



Computer Systems and Networks

ECPE 170 – Jeff Shafer – University of the Pacific

Performance Measurement

Lab Schedule

Activities

- **Today**
 - Discussion on Performance Measurement (Lab 5)
 - **Finish Lab 4!**
- **Next Week**
 - **Lab 5 – Performance Measurement**

Assignments Due

- **Lab 4**
 - **Due by Feb 16th 5:00am**
- **Lab 5**
 - **Due by Feb 23rd 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

Memory Leaks



Problem 1

```
int main() {
    int *array;
    array=(int *)malloc(sizeof(int)*1000);

    for(i=0;i<1000;i++)
        array[i] = i;

    return 0;
}
```

Where is the Memory Leak?

Problem 2

```
int main() {
    int **array;
    array=(int **)malloc(sizeof(int *)*1000);

    for(i=0;i<1000;i++)
        array[i] = (int *)malloc(sizeof(int)*500);

    free(array);
    return 0;
}
```

(a) Where is the Memory Leak?

(b) How do you fix it?



P2

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





Terminal window titled "ECPE 170" showing a shell prompt and a large text overlay.

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

Program to Benchmark

- DataNode modifications
- Good CV - Applic...le.pdf
- Trends Disk GPU N...k.xlsx
- 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**