SIGPwny

FA2024 Week 05 • 2024-10-03

Reverse Engineering I

Juniper

Announcements

- BRICS+ CTF Qualifer
  - Saturday 5 AM - Sunday 5 AM
  - Room TBD

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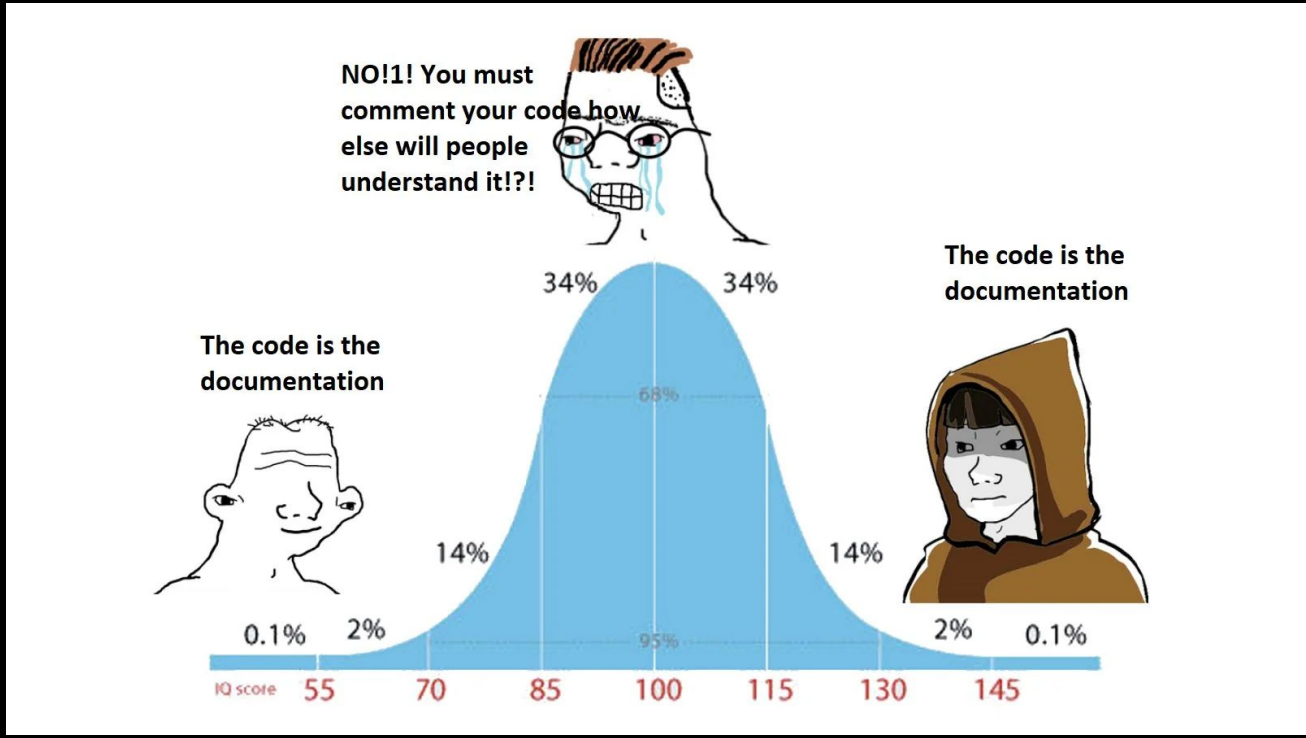


Which is easier to understand?

```python
def fibonacci(n):
    if n <= 0:
        return []
    elif n == 1:
        return [0]
    elif n == 2:
        return [0, 1]
    else:
        fib_sequence = [0, 1]
        while len(fib_sequence) < n:
            next_num = fib_sequence[-1] + fib_sequence[-2]
            fib_sequence.append(next_num)
        return fib_sequence
```

```python
def aaoaaaa04922(aa27619):
    aaoaaaoa20551 = -1
    aa276l9 = aa27619 + 1
    aa27618 = -aa27619
    if aa27618 > 0:
       return []
    elif not bool(aa276l9 - 2):
        return [] * aa27618
    elif aa27619 == 1:
        return [aa276l9-1]
    else:
        aaoaaaoa32021 = [0, 1]
        while True:
            if not (len(aaoaaaoa32021) < aa27619):
               break
            aaoaaaoa21049 = aaoaaaoa32021[-aaoaaaoa32021[1]]
            aaoaaaoa21049 += aaoaaaoa32021[aaoaaaoa20551**2 - 3]
            aaoaaaoa32021.append(aaoaaaoa21049)
        else:
            aaoaaa3322 = 23
            return [aaoaaa3322 + i for i in aaoaaaoa32021]
    return aaoaaaoa32021
```

Overview

- Basics
  - Motivation
  - Types of analysis
  - Abstraction levels
- Techniques
  - Common patterns
  - Tools
- Examples

Basics

What is reverse engineering?

