Reverse Engineering 101

Take a peek under the hood!

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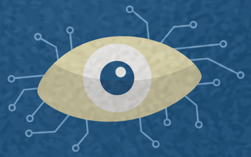
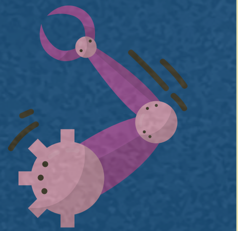
Live Demo

Reversing a compiled executable

INTRODUCTION

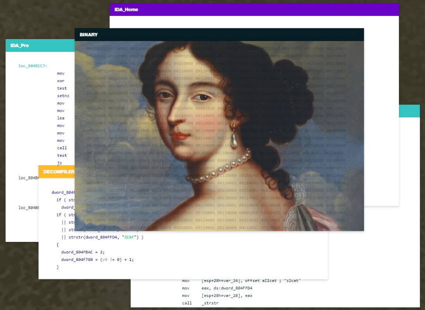
What is reverse engineering?





Reverse Engineering

- The process of analyzing the internals of a piece of software, to figure out how it does what it does
- Various processes and tools for doing so
  - Ghidra, IDA Pro, Radare, etc.
- Static and Dynamic Analysis



Compilers & ASM

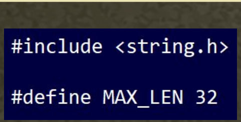
How do processors execute code? How do programming languages compile to executable code?

Compiled Languages

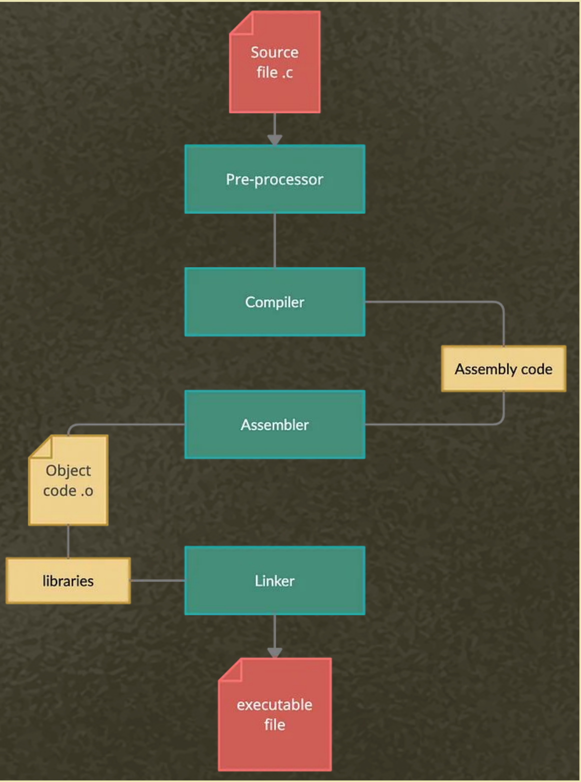
- Some high level languages are compiled into machine code
    - C, C++, Go, Rust
- Machine code is directly interpreted by the processor
    - EXE, DLL, OSX, ELF files contain machine code
- Machine code is composed of instructions that the processor executes
    - mul (multiply), add (add), mov (move), jmp (jump)
- The format and set of instructions is defined by the ISA
    - Instruction Set Architecture

How Does Compilation Work?

- Preprocessing
    - Stripping comments, preprocessor directives
- Compilation
    - AST construction, intermediate representation (IR)
- Assembly
    - From IR, to assembly, to machine code (object files)
- Linking
    - Stitching object files together, adding dynamic library entries

