



# Computer Systems and Networks

ECPE 170 – Jeff Shafer – University of the Pacific

# Performance Measurement

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# Lab Schedule

## Activities

- **Today**
  - Background discussion
  - **Lab 5 – Performance Measurement**
- **Next Tuesday**
  - **Lab 5 – Performance Measurement**
- **Next Thursday**
  - **Lab 6 – Performance Optimization**

## Assignments Due

- **Lab 4**
  - **Due by Feb 16<sup>th</sup> 5:00am**
- **Lab 5**
  - **Due by Feb 23<sup>rd</sup> 5:00am**

# Person of the Day: Bill Joy



- Co-founder of **Sun Microsystems**
- Author of **vi text editor**
- Key contributor to original BSD Unix while a Berkeley grad student
  - First open-source OS with TCP/IP

# Performance Measurement



# Lab 5 Goals

1. Measure program **execution time**
2. Break down program execution time by **specific subroutines / lines** of code
3. Monitor program for **memory leaks**
  - Not really “performance”, but uses same tool

# Performance Measurement

- **Why is it important to measure application performance *in detail*?**

# Valgrind



<http://valgrind.org/>

# Valgrind Features

- **Memcheck** module – Memory error detector
- Access 1 beyond the beginning / end of your array?
- Access un-initialized memory?
- Reading/writing memory after calling free()?
- Memory leak? (Lost pointer to a malloc() block)
- **Valgrind produces a report that identifies these errors**



# Valgrind Features

- **Callgrind** module – Program profiler
- Callgraph shows you what function called what other functions
- How much CPU time does each function / code line consume?
- **Valgrind produces a report that summarizes CPU usage of your program**

# Valgrind Features

- **Massif** module – Heap profiler
  - Optimize your program to use less memory (by identifying where memory is being used)
- **Helgrind** module – Threading profiler
  - Bugs in multi-threaded programs are especially difficult to find!
- ... and more modules ...

# Valgrind Common Uses

- **Your program runs and suddenly segfaults**
  - Recall a segfault means a memory address was accessed that doesn't exist for your program
  
- How do I find where this error is?
  - Valgrind can monitor your program and detect accesses outside of static variables and dynamic memory regions

# Valgrind Common Uses

- **Your program gets slower and slower the longer it runs**
  - Memory leak? (Slowing running out of heap memory because you `malloc()` without ever calling `free()`)
- How do I find where this error is?
  - Valgrind can monitor your program. It can't tell you where you *should* free it, but it will tell you where you originally called `malloc()`, or where the pointer was lost

# Valgrind Behind-the-Scenes

- **Just-in time compiler**
  - Your program is re-compiled onto a virtual (simulated) processor
  - Another example of a virtual machine!
- Benefit – Valgrind can observe your program running at the machine instruction level
- Drawback – Slow! (5x slower than normal)
  - *But it's still better than fixing bugs without a tool...*

# Profiling Basics



# Profiling Basics

- The next labs (5-7) ask you to **measure application performance** by conducting experiments
  - Execution time
  - Processor usage
  - Memory usage
  
- **Which of these system configuration do you think would be best in terms of producing the cleanest, most accurate, most reproducible results?**

jshafer@ecpe170: ~

jshafer@ecpe170:~\$

# Program to Benchmark





ECPE 170

Terminal

jshafer@ecpe170: ~

```
jshafer@ecpe170:~$
```

# Program to Benchmark

9:39 PM Jeff Shafer

The terminal window is titled 'Terminal' and shows the user 'jshafer' at the host 'ecpe170'. The prompt is 'jshafer@ecpe170:~\$'. A large, semi-transparent purple box with the text 'Program to Benchmark' is overlaid on the terminal content.

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- Compile FreeBSD
- mount\_nas
- Festival of Light\_2008.ppt
- backup\_mac\_contacts



Terminal

```
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jshafer@ecpe170:~$
```

# Program to Benchmark

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# Profiling Basics

- **The best approach (directly booting Linux) may not be convenient to achieve for this class**
- **But you can *\*definitely\** avoid the worst configuration!**
- **Keep your system simple when benchmarking**