

Homework #1

Due: February 27, 2019 at 11:55 pm

Academic Honesty

Aside from the narrow exception for collaboration on homework, all work submitted in this course must be your own. Cheating and plagiarism will not be tolerated. If you have any questions about a specific case, please email the TA's or me. We will be checking for this!

NYU Poly's Policy on Academic Misconduct: <http://engineering.nyu.edu/academics/code-of-conduct/academic-misconduct>

Homework Notes

General Notes

- Read the assignment carefully, including what files to include.
- Don't assume limitations unless they are explicitly stated.
- Treat provided examples as just that, not exhaustive list of cases that should work.
- When in doubt regarding what needs to be done, ask. Another option is test it in the real UNIX operating system. Does it behave the same way?
- **TEST** your solutions, make sure they work. It's obvious when you didn't test the code.

Rubric

Since we had some issues before on homework 1. Here are **some** of the things we know we will test, but these are not the **only** things we will test. Therefore make sure to test your program thoroughly and thoughtfully.

Total: 100 points

- -10: Can't specify number of lines when input is from a pipe
- -10: No `exit()` at the end of `hello.c`
- -10: Does not handle long lines (more than 512 characters)

- -20: `head` does not allow specifying number of lines
- -50: `head` does not work
- -10: Debug `printf` left in code
- -10: "`cat README | head`" does not work
- -5: "`cat README | head | head -5`" does not work

In this assignment, you'll start getting familiar with xv6 by writing a couple simple programs that run in the xv6 OS.

As a prerequisite, make sure that you have followed the install instructions from NYU classes to get your build environment set up. A common theme of the homework assignments is that we'll start off with xv6, and then add something or modify it in some way. This assignment is no exception.

Henceforth the commands typed in the terminal, and their output, shall be shown using a monospace font and the commands type will be presided by the prompt i.e. '\$' symbol.

Start by getting a copy of xv6 using the `git clone` command

```
$ git clone https://github.com/gussand/xv6-public.git
Cloning into 'xv6-public'...
remote: Enumerating objects: 4517, done.
remote: Total 4517 (delta 0), reused 0 (delta 0), pack-reused 4517
Receiving objects: 100% (4517/4517), 11.67 MiB | 466.00 KiB/s, done.
Resolving deltas: 100% (1820/1820), done.
Checking connectivity... done.
```

Make sure you can build and run xv6. To build the OS, use `cd` to change to the xv6 directory, and then run `make` to compile xv6:

```
$ cd xv6-public
$ make
```

Then, to run it inside of QEMU, you can do:

```
$ make qemu
```

QEMU window should appear and show the xv6 command prompt, where you can run programs inside xv6. It will look something like this:

```
QEMU
SeaBIOS (version rel-1.8.1-0-g4adadb-20150316_085822-nilsson.home.kraxel.org)

iPXE (http://ipxe.org) 00:03.0 C980 PCI2.10 PnP PMM+1FF93BE0+1FEF3BE0 C980

Booting from Hard Disk...

cpu0: starting xv6
cpu1: starting
cpu0: starting
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap star
t 58
init: starting sh
$
```

You can play around with running commands such as `ls`, `cat`, etc. by typing them into the QEMU window. For example, this is what it looks like when you run the `ls` command in xv6:

```
QEMU
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap star
t 58
init: starting sh
$ ls
.          1 1 512
..         1 1 512
README    2 2 1973
cat        2 3 14028
echo       2 4 12993
forktest  2 5 8505
grep       2 6 15956
init       2 7 13894
kill       2 8 13125
ln         2 9 13023
ls         2 10 15891
mkdir     2 11 13154
rm         2 12 13131
sh         2 13 25951
stressfs  2 14 14113
usertests  2 15 68572
wc         2 16 14614
zombie    2 17 12755
console   3 18 0
$
```

Part 1: Hello World (20 points)

There are in **total 3 parts** in this assignment. For part 1 write a program for xv6 that, when run, prints "Hello world" to the xv6 console. This can be broken up into a few steps:

1. Create a file in the xv6 directory named `hello.c`
2. Code your program in `hello.c` such that it implements printing "Hello world"
3. Edit the file `Makefile`, find the section `UPROGS` which contains a list of programs to be built, and add a line to tell it to build your Hello World program. When you're done that portion of the `Makefile` should look like:

```
UPROGS=\
    _cat\
    _echo\
    _forktest\
    _grep\
    _init\
    _kill\
    _ln\
    _ls\
    _mkdir\
    _rm\
    _sh\
    _stressfs\
    _usertests\
    _wc\
    _zombie\
    _hello\
```

4. Run `make` to build xv6, including your new program (repeating steps 2 and 4 until you have compiling code)
5. Run `make qemu` to launch xv6, and then type `hello` in the QEMU window. You should see "Hello world" be printed out.

Note: use the `make clean` command to clear the compiled files whenever necessary.

Of Course step 2 is where the bulk of the work lies. You will find that many things are subtly different from the programming environments you've used before. For example, the `printf` function takes an extra argument that specifies where it should print to.

This is because you're writing programs for a new operating system, and it doesn't have to follow the conventions of anything you've used before.

To get a feel for how programs look in xv6, and how various APIs should be called, you can look at the source code for other utilities: `echo.c`, `cat.c`, `wc.c`, `ls.c`.

Hints:

1. In places where something asks for a file descriptor, you can use either an actual file descriptor (i.e., the return value of the `open` function), or one of the standard I/O descriptors: 0 is "standard input", 1 is "standard output", and 2 is "standard error". Writing to either 1 or 2 will result in something being printed to the screen.
2. The standard header files used by xv6 programs are "`types.h`" (to define some standard data types) and "`user.h`" (to declare some common functions). You can look at these files to see what code they contain and what functions they define.

A brief digression on IDEs and text editors

I do not have strong preferences as to how you create source code. I personally prefer to use a traditional text editor that can be run at the command line such as `pico`. Although `vim` and `emacs` are great as well and there are plenty of alternatives out there.

On macOS, some may prefer to use Xcode, others may prefer to use something like TextMate or Sublime Text. In the Linux VM I have provided, `pico` works fine. As long as you get a plain text file out of it with valid C syntax, you can choose whatever you like.

How you *compile* the code is another matter. The xv6 OS is set up to be built using `make`, which uses the rules defined in Makefile to compile the various pieces of xv6, and to allow you to run the code. The simplest way to build and run it is to use this system. Trying to coerce an IDE such as Xcode into building xv6 is far more trouble than it's worth.

Part 2: Implementing the 'head' command (50 points)

Write a program that prints the first 10 lines of its input. If a filename is provided on the command line (i.e., `head FILE`) then head should open it, read and print the first 10 lines, and then close it. If no filename is provided, head should read from standard input.

```
$ head README
xv6 is a re-implementation of Dennis Ritchie's and Ken Thompson's
Unix
Version 6 (v6).  xv6 loosely follows the structure and style of v6,
but is implemented for a modern x86-based multiprocessor using ANSI
C.

ACKNOWLEDGMENTS

xv6 is inspired by John Lions's Commentary on UNIX 6th Edition (Peer
to Peer Communications; ISBN: 1-57398-013-7; 1st edition (June 14,
2000)).  See also http://pdos.csail.mit.edu/6.828/2014/xv6.html, which
provides pointers to on-line resources for v6.
```

You should also be able to invoke it without a file, and have it read from standard input. For example, you can use a pipe to direct the output of another xv6 command into head:

```
$ grep the README | head
Version 6 (v6).  xv6 loosely follows the structure and style of v6,
xv6 borrows code from the following sources:
    JOS (asm.h, elf.h, mmu.h, bootasm.S, ide.c, console.c, and
others)
    Plan 9 (entryother.S, mp.h, mp.c, lapic.c)
In addition, we are grateful for the bug reports and patches
contributed by
The code in the files that constitute xv6 is
To run xv6, install the QEMU PC simulators.  To run in QEMU, run
"make qemu".
To create a typeset version of the code, run "make xv6.pdf".  This
requires the "mpage" utility.  See http://www.mesa.nl/pub/mpage/.
```

The above command searches for all instances of the word the in the file README, and then prints the first 10 matching lines.

Hints:

1. Many aspects of this are similar to the `wc` program: both can read from standard input if no arguments are passed or read from a file if one is given on the command line. Reading its code will help you if you get stuck.

Part 3: Extending 'head' (30 points)

The traditional UNIX `head` utility can print out a configurable number of lines from the start of a file. Implement this behavior in your version of `head`. The number of lines to be printed should be specified via a command line argument as `head -NUM FILE`, for example `head -3 README` to print the first 3 lines of the file `README`. The expected output of that command is:

```
$ head -3 README
xv6 is a re-implementation of Dennis Ritchie's and Ken Thompson's
Unix
Version 6 (v6).  xv6 loosely follows the structure and style of v6,
but is implemented for a modern x86-based multiprocessor using ANSI
C.
```

If the number of lines is not given (i.e., if the first argument does not start with `-`), the number of lines to be printed should default to 10 as in the previous part.

Hints:

1. You can convert a string to an integer with the `atoi` function.
2. You may want to use pointer arithmetic (discussed in class in Lecture 2) to get a string suitable for passing to `atoi`.

Submitting the Assignment

Submit `hello.c` and the completed `head.c` on NYU Classes.