Motivation

- Reverse engineering: reason about original meaning of code
- Goal is to understand the code
  - The code is never "wrong" — it is the ultimate "documentation"
- Not all code is easy to read or well-documented
- Sometimes code is intentionally hard to understand (i.e. obfuscated)

Static vs Dynamic Analysis

- Static Analysis
  - Reading code
  - Using tools to understand code

Most helpful if...
- Code is simple - Code is hard to run

- Dynamic Analysis
  - Running code
  - Inspecting program state as it is running

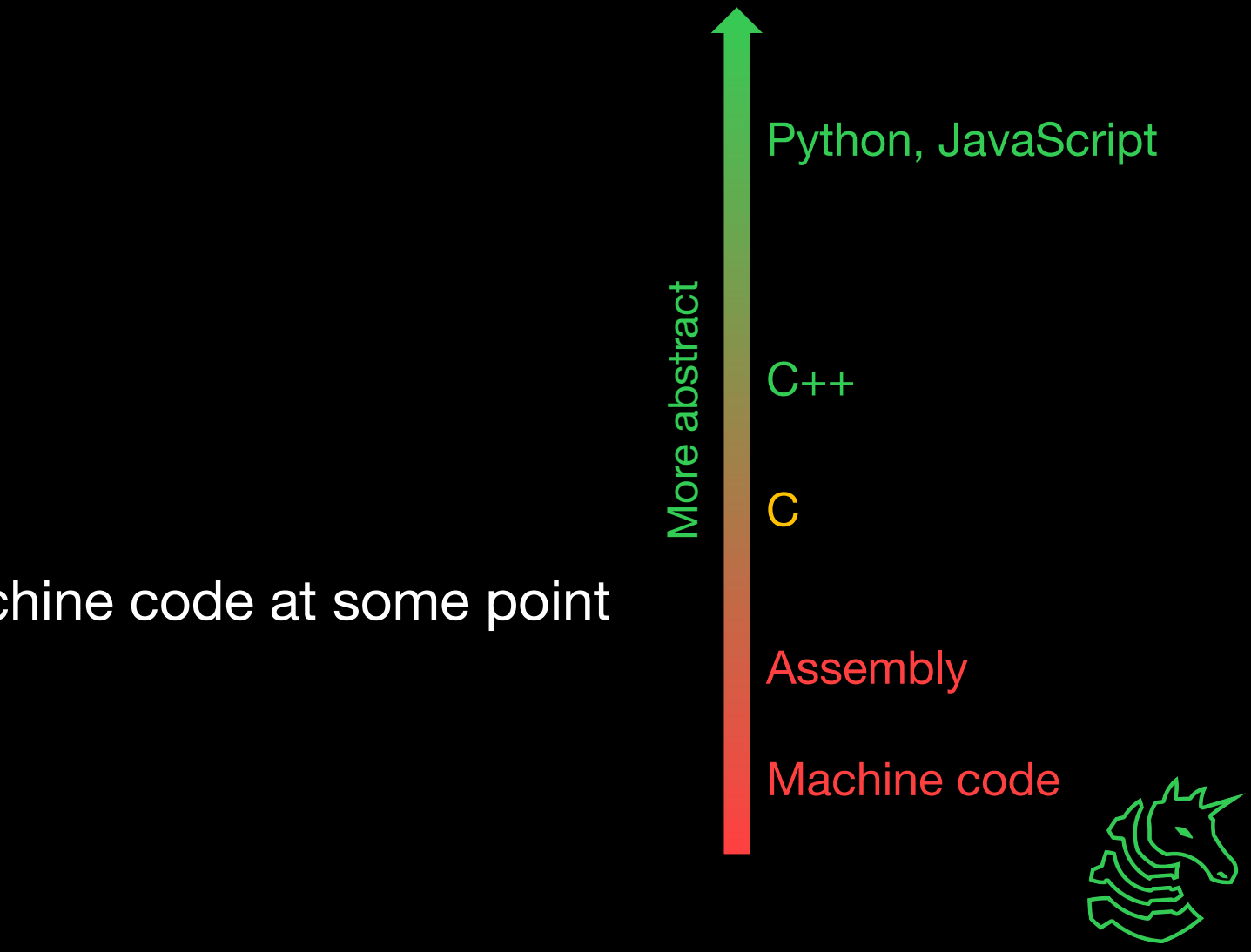
Most helpful if...
- Code is complex - Useful data in memory

Static and and dynamic analysis are not a dichotomy! Use them together!

Abstraction Levels

- High level
  - Python, JavaScript, etc.
  - Easy to analyze

- Low level
  - C, assembly, etc.
  - Hard to analyze
  - Everything is ran as machine code at some point



Example: Dynamic analysis

```
Give me a number: 4
4
Give me a number: 10
11
Give me a number: 0
2
Give me a number: -4
-1
Give me a number: 7
```

What is the next output?

What does the code look like?

The Code

```
i = 0
while True:
    val = int(input('Give me a number: '))
    i += 1
    print(val + i)
```

Making Assumptions

- Occam's razor: the simplest solution is often the right one
- But always remember that assumptions can be wrong

```
i = 0
while True:
    val = int(input('Give me a number: '))
    i += 1
    if i > 20:
        val = -val
    print(val + i)
```

What if the previous code looked like this?