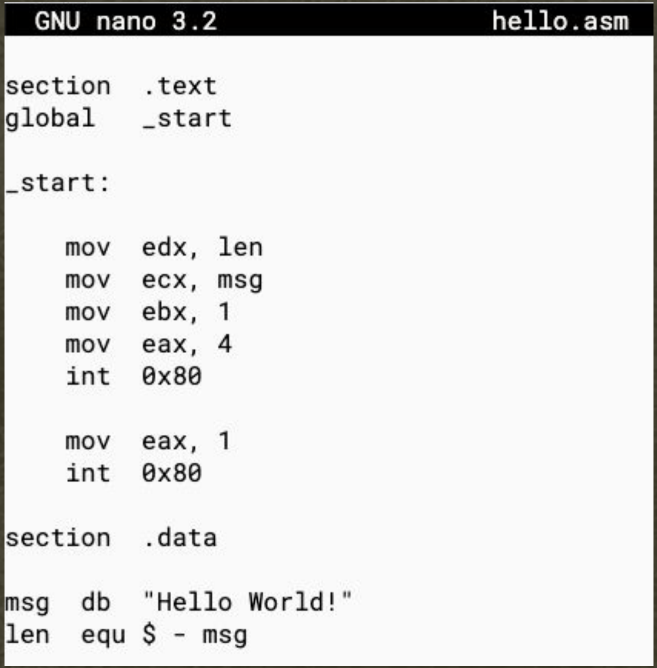


```
#include <string.h>

#define MAX_LEN 32
```



Assembly

- Machine code consists of non-human readable instructions
- Assembly is essentially human-readable machine code
  - An architecture-specific programming language
- x86, ARM, MIPS, RISC-V, etc.



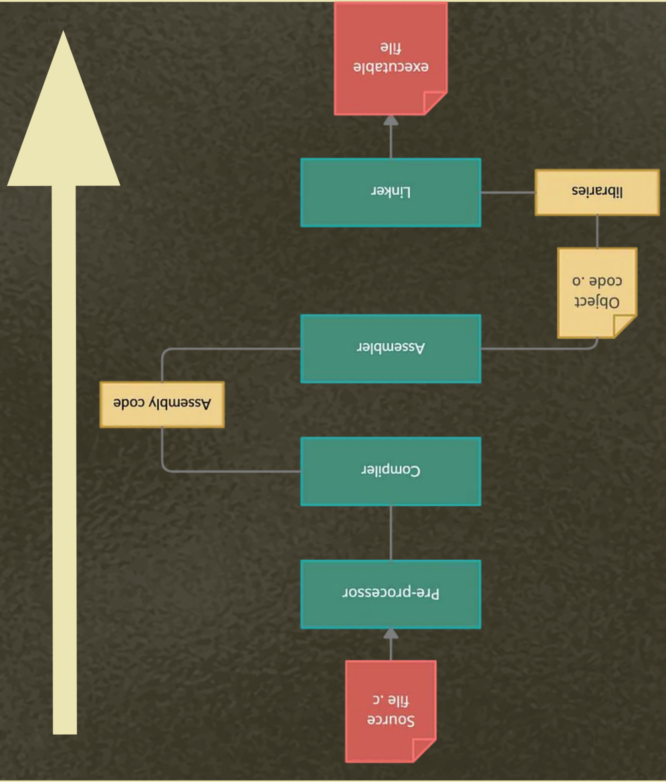
```
section   .text
global    _start

_start:

    mov   edx, len
    mov   ecx, msg
    mov   ebx, 1
    mov   eax, 4
    int   0x80

    mov   eax, 1
    int   0x80

section   .data

msg   db   "Hello World!"
len   equ $ - msg
```

Reversing Basics

How do we disassemble executables? Can we derive the original source code from a compiled executable?

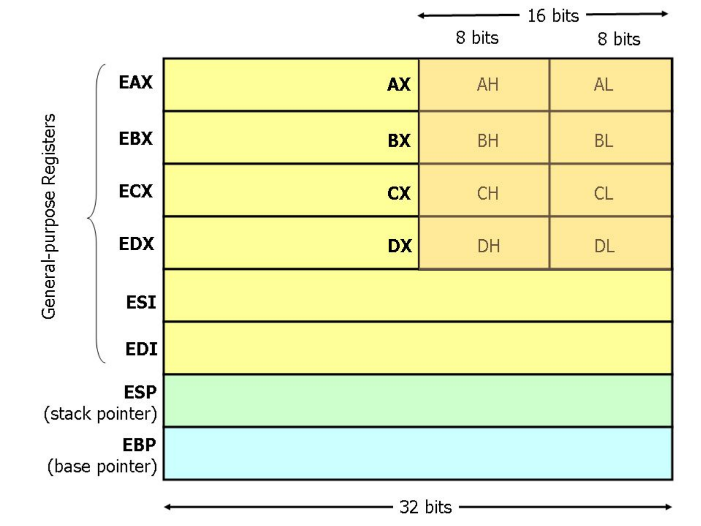
A 30,000 foot view

- Static Analysis
  - Disassembly
  - Decompilation
- Dynamic Analysis
  - Debugging (GDB)
  - System call tracing
  - Network activity tracing



