

Computer Systems and Networks



ECPE 170 – Dr. Pallipuram– University of the Pacific

Performance Measurement

Slides are courtesy of Dr. Shafer

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?



P1

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?



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?**



ECPE 170

Terminal

jshafer@ecpe170: ~

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

Program to Benchmark

9:39 PM Jeff Shafer

The image shows a Mac OS X desktop environment. A terminal window titled 'Terminal' is open, displaying the prompt 'jshafer@ecpe170: ~' and the command 'jshafer@ecpe170:~\$'. A large, semi-transparent purple box is overlaid on the terminal, containing the text 'Program to Benchmark' in white. The terminal window's title bar shows 'ECPE 170' and system status icons. The desktop background features a large image of a dinosaur's tail. The dock on the left contains various application icons, and the desktop on the right has several files and folders, including 'DataNode modifications', 'Good CV - Applic...le.pdf', 'Trends Disk CPU N...k.xlsx', 'Compile FreeBSD', 'mount_nas', 'Festival of Light 2008.ppt', and 'backup_mac_contacts'.

- DataNode modifications
- Good CV - Applic...le.pdf
- Trends Disk CPU N...k.xlsx
- Compile FreeBSD
- mount_nas
- Festival of Light 2008.ppt
- backup_mac_contacts



Terminal window showing a shell prompt:

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

Program to Benchmark

Downloads window showing a list of files:

- Today
 - Sep 18, 2012 ubuntu-12.04.1-desktop-i386.iso 476 KB/s - 36.2 MB of 695 MB, 23 mins left
<http://releases.ubuntu.com//precise/ubuntu-12.04.1-desktop-i386.iso>
Pause Cancel
- Sep 13, 2012 05-c-programming.pdf Removed
http://ecs-network.serv.pacific.edu/ecpe-170/slides/05cprogramming.pdf/at_do...
Remove from list
- Removed BIOS_Acor_7_10_A_A.zip Removed

iTunes window showing a music player:

Alone in the Cosmos
Glint — Sound in Silence
0:19 / -4:22

ESPN website showing sports scores and news:

ESPN: The Worldwide Leader

espn.go.com

EDITIONS: USA DEPORTES More

CITIES: BOSTON CHICAGO DALLAS LOS ANGELES NEW YORK

MLB Full Scoreboard

Bottom 9th	Top 8th	Top 7th	F/12	Final	Final	F/10	Final	Final
BAL 2 SEA 2	COL 0 SF 4	TEX 3 LAA 10	MIN 6 CLE 5	OAK 2 DET 12	MIL 6 PIT 0	ATL 3 MIA 4	BOS 7 TB 5	CIN 3 CHC 1

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- Falcons' Turner charged with DUI, speeding
- Ex-ref blasts Goodell | Sub refs under fire
- Late Ronaldo goal jolts City in thriller | Blog

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**