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## CS342 Operating Systems Homework 1

1. For this process, I have installed VMware Fusion 8 on my MacBook. I found a simple guide on the internet on how to install Ubuntu on a virtual environment using VMware. Once I started VMware, I have pointed it to the .iso file which I downloaded from Ubuntu's website. The next thing I saw was a flashy window blinking with a cursor. Next, a setup screen was shown and I followed some simple steps to proceed with the installation. Then, the guide said I had to install VMware tools to ensure full performance on my virtual machine. I think the tools contain required drivers for the OS to communicate properly with the virtual machine instance. Overall, the experience was fairly smooth and simple. I did not encounter any errors. VMware made it really easy.

2. the kernel executable file is located in the /boot directory of the root. The version number is: 4.4.0-62-generic

3. the names of the subdirectories are as follows (files are not listed since the question only asks about the subdirectories)

- crypto
- ipc
- scripts
- drivers
- kernel
- security
- Documentation
- firmware
- lib
- sound
- arch
- fs
- mm
- tools
- block
- include
- net
- usr
- certs
- init
- samples
- virt

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#### 4. Source Code and Sample Programs:

##### **btree.c:**

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

typedef struct bin_node {
    char *data;
    struct bin_node *right, *left;
} node; //typedef bin_node -> node. Whenever I write node somewhere,
compiler automatically replaces it with struct bin_node

void insert(node **tree, char *val) {
    node *temp = NULL;
    if (!(*tree)) {
        temp = (node *) malloc(sizeof(node));
        temp->left = temp->right = NULL;

        char * val_copy;
        val_copy = (char*)malloc(sizeof(char) * strlen(val));
        strcpy(val_copy, val);

        temp->data = val_copy;
        *tree = temp;
        return;
    }

    //do not insert the new string if it exists in the tree -> do not
handle the case for strcmp == 0
    if (strcmp(val, (*tree)->data) < 0) {
        insert(&(*tree)->left, val);
    } else if (strcmp(val, (*tree)->data) >= 0) {
        insert(&(*tree)->right, val);
    }
}

void inorder(node *tree, FILE* fp) {
    if (tree) {
        inorder(tree->left, fp);
        //printf("%s\n", tree->data); // this part is going to be replaced
by -write output to file-

        fprintf(fp, "%s\n", tree->data);

        inorder(tree->right, fp);
    }
}

int main(int argc, char *argv[]) {

    // argv[0] is the name of the program
```

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```

    const char *const inputFileName = argv[1]; //this is a constant
pointer to a constant char. confusing stuff
    const char *const outputFileName = argv[2];

    node *root;
    root = NULL; //root is initialized to some random address if not
specified explicitly like this

    //file reading part is taken from the C language library guides. The
following is possibly the best way to do it since you don't have to allocate a
pre-determined size for the input buffer
    FILE * fp;
    char * line = NULL;
    size_t len = 0;
    ssize_t read;

    fp = fopen(inputFileName, "r");
    if (fp == NULL)
        exit(EXIT_FAILURE);

    while ((read = getline(&line, &len, fp)) != -1) {

        if( line[read-1] == '\n' ) //replace line endings with string
terminators. Well, maybe this results in a memory leak because "someString\n\0"
becomes "someString\0\0". Not sure about that though.
            line[read-1] = '\0';

        /* pointer errors sometimes figure out days to figure out. By not
doing a deep copy in the insert function, I was overwriting the current root's
*data.
            * always do a deep copy while working with strings and trees...
*/
        insert(&root, line);
    }

    fp = fopen(outputFileName, "w+");
    inorder(root, fp);

    fclose(fp);

    return 0;
}

```

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**Sample input:**

state  
age  
ethnic  
grand  
drag  
cheat  
age  
holiday  
ethnic  
orientation  
paralyzed

**Sample output:**

age  
age  
cheat  
drag  
ethnic  
ethnic  
grand  
holiday  
orientation  
paralyzed  
state

**5. strace of some programs****1) Output for btree program**

```
execve("./btree", ["../btree", "in.txt", "out.txt"], [/* 77 vars */]) = 0
brk(NULL)                               = 0x1c3e000
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or directory)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f75e78cc000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=108049, ...}) = 0
mmap(NULL, 108049, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f75e78b1000
close(3)                                = 0
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
```

```

read(3, "\\177ELF\\2\\1\\1\\3\\0\\0\\0\\0\\0\\0\\0\\0\\3\\0>\\0\\1\\0\\0\\0P\\t\\2\\0\\0\\0\\0\\0"... ,
832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1864888, ...}) = 0
mmap(NULL, 3967392, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f75e72e0000
mprotect(0x7f75e749f000, 2097152, PROT_NONE) = 0
mmap(0x7f75e769f000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x1bf000) = 0x7f75e769f000
mmap(0x7f75e76a5000, 14752, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_ANONYMOUS, -1, 0) = 0x7f75e76a5000
close(3) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f75e78b0000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f75e78af000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f75e78ae000
arch_prctl(ARCH_SET_FS, 0x7f75e78af700) = 0
mprotect(0x7f75e769f000, 16384, PROT_READ) = 0
mprotect(0x600000, 4096, PROT_READ) = 0
mprotect(0x7f75e78ce000, 4096, PROT_READ) = 0
munmap(0x7f75e78b1000, 108049) = 0
brk(NULL) = 0x1c3e000
brk(0x1c5f000) = 0x1c5f000
open("in.txt", O_RDONLY) = 3
fstat(3, {st_mode=S_IFREG|0664, st_size=75, ...}) = 0
read(3, "state\\nage\\nethnic\\ngrand\\ndrag\\nchea"... , 4096) = 75
read(3, "", 4096) = 0
open("out.txt", O_RDWR|O_CREAT|O_TRUNC, 0666) = 4
fstat(4, {st_mode=S_IFREG|0664, st_size=0, ...}) = 0
write(4, "age\\nage\\ncheat\\ndrag\\nethnic\\nethnic"... , 75) = 75
close(4) = 0
exit_group(0) = ?
+++ exited with 0 +++

```

## 2) output for top program which displays the running processes and resource usage in linux

```

access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/usr/lib/x86_64-linux-gnu/libnuma.so.1", O_RDONLY|O_CLOEXEC) = 3
read(3, "\\177ELF\\2\\1\\1\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\3\\0>\\0\\1\\0\\0\\0p\\.\\0\\0\\0\\0\\0\\0"... , 832)
= 832
fstat(3, {st_mode=S_IFREG|0644, st_size=43936, ...}) = 0
mmap(NULL, 2140064, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f7968242000
mprotect(0x7f796824c000, 2093056, PROT_NONE) = 0
mmap(0x7f796844b000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x9000) = 0x7f796844b000
close(3) = 0
mprotect(0x7f796844b000, 4096, PROT_READ) = 0
open("/proc/self/status", O_RDONLY) = 3
fstat(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
read(3, "Name:\\ttop\\nState:\\tR (running)\\nTgi"... , 1024) = 947
close(3) = 0
open("/sys/devices/system/node", O_RDONLY|O_NONBLOCK|O_DIRECTORY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFDIR|0755, st_size=0, ...}) = 0
getdents(3, /* 10 entries */, 32768) = 312
open("/sys/devices/system/node/node0/meminfo", O_RDONLY) = 4
fstat(4, {st_mode=S_IFREG|0444, st_size=4096, ...}) = 0
read(4, "Node 0 MemTotal:          3896036 "... , 4096) = 1000
read(4, "", 4096) = 0
close(4) = 0
getdents(3, /* 0 entries */, 32768) = 0
close(3) = 0

```



```

rt_sigaction(SIGRT_4, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGRT_3, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGRT_2, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGSYS, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGPWR, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGIO, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGWINCH, {0x404010, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) =
0
rt_sigaction(SIGPROF, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGVTALRM, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) =
0
rt_sigaction(SIGXFSZ, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGXCPU, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGURG, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGTTOU, {0x407fc0, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGTTIN, {0x407fc0, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGTSTP, {0x407fc0, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGCONT, {0x404010, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) = 0
rt_sigaction(SIGSTKFLT, {0x405890, [], SA_RESTORER, 0x7f79698874b0}, NULL, 8) =
0

```

### 3) strace for ls command

```

execve("/bin/ls", ["ls"], [/ * 77 vars */]) = 0
brk(NULL) = 0x1134000
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f6bceeac000
access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=108049, ...}) = 0
mmap(NULL, 108049, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f6bcee91000
close(3) = 0
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libselinux.so.1", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260Z\0\0\0\0\0"...,
832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=130224, ...}) = 0
mmap(NULL, 2234080, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f6bcea67000
mprotect(0x7f6bcea86000, 2093056, PROT_NONE) = 0
mmap(0x7f6bcec85000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x1e000) = 0x7f6bcec85000
mmap(0x7f6bcec87000, 5856, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_ANONYMOUS, -1, 0) = 0x7f6bcec87000
close(3) = 0
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0P\t\2\0\0\0\0"...,
832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1864888, ...}) = 0
mmap(NULL, 3967392, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f6bce69e000
mprotect(0x7f6bce85d000, 2097152, PROT_NONE) = 0
mmap(0x7f6bcea5d000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x1bf000) = 0x7f6bcea5d000
mmap(0x7f6bcea63000, 14752, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_ANONYMOUS, -1, 0) = 0x7f6bcea63000
close(3) = 0
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libpcr.so.3", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0000\25\0\0\0\0\0"...,
832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=456632, ...}) = 0

```



```

mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f6bcee90000
mmap(NULL, 2552072, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f6bce42e000
mprotect(0x7f6bce49c000, 2097152, PROT_NONE) = 0
mmap(0x7f6bce69c000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x6e000) = 0x7f6bce69c000
close(3) = 0
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libdl.so.2", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\240\r\0\0\0\0\0"...,
832) = 832
fstat(3, {st_mode=S_IFREG|0644, st_size=14608, ...}) = 0
mmap(NULL, 2109680, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f6bce22a000
mprotect(0x7f6bce22d000, 2093056, PROT_NONE) = 0
mmap(0x7f6bce42c000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x2000) = 0x7f6bce42c000
close(3) = 0
access("/etc/ld.so.nohwcap", F_OK) = -1 ENOENT (No such file or directory)
open("/lib/x86_64-linux-gnu/libpthread.so.0", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\0\0\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260\r\0\0\0\0\0"...,
832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=138696, ...}) = 0
mmap(NULL, 2212904, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f6bce00d000
mprotect(0x7f6bce025000, 2093056, PROT_NONE) = 0
mmap(0x7f6bce224000, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_DENYWRITE, 3, 0x17000) = 0x7f6bce224000
mmap(0x7f6bce226000, 13352, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|
MAP_ANONYMOUS, -1, 0) = 0x7f6bce226000
close(3) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f6bcee8f000
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x7f6bcee8d000
arch_prctl(ARCH_SET_FS, 0x7f6bcee8d800) = 0
mprotect(0x7f6bcea5d000, 16384, PROT_READ) = 0
mprotect(0x7f6bce224000, 4096, PROT_READ) = 0
mprotect(0x7f6bce42c000, 4096, PROT_READ) = 0
mprotect(0x7f6bce69c000, 4096, PROT_READ) = 0
mprotect(0x7f6bcec85000, 4096, PROT_READ) = 0
mprotect(0x61d000, 4096, PROT_READ) = 0
mprotect(0x7f6bceeae000, 4096, PROT_READ) = 0
munmap(0x7f6bcee91000, 108049) = 0
set_tid_address(0x7f6bcee8dad0) = 2560
set_robust_list(0x7f6bcee8dae0, 24) = 0
rt_sigaction(SIGRTMIN, {0x7f6bce012b50, [], SA_RESTORER|SA_SIGINFO,
0x7f6bce01e390}, NULL, 8) = 0
rt_sigaction(SIGRT_1, {0x7f6bce012be0, [], SA_RESTORER|SA_RESTART|SA_SIGINFO,
0x7f6bce01e390}, NULL, 8) = 0
rt_sigprocmask(SIG_UNBLOCK, [RTMIN RT_1], NULL, 8) = 0
getrlimit(RLIMIT_STACK, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
statfs("/sys/fs/selinux", 0x7ffffbf263710) = -1 ENOENT (No such file or
directory)
statfs("/selinux", 0x7ffffbf263710) = -1 ENOENT (No such file or directory)
brk(NULL) = 0x1134000
brk(0x1155000) = 0x1155000
open("/proc/filesystems", O_RDONLY) = 3
fstat(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
read(3, "nodev\tsysfs\nnodev\trootfs\nnodev\ttr"..., 1024) = 344
read(3, "", 1024) = 0
close(3) = 0
open("/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3

```



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```

fstat(3, {st_mode=S_IFREG|0644, st_size=4417264, ...}) = 0
mmap(NULL, 4417264, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f6bcd6d6000
close(3) = 0
ioctl(1, TCGETS, {B38400 opost isig icanon echo ...}) = 0
ioctl(1, TIOCGWINSZ, {ws_row=24, ws_col=80, ws_xpixel=0, ws_ypixel=0}) = 0
open(".", O_RDONLY|O_NONBLOCK|O_DIRECTORY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFDIR|0775, st_size=4096, ...}) = 0
getdents(3, /* 7 entries */, 32768) = 208
getdents(3, /* 0 entries */, 32768) = 0
close(3) = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(136, 4), ...}) = 0
write(1, "btree btree.c\tin.txt\tMakefile "..., 40btree btree.c in.txt
      Makefile out.txt
) = 40
close(1) = 0
close(2) = 0
exit_group(0) = ?
+++ exited with 0 +++

```