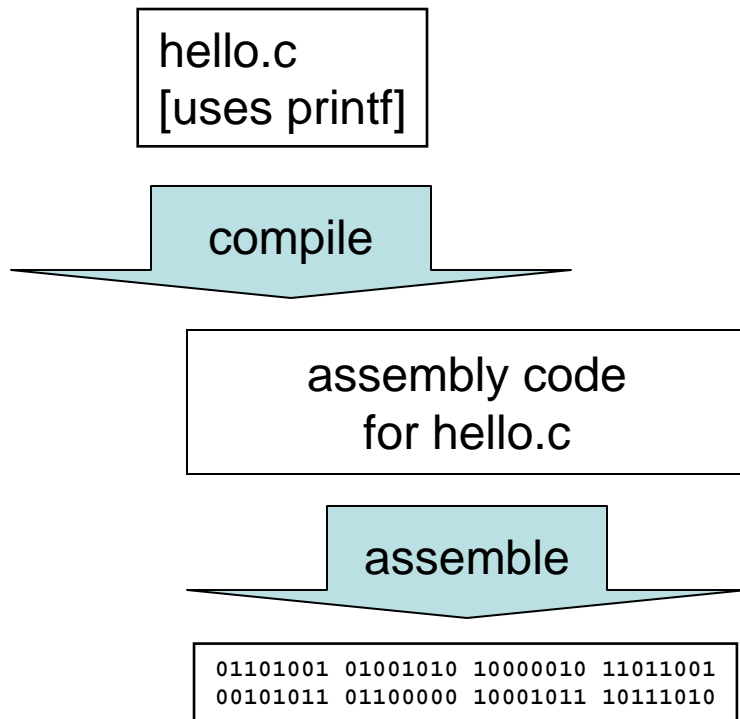
```
.file "hello.c"
.section .rodata
.LC0:
.string "hello, world\n"
.text
.globl main
.type main, @function
main:
pushl %ebp
movl %esp, %ebp
subl $8, %esp
andl $-16, %esp
movl $0, %eax
addl $15, %eax
addl $15, %eax
shrl $4, %eax
sall $4, %eax
subl %eax, %esp
subl $12, %esp
pushl $.LC0
call printf
addl $16, %esp
leave
ret
.size main, .-main
.section .note.GNU-stack,"",@progbits
.ident "GCC: (GNU) 3.4.6 20060404 (Red Hat 3.4.6-10)"
```

assemble

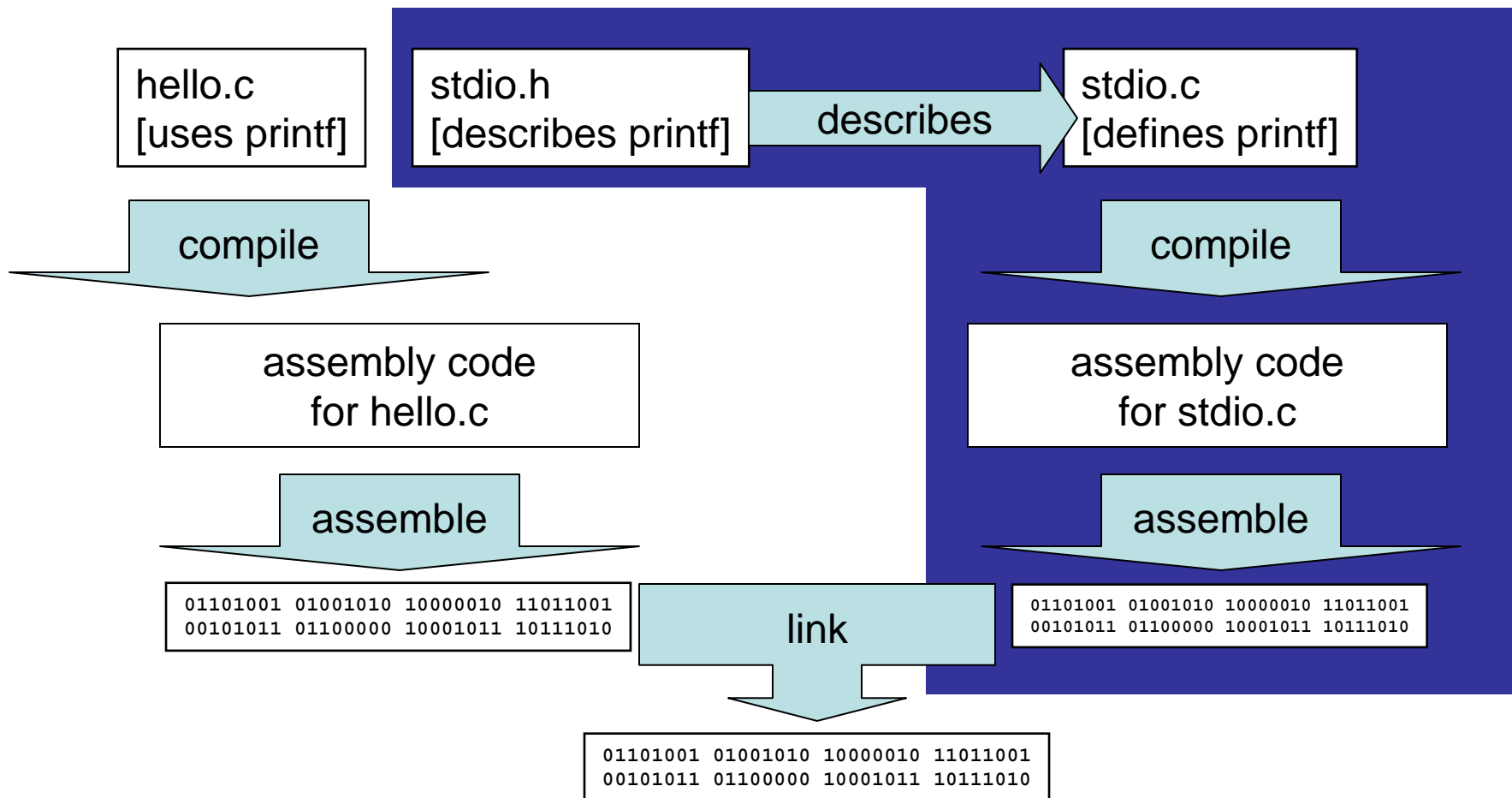
object code

```
01101001 01001010 10000010 11011001
00101011 01100000 10001011 10111010
```

