Lecture 34 - Last lecture before final review.

Videos

https://youtu.be/EEdrW-P7kXc - Lect-34-pt1-debuging.mp4
https://youtu.be/BQDaOq3x1cc - Lect-34-pt2-debuging.mp4
https://youtu.be/RFn-kSJbJOA - Lect-34-pt3-visualization.mp4
https://youtu.be/mJPUrVMQLkg - Lect-34-pt4-system-calls-web-debuging.mp4
https://youtu.be/EKEVAD8fq5M - Lect-34-2150-pt5-profiling.mp4

From Amazon S3 - for download (same as youtube videos)

http://uw-s20-2015.s3.amazonaws.com/Lect-34-pt1-debuging.mp4
http://uw-s20-2015.s3.amazonaws.com/Lect-34-pt2-debuging.mp4
http://uw-s20-2015.s3.amazonaws.com/Lect-34-pt3-visualization.mp4
http://uw-s20-2015.s3.amazonaws.com/Lect-34-pt4-system-calls-web-debuging.mp4
http://uw-s20-2015.s3.amazonaws.com/Lect-34-2150-pt5-profiling.mp4

Debugging and Profiling Code

So what is debuting - debuting is taking your code and making it do what you expect instead of why you put into the computer. Computers are the ultimate literalist. They do exactly what you tell them to do - no more and no less. You have an expectation that the code will do A, but you told the computer to do B. It will do B until you change the code. Debugging is the process of changing the code to get it to do A.

Old School

Hardware: Use a Logic Analyzer. Use a 7 segment display. Get output.

In Code: Use print statements.

Send data to a “log” file. Or Collect it for remote access later. Be able to turn-on/off the detail of this information.

Advantages:

1. It is simple.
2. It works on all sorts of environments.
3. It woks remotely.

4. You can look through the output multiple times.
5. It is permanent.
6. It leaves a ‘residual trace’ of the debugging effort.

Tricks:

Print out the file and line number. In C/C++:

```
	printf ( "Line No: %d\n", __LINE__ );
```

In Go I developed a package to do this:

```
import "pschlump/godebug"

...

func main() {
	fmt.Printf ( "Line: %s\n", godebug.LF())
}
```

In JavaScript (Node.js and front end):

```
// ln will return the line number that you are currently at - for debuging.
function ln() {
	var stack = stackTrace();
	var frameRE = /:(\d+):(?:\d+)[^\d]*$/;
	do {
		var frame = stack.shift();
	} while (!frameRE.exec(frame) && stack.length);
	return frameRE.exec(stack.shift())[1];
}

console.log ( "Line: ", ln())
```

In Python:

```
from inspect import currentframe

def get_linenumber():
    cf = currentframe()
    return cf.f_back.f_lineno

print "This is line 7, python says line ", get_linenumber()
```

Know when to flush the output! Normally output is buffered. If your program is dying in the middle - then you need to flush the output - wait for the output to occur before going on. In C:

```
flush(stdout);
```

In `C++` using `std::`

```
cout << std::flush;
```

There are similar capabilities in other languages.

Standard Log Files

Windows has a “logging facility” that I find really horrid. This is because the only way to access it is via a single GUI tool and it has no search!

Linux/Unix looks at it more like it is a file. Apache and Nginx log to files. Lots of other tools log to the standard system log. Usually you will need to take the log and do some data-manipulation to get to what you want in the log. To get the log you use the commands “log show” or “dmesg”. When I demoed a few lectures ago with VI on accessing a log I got the log via dmesg, then copied the file using scp. Look in /var/log for most log files.

There is a command for sending stuff to the system log from a shell script.

```
$ logger "Hello Logs"
```

On BSD based systems like MacOS

```
$ log show ——last 1m | grep Hello
```

On Linux/Unix and System V based Unix

```
# journalctl ——since "1m ago" | grep Hello
```

Debuggers - New School

Python has a “debuger” called pdb. C/Fortran/C++ you are looking at things like “gdb”. If you use a compiler based on llvm (XCode on a mac) then “lldb”. All of these allow you to access and manipulate a running program. I use all of them at one time or another. If you are working on the

Unix/Linux kernel - then look into using “adb”. “adb” is really scary - you can use it to debug a currently running kernel!

