CS240 Laboratory 6
Disassembly and Reverse Engineering

Memory Layout

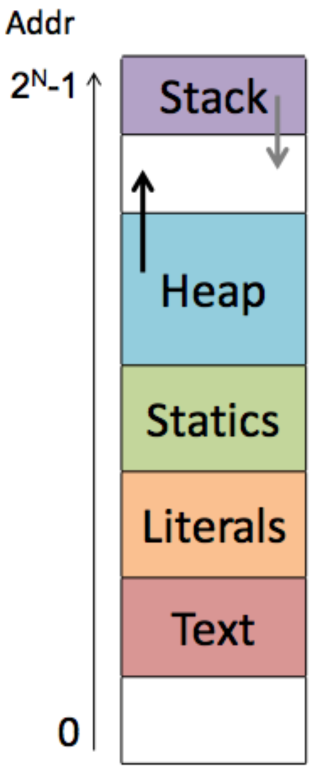
Kernel
above 0x7fffffff

Stack
below Ox7fffffff
grows down

Heap
above Data segment

Data segment
statics and literals

Text segment
starts at 0x400000



Perm	Contents	Managed by	Initialized
RW	Procedure context	Compiler	Run-time
RW	Dynamic data structures	Programmer, malloc/free, new/GC	Run-time
RW	Global variables/ static data structures	Compiler/ Assembler/Linker	Startup
R	String literals	Compiler/ Assembler/Linker	Startup
X	Instructions	Compiler/ Assembler/Linker	Startup

Instructions

Moving Data

mov Src,Dest

Note: the size of the data being referenced is often specified with an additional character:

b (byte)
w (2 bytes)
l (4 bytes), or
q (8 bytes).

Arithmetic/Logical operations – 2 operands

add *Src,Dest*
sub *Src,Dest*
imul *Src,Dest*

shr *Src,Dest*
sar *Src, Dest*
shl *Src,Dest*
sal *Src, Dest*
shr *Src,Dest*

xor *Src,Dest*
and *Src,Dest*
or *Src,Dest*

mul *Src,Dest*
imul *Src,Dest*
div *Src,Dest*
idiv *Src,Dest*

Arithmetic/Logical operations – 1 operand

inc *Dest*
del *Dest*
neg *Dest*
not *Dest*

Setting Condition Codes Explicitly – used for control flow

cmp *Src2,Src1* sets flags based on value of Src2 – Src1, discards result
test *Src2,Src1* sets flags based on a & b, discards result

Operand Types

Immediate $0x400, $-533

Register: %rax,%rbx,%rcx,%rdx,%rsi,%rdi,%rbp,%rsp,
%r8,%r9,%r10,%r11,%r12,%r13,%r14,%r15

some have special purpose: **%rsp** is stack pointer, **%rax** always used to return value from functions

Memory -0x18(%rsp)

Most General Form:

D(Rb,Ri,S) **Mem[Reg[Rb] + S*Reg[Ri] + D]**

D: Constant "displacement" value represented in 1, 2, or 4 bytes

Rb: Base register: Any register

Ri: Index register: Any except %esp (or %rsp if 64-bit) ; %ebp unlikely

S: Scale: 1, 2, 4, or 8 (*why these numbers?*)

Special Cases: can use any combination of D, Rb, Ri and S

(Rb,Ri)	**Mem[Reg[Rb]+Reg[Ri]]**	(S=1, D=0)
D(Rb,Ri)	**Mem[Reg[Rb]+Reg[Ri]+D]**	(S=1)
(Rb,Ri,S)	**Mem[Reg[Rb]+S*Reg[Ri]]**	(D=0)

Control Flow

Conditional jump instructions in X86 implement the following high-level constructs:

- if (condition) then {...} else {…}
- while (condition) {…}
- do {…} while (condition)
- for (initialization; condition; iterative) {...}