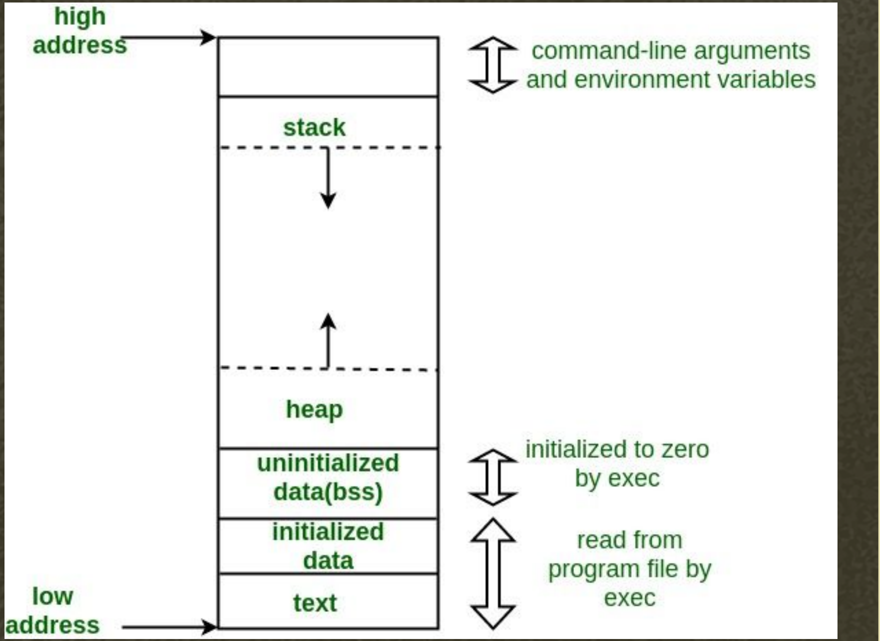
How to Read Assembly

- Registers
  - eax, ebx, ebp, esp (x86)
- Basic instructions and their operands
  - e.g. mul eax, ebx
- The C Calling Convention (cdecl)
  - How function calls are implemented in C
  - How accessing variables work
- Executable File Sections
  - What each section does and its properties
  - (for ELF) .text, .data, .bss, .rodata



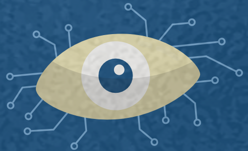
1 More Thing - The Stack

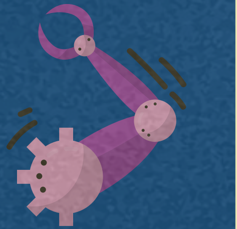
- Some memory space used primarily for:
  - Local variables
  - Passing function arguments
- Behaves like a stack
  - Push & Pop operations
- Grows into lower address space
  - RBP is higher than RSP

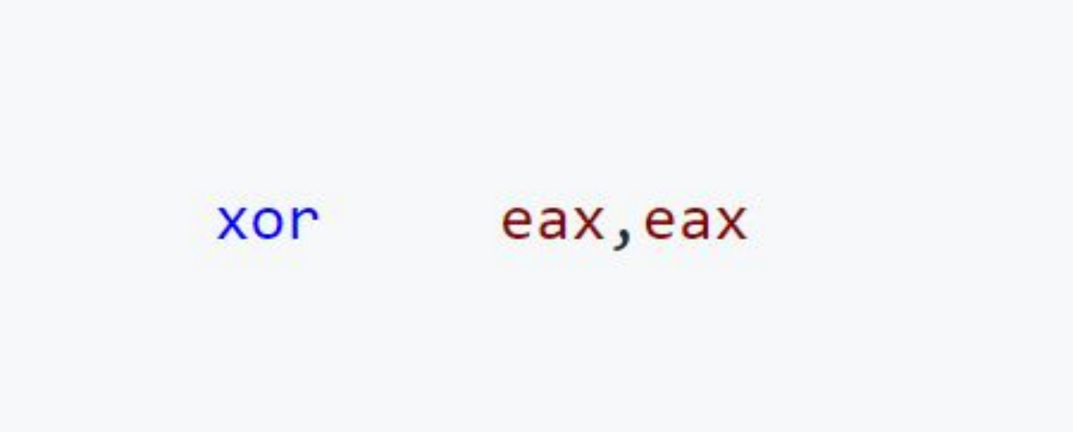

high address
command-line arguments and environment variables
stack
heap
uninitialized data(bss)
initialized to zero by exec
initialized data
read from program file by exec
text
low address