Let’s run ‘pdb’:

```
$ python3 -m pdb demo.py
```

Documentation on pdb: https://docs.python.org/3/library/pdb.html.

pdb is represenatative of debuggers - this is a quick overview of the commands.

C	Command	Description
q	quit	Exit debugger.
l	list	Displays 11 lines around the current line (PC) or continue the previous listing.
s	step	Execute 1 more line, stop at the first possible occasion.
n	next	Continue execution until the next line in the current function is reached or it returns.
b	break	Set a breakpoint - a breakpoint is a place to stop when you run.
p	print	Evaluate the expression in the current context and print its value.
r	return	Continue execution until the current function returns.

Tracing System Calls

Sometimes you need to poke into code that you did not create. There are specialized tools for this. One way is to look at the system calls that the code is using. dtrace(Linux) and strace(Mac) are good for this.

Linux

```
sudo strace -e lstat ls -l > /dev/null
```

On macOS

```
sudo dtruss -t lstat64_extended ls -l > /dev/null
```

Another way is to poke into what the network is doing.

Look at the network packets to figure out the issue in your program. Use tcpdump and Wireshark are network packet analyzers that let you read the contents of network packets and filter them based on different criteria. Also using a “proxy” that lets you dig into network communication can be very valuable.

Web Development

The Chrome/Firefox developer tools are very useful.

You can bring them up by right clicking (or control click) and you get a popup menu. Try “inspect” or “console”.

Look at: Source code - HTML/CSS/JS source code of any website.

Live HTML, CSS, JS modification - Change the website content, styles and behavior to your tastes.

The console gives you a “Live” JavaScript (Ecma-262-Script) console. You can print out stuff, run stuff etc.

The network tab shows you the network communication and timing.

The “application” tab has cookies and local storage.

Profiling

Time based profiling

This is really how much CPU time a program uses. This is the most common form of profiling. Sometimes you will need to look at other things like memory usage or network usage.
The two common types are tracing - where the profiler watches where the code runs and counts it and sampling - where the profiler looks at where the code is periodically and then counts that location.

Most languages have some sort of a profiler either built in or as a part of the IDE that you are using. In python there is a command line based profiler that I will give a quick demo of. It is called cProfile and returns the amount of time per function call.

Using a simple chunk of code:

```
import sys, re

def grep(pattern, file):
    with open(file, 'r') as f:
        print(file)
        for i, line in enumerate(f.readlines()):
            pattern = re.compile(pattern)
```

```
            match = pattern.search(line)
            if match is not None:
                print("{}: {}".format(i, line), end="")

if __name__ == '__main__':
    times = int(sys.argv[1])
    pattern = sys.argv[2]
    for i in range(times):
        for file in sys.argv[3:]:
            grep(pattern, file)
```

we run

```
$ python -m cProfile -s tottime grep.py 1000 '^(import|\s*def)[^,]*$' *.py
```