Techniques

How to reverse engineer?

Static Analysis

- Function rewriting
  - Simplify complex portions of code
- Find known algorithms/patterns
- Decompilers
  - Automatically extract abstractions from low level programs
  - Turn assembly into more readable C
  - Will be covered in depth in Reverse Engineering II meeting

Example: Common patterns

```
arr = [0] * 10
i = 9
while i >= 0:
  arr[i] = i * 2
  i -= 1
```

Can you simplify this code?

Example: Common patterns

```
arr = [0] * 10
for i in range(9, 0 - 1, -1):
  arr[i] = i * 2
```

Simplify even more?

Example: Common patterns

```
arr = [0] * 10
for i in range(0, 10):
  arr[i] = i * 2
```

Even simpler?

Example: Common patterns

```
arr = [i*2 for i in range(0, 10)]
```

Example: Common patterns

Which level of simplification is the most useful?

```python
arr = [0] * 10
i = 9
while i >= 0:
  arr[i] = i * 2
  i -= 1
```

```python
arr = [0] * 10
for i in range(9, 0 - 1, -1):
  arr[i] = i * 2
```

```python
arr = [0] * 10
for i in range(0, 10):
  arr[i] = i * 2
```

```python
arr = [i*2 for i in range(0, 10)]
```

Dynamic Analysis

- Partial evaluation
  - Evaluate small portions of the code to reduce complexity

- Modifying programs
  - Add or remove code
  - Add print statements
  - "Patching" binaries

Advanced Dynamic Analysis

Will be covered in depth in Reverse Engineering II meeting

- Debuggers
  - `gdb`, `pdb`

- Side channels
  - Instruction counting, time counting

Examples

Goal: input flag to pass checks
(doesn't print "wrong")

```python
f = input('What is the flag? ')

va = [1751, 1649, 1836, 1734]
arr = ''.join([chr(va[len(va)-1-i]//17) for i in range(len(va))])

if f[0] != 'f':
    print("That's definitely wrong.")
else:
    it = len(arr)
    while it > 0:
        it -= 1
        if arr[it] != f[it]:
            print('Wrong flag!')
            exit(1)
```

User input

Rewriting: this is a backwards for loop

Don't want this to run

```python
f = input('What is the flag? ')

va = [1751, 1649, 1836, 1734]
arr = ''.join([chr(va[len(va)-1-i]//17) for i in range(len(va))])

if f[0] != 'f':
    print("That's definitely wrong.")
else:
    for it in range(len(arr)-1, -1, -1):
        if arr[it] != f[it]:
            print('Wrong flag!')
            exit(1)
```

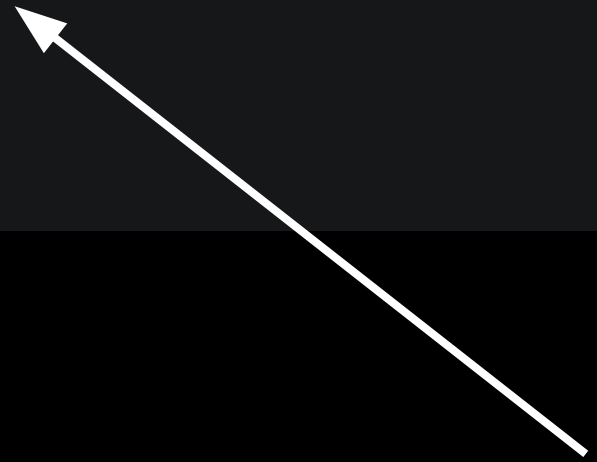
Two ways to solve: partial evaluation or patching

```python
f = input('What is the flag? ')

va = [1751, 1649, 1836, 1734]
arr = ''.join([chr(va[len(va)-1-i]//17) for i in range(len(va))])

print(arr)

if f[0] != 'f':
    print("That's definitely wrong.")
else:
    for it in range(len(arr)-1, -1, -1):
        if arr[it] != f[it]:
            print('Wrong flag!')
            exit(1)
```

One way: patching (adding print)

```
$ python3 test.py
What is the flag? aaaa
flag
That's definitely wrong.
```

```
$ python3
Python 3.11.5 (main, Aug 24 2023, 15:09:45) [Clang 14.0.3 (clang-
1403.0.22.14.1)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> va = [1751, 1649, 1836, 1734]
>>> arr = ''.join([chr(va[len(va)-1-i]//17) for i in range(len(va))])
>>> arr
'flag'
```



Second way: evaluate the portion in Python REPL

Go try challenges!

- Go to **ctf.sigpwny.com**
- Start with **Python RE 1: Easy rev**

- If you don't have Python installed, see slides from setup meeting (Intro to Terminal and Setup)

Next Meetings

2024-10-06 • This Sunday

- x86-64 Assembly
- Learn about low-level programming with Sam and Emma!

2024-10-10 • Next Thursday

- Reverse Engineering II
- Learn x86 reverse engineering with Nikhil!

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Meeting content can be found at sigpwny.com/meetings.

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