Memory layout of a program

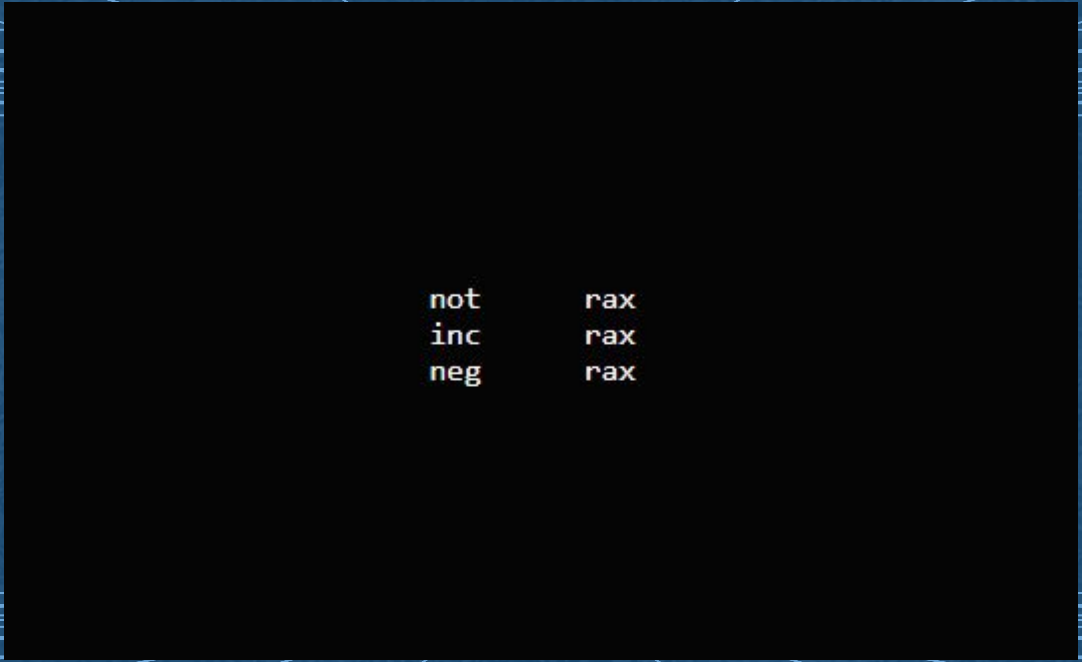
Reading ASM







```
xor     eax,eax
```



```
not     rax
inc     rax
neg     rax
```