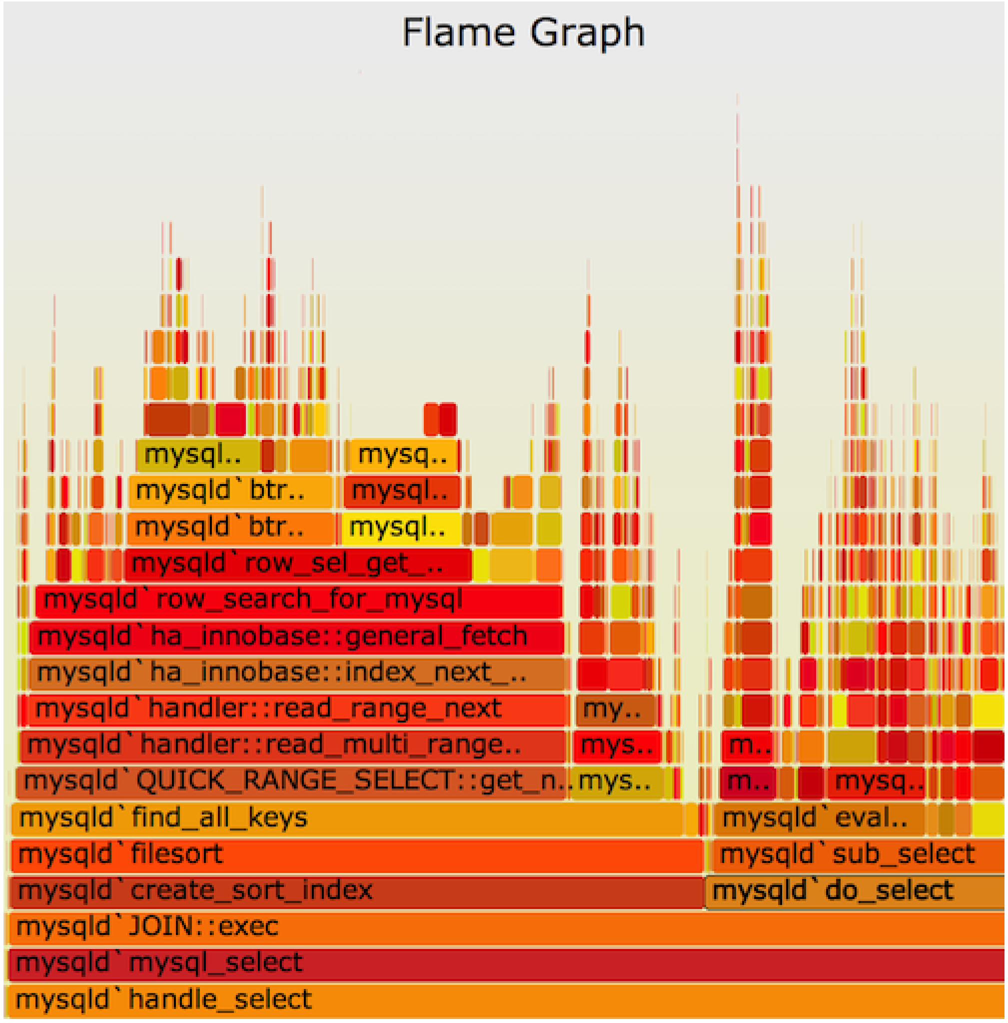
Output:

```
   227401 function calls (227382 primitive calls) in 0.178 seconds

     Ordered by: internal time

     ncalls  tottime  percall  cumtime  percall filename:lineno(function)
       2000    0.040    0.000    0.046    0.000 {built-in method io.open}
      41000    0.031    0.000    0.040    0.000 re.py:271(_compile)
       2000    0.029    0.000    0.175    0.000 grep.py:7(grep)
      41000    0.020    0.000    0.020    0.000 {method 'search' of 're.Pattern' objects}
       2000    0.018    0.000    0.023    0.000 {method 'readlines' of '_io._IOBase' obje
       2000    0.010    0.000    0.010    0.000 {built-in method builtins.print}
      80050    0.009    0.000    0.009    0.000 {built-in method builtins.isinstance}
      41000    0.008    0.000    0.048    0.000 re.py:232(compile)
          1    0.003    0.003    0.178    0.178 grep.py:5(<module>)
       4000    0.003    0.000    0.005    0.000 codecs.py:319(decode)
       2000    0.002    0.000    0.002    0.000 {built-in method _locale.nl_langinfo}
       4000    0.002    0.000    0.002    0.000 {built-in method _codecs.utf_8_decode}
       2000    0.002    0.000    0.004    0.000 _bootlocale.py:33(getpreferredencoding)
       2000    0.001    0.000    0.002    0.000 codecs.py:309(__init__)
       2000    0.001    0.000    0.001    0.000 codecs.py:260(__init__)
        3/1    0.000    0.000    0.000    0.000 sre_parse.py:475(_parse)
        6/1    0.000    0.000    0.000    0.000 sre_compile.py:71(_compile)
         44    0.000    0.000    0.000    0.000 sre_parse.py:164(__getitem__)
        7/2    0.000    0.000    0.000    0.000 sre_parse.py:174(getwidth)
         22    0.000    0.000    0.000    0.000 sre_parse.py:233(__next)
        2/1    0.000    0.000    0.000    0.000 sre_parse.py:417(_parse_sub)
          1    0.000    0.000    0.000    0.000 sre_compile.py:759(compile)
 [Omitted Lines - lots of stuff called that will have any effect]
```

This kind of output can be hard to visualize. For this reason this can be converted into a “flame graph” that shows where most of the time is spent. This is an example:



Flame Graph See: http://www.brendangregg.com/flamegraphs.html.

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