Linking against Libraries

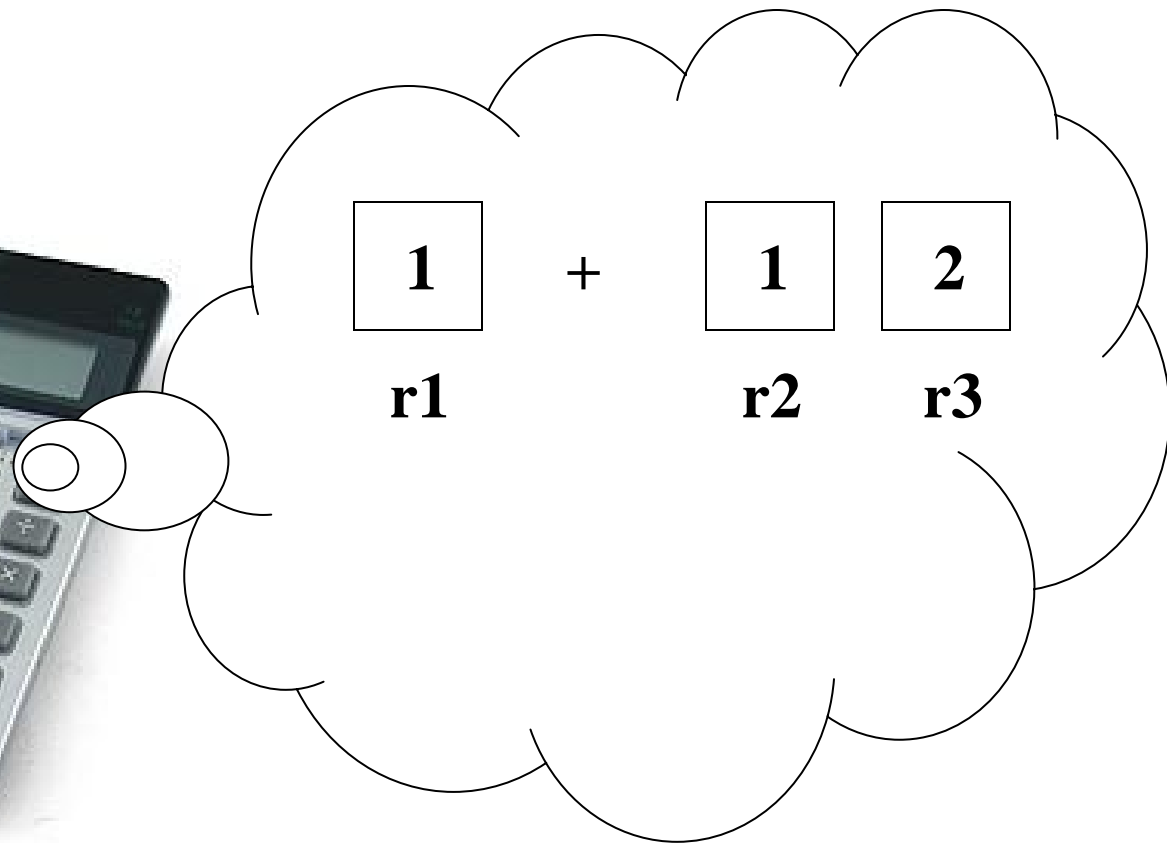


Linking against Libraries



Underneath the Hood

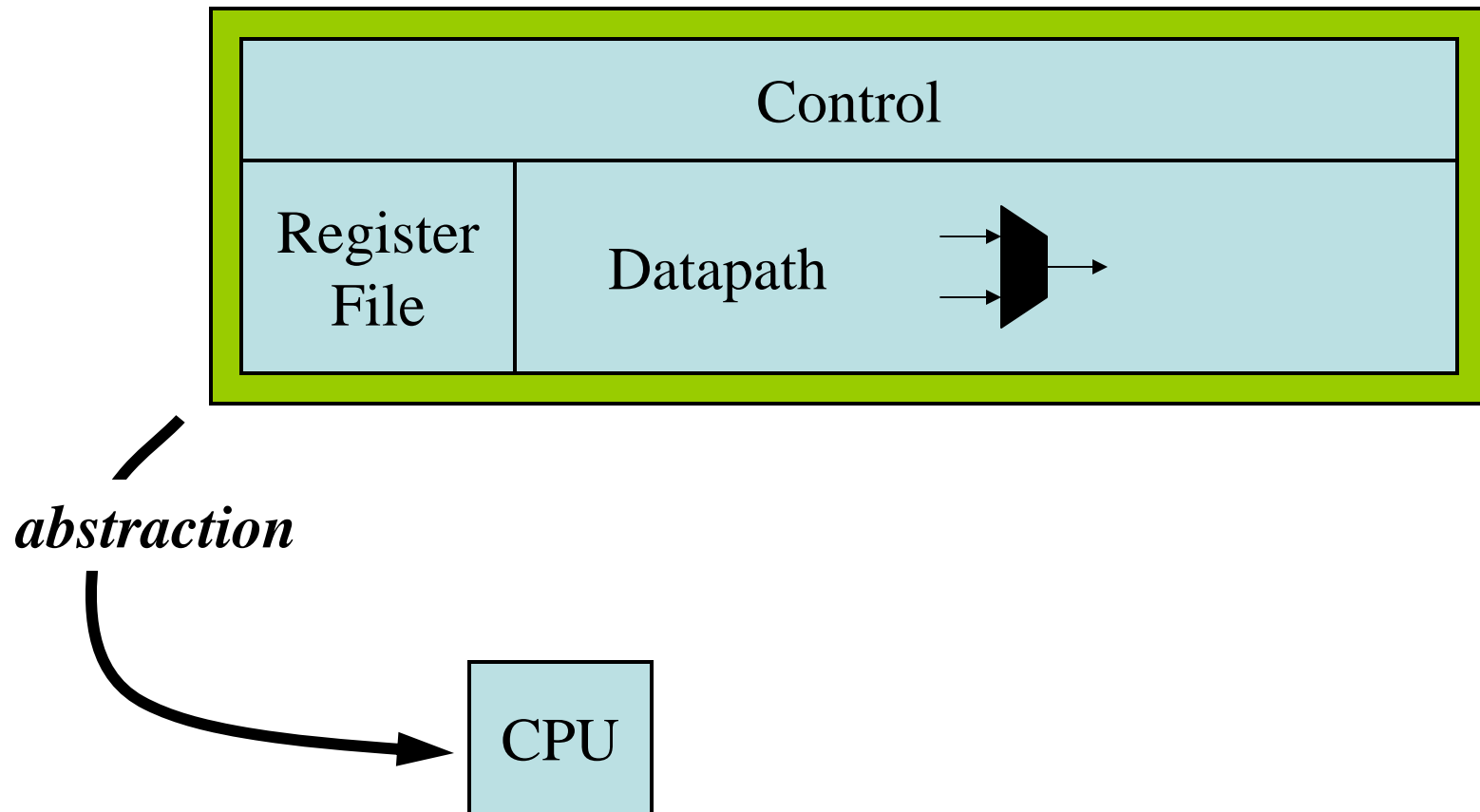
Hardware



What's in the Box?

- :: Registers
 - :: very fast temporary memory
 - :: few of them (16 or 32)
- :: Program counter
 - :: special register for tracking the next instruction to execute
- :: Memory
 - :: storage for program code and data
- :: Control unit
 - :: translates instructions into commands for registers and datapath
- :: Datapath
 - :: carries out basic operations (arithmetic, logical)
- :: I/O devices
 - :: supports flow of data into and out of the machine

What's in the CPU?



What can a CPU do?

x86 Instruction Set

- :: `addl`
- :: `call`
- :: `leave`
- :: `movl`
- :: `pushl`
- :: `ret`
- :: `sall`
- :: `shrl`
- :: `subl`
- :: ...

What can a CPU do?

x86 Instruction Set

ADD - Arithmetic Addition

Usage: ADD dest,src

Modifies Flags: AF CF OF PF SF ZF

Adds "src" to "dest" and replacing the original contents of "dest". Both operands are binary.

operands	Clocks			Size Bytes
	286	386	486	
reg,reg	2	2	1	2
mem,reg	7	7	3	2-4
reg,mem	7	6	2	2-4
reg,immed	3	2	1	3-4
mem,immed	7	7	3	3-6
accum,immed	3	2	1	2-3



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