xchng rax, rax

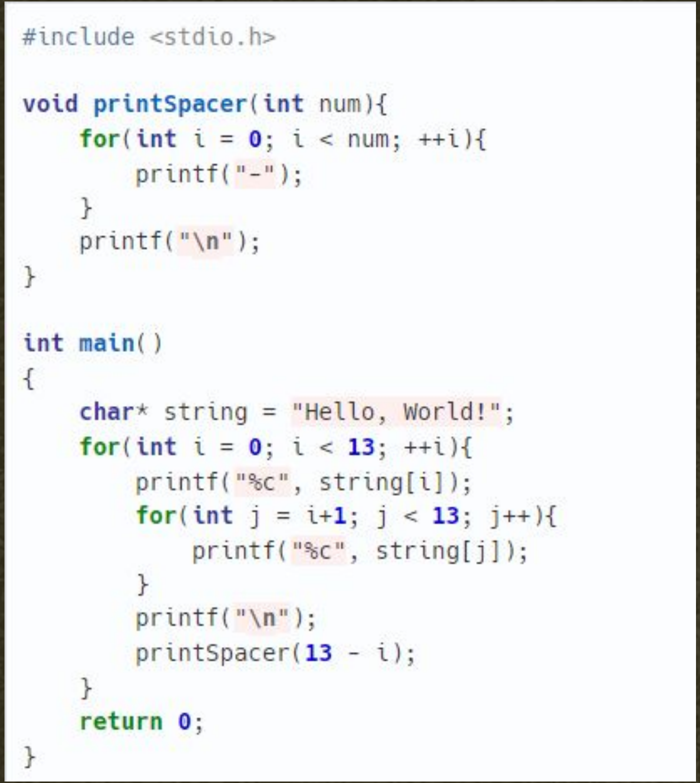
Translating C to ASM

- While loops, For loops
- Conditions
- Function Calls

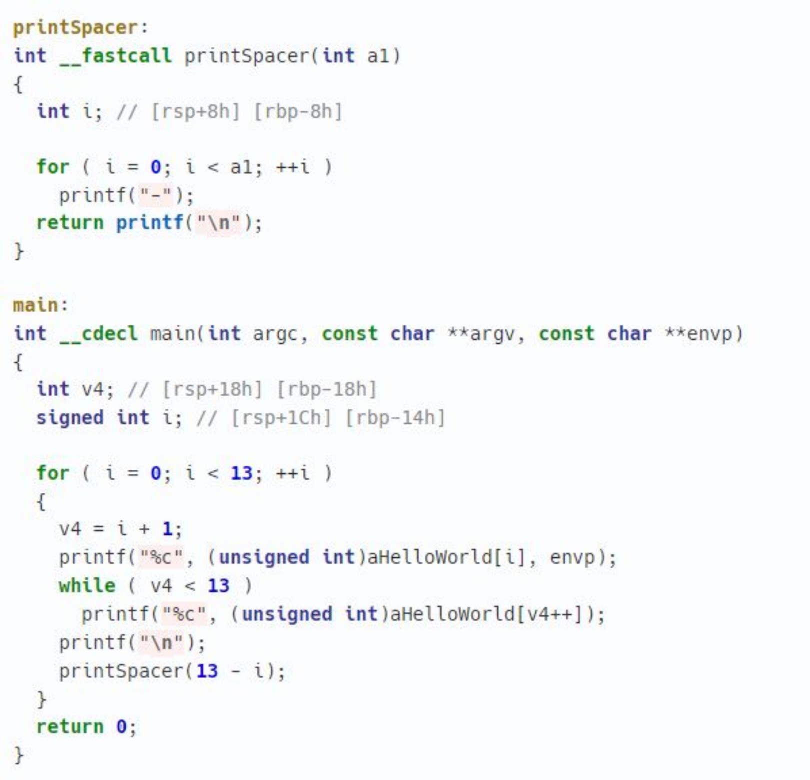
https://godbolt.org/

Decompilation

- Inverse operation of compilation - generating high level source code from a compiled binary
- Tools:
    - IDA Hex Rays
    - Ghidra
- Translation to high level pseudocode may not be 1-to-1
    - We’ll be taking a look at this



```c
#include <stdio.h>

void printSpacer(int num){
    for(int i = 0; i < num; ++i){
        printf("-");
    }
    printf("\n");
}

int main()
{
    char* string = "Hello, World!";
    for(int i = 0; i < 13; ++i){
        printf("%c", string[i]);
        for(int j = i+1; j < 13; j++){
            printf("%c", string[j]);
        }
        printf("\n");
        printSpacer(13 - i);
    }
    return 0;
}
```



```c
printSpacer:
int __fastcall printSpacer(int a1)
{
  int i; // [rsp+8h] [rbp-8h]

  for ( i = 0; i < a1; ++i )
    printf("-");
  return printf("\n");
}

main:
int __cdecl main(int argc, const char **argv, const char **envp)
{
  int v4; // [rsp+18h] [rbp-18h]
  signed int i; // [rsp+1Ch] [rbp-14h]

  for ( i = 0; i < 13; ++i )
  {
    v4 = i + 1;
    printf("%c", (unsigned int)aHelloWorld[i], envp);
    while ( v4 < 13 )
      printf("%c", (unsigned int)aHelloWorld[v4++]);
    printf("\n");
    printSpacer(13 - i);
  }
  return 0;
}
```

ctf101.org

What's The Point?

- Malware analysis
- Become a better developer
  - Understanding how programs may be vulnerable
- Embedded programming
- CTFs!
  - https://ctf.gdscutm.com/

Cool Applications

THANKS!

@gdscutm

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