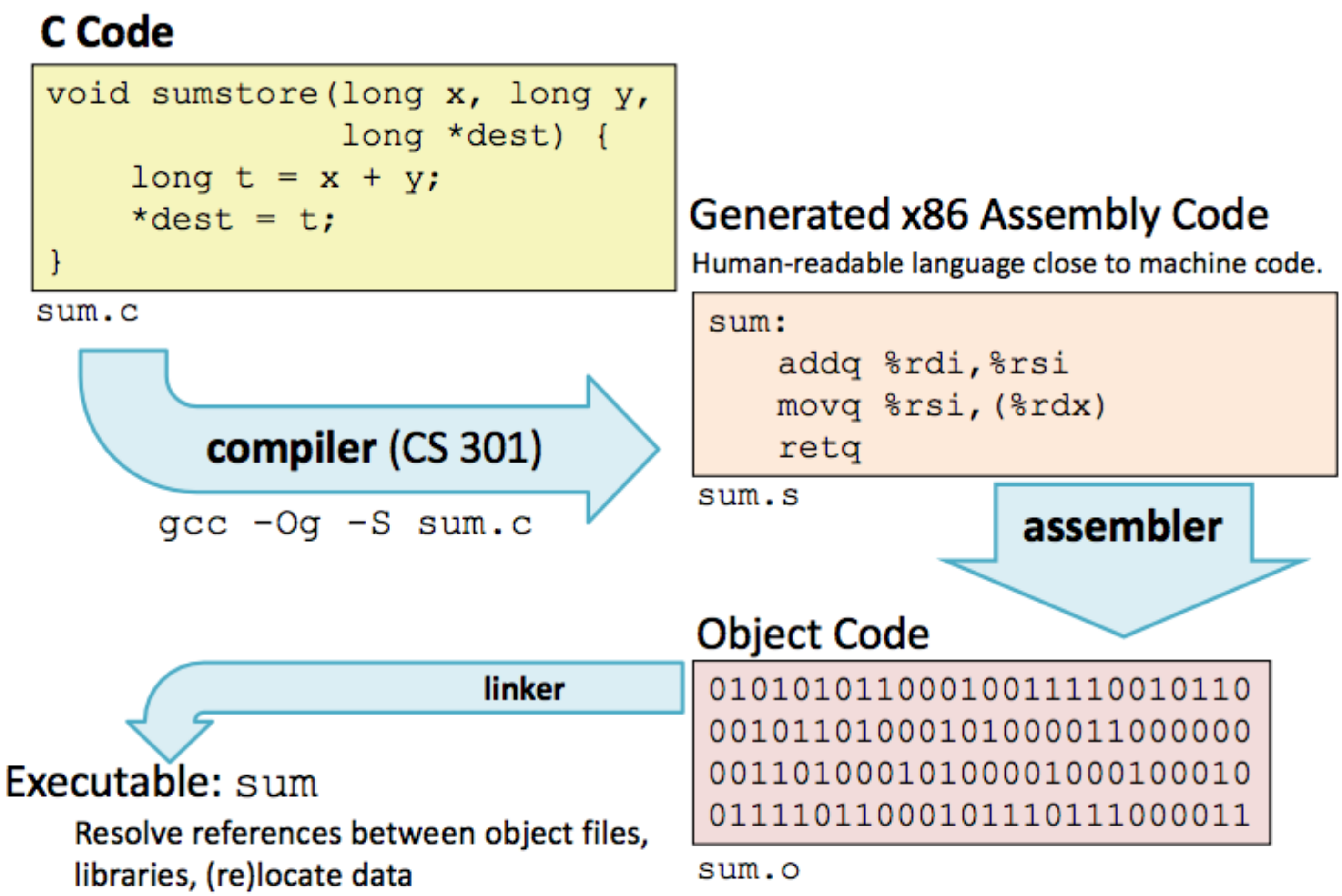
Unconditional jumps are used for high-level constructs such as:

- break
- continue

jX	Condition	Description
jmp	1	Unconditional
je	ZF	Equal / Zero
jne	~ZF	Not Equal / Not Zero
js	SF	Negative
jns	~SF	Nonnegative
jg	~(SF^OF)&~ZF	Greater (Signed)
jge	~(SF^OF)	Greater or Equal (Signed)
jl	(SF^OF)	Less (Signed)
jle	(SF^OF)|ZF	Less or Equal (Signed)
ja	~CF&~ZF	Above (unsigned)
jb	CF	Below (unsigned)

Jump instructions encode the offset from next instruction to destination PC, instead of the absolute address of the destination (makes it easier to relocate the code)

Turning C into Machine Code



- X86 instructions can be in different order from C code
- Some C expressions require multiple X86 instructions
- Some X86 instructions can cover multiple C expressions
- Compiler optimization can do some surprising things!
- Local or temporary variables can be stored in registers or on the stack

Function Calling Conventions

- Arguments for functions are stored in registers, in the following order: arg1 – arg6: %rdi,%rsi,%rdx,%rcx,%r8,%r9
- If there are more than 6 parameters for a function, the rest of the arguments are stored on the stack before the function is called
- Return value from function is always in %rax

The compiler will use only part of a register if the value stored there will fit in less than 64 bits (8 bytes). This is an optimization that makes instructions a bit shorter.

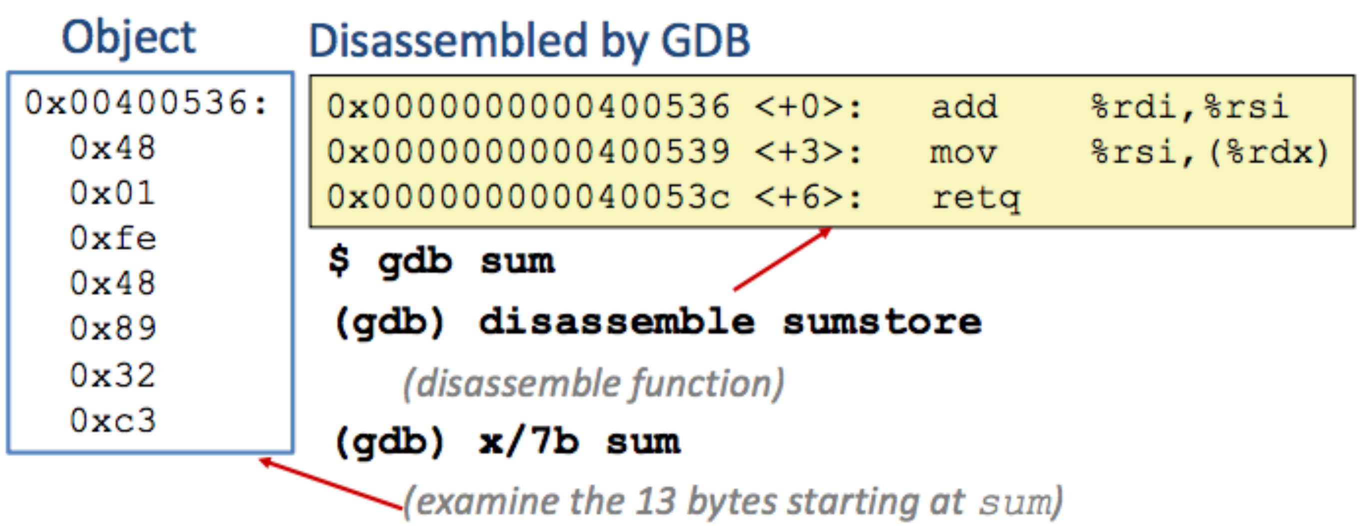
So, in the code, you may see register names of the following form, all of which refer to %rax:

%**r**ax = 8 byte value
%**e**ax = 4 byte value
%ax = 2 byte value
%al = 1 byte value

Tools

Tools can be used to examine bytes of object code (executable program) and reconstruct (reverse engineer) the assembly source.

gdb – disassembles an executable file into the associated assembly language representation, and provides tools for memory and register examination, single step execution, breakpoints, etc.



objdump

can also be used to disassemble and display information

$ *objdump –t p*

Prints out the program's symbol table. The symbol table includes the names of all functions and global variables, the names of all the functions the called, and their addresses.

$ *objdump -d p*

Object Code

```
0x401040 <sum>:
0x55
0x89
0xe5
0x8b
0x45
0x0c
0x03
0x45
0x08
0x89
0xec
0x5d
0xc3
```

Disassembled version

```
00401040 <_sum>:
 0:   55         push %ebp
 1:   89 e5      mov %esp,%ebp
 3:   8b 45 0c   mov 0xc(%ebp),%eax
 6:   03 45 08   add 0x8(%ebp),%eax
 9:   89 ec      mov %ebp,%esp
 b:   5d pop     %ebp
 c:   c3         ret
```

strings

$ *strings –t x p*

Displays the printable strings in your program.