CS51 PROBLEM SET 0:
GETTING STARTED ON WINDOWS 10

0. Introduction

This problem set has several goals.

First, we will walk you through setting up your `OCaml` development environment. We do this rather than providing automated setup so that you have a sense of what a local development environment (rather than, for example, Cloud9) requires, but it should not take much longer than running a script would.

After your environment is configured, you'll finish up the problem set by writing a first program in `OCaml`.

This problem set is graded only for submission. Submission means filling in `ps0.ml`, pushing to GitHub, and submitting to Gradescope.

GitHub
Gradescope

There are questions listed throughout the problem set whose answers would be useful for you to know, but written answers to the questions are not required.

1. Windows Configuration

Microsoft recently released an update that significantly simplifies the process of developing software on Windows 10. Since your system is running Windows 10, you can take advantage of this new system, which gives developers access to an Ubuntu Linux subsystem running natively on Windows.

1.1. **Update Windows.** Navigate to the `Settings` application and choose `System`. At the left side, choose `About`, and verify that the `OS Build` field is at least 14393 and that `System Type` says 64-bit. If these requirements are not satisfied, update your system using the directions at this link.

1.2. **Install Ubuntu.** The next step is to follow the instructions listed on Microsoft's website at this link about setting up the Linux subsystem. You can then proceed with the directions below using the `bash` shell on Windows after you have set it up.

Date: January 24, 2017.

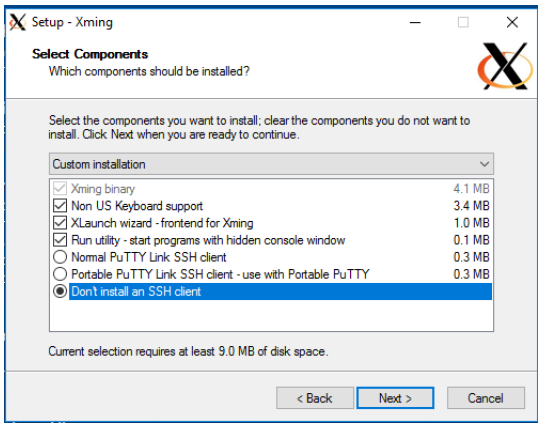

FIGURE 1. Choose the options shown above in the XMing setup.

1.3. **Install XServer.** Because one of the problem sets at the end of the semester requires a graphical user interface (more on that later), you need to install a program to run `X` applications. To download the program you need, follow this link. You should follow the default setup instructions in the `.exe` that you download, except on the screen shown in Figure 1, on which you should choose the options in Figure 1.

To complete the setup process, execute the following command from the Ubuntu `bash` shell that you just configured:

```
$ echo "export DISPLAY=:0" >> ~/.bashrc
```

N.B. You'll likely need to type the command above manually if the characters do not copy correctly.

2. SETTING UP A DEVELOPMENT ENVIRONMENT

Linux operating systems are successors of `Unix`, a family of operating systems developed beginning at Bell Labs in the 1970s. Modern Linux operating systems have many newer user interface features, but some of the original features from `Unix` will be the most useful in CS 51.

Users of the early `Unix` systems interacted with their computers exclusively through the keyboard, via a command line. They would type commands (short programs) that directed the computer to take action, like running a program to switch to a different folder in the file system or to create or delete a text file.

If you took CS 50, you ran commands at the command line in the CS 50 IDE. While you may never have done so before, you can also interact with your Linux computer via the command line. You will spend a good deal of time at the

command line in CS 51, and comfort at the command line, developed over time, will be one of the skills you build in this course.

The first step is to open a TERMINAL window. On Windows, this means opening the Ubuntu Bash program you configured in the first section. TERMINAL

Question 1. *Open a Terminal on your system. What is the Terminal? What is it for?* □

Let's investigate some programs that are useful for interacting with the command line.

Question 2. *Give a two or three word description of each of the following programs.*

(1) *man*
(2) *mkdir*
(3) *cd*
(4) *ls*
(5) *rm*
(6) *touch*

□

`man` and `touch` may be new to you; hopefully the others are familiar. `man` will be helpful through the semester when you need information about your system or a program. You might think of each of the listings above as "commands," but they are actually programs. Thinking of them as programs will be helpful when we start to install new ones, and you should be aware that these programs can be run with many different interesting and powerful options. (Take a look at `man ls`. Type `q` to close.)

For more guidance on the command line, check out this link.

Now that you know what the command line is and how to move around, it's time to start installing software. You'll need a number of different things: a version control system called `git`, the `OCaml` compiler and interpreter, and the `OCaml` package manager, among others.

To install all of these things, you could search the web for instructions and download `.zip` files. This is how you may have installed software in the past. Since we're going to be building our own software, however, we care a great deal about keeping careful track of what software we have installed. As such, we're going to use a PACKAGE MANAGER. With a quick web search, figure out what the most widely used package manager is for your system. PACKAGE MANAGER

Question 3. *What's an appropriate package manager for your system? What does a package manager do?* □

For Linux systems, the answer varies, but if you're running `Ubuntu`, the answer is `apt-get`.

2.0.1. *Installing* `apt-get`. Your Linux distribution should come with `apt-get` pre-installed. To make sure, type

```
$ sudo apt-get
```

You should see a help menu printed. (Throughout the course, the `$` symbol represents the Unix command line prompt, and indicates commands that should be typed at the Unix command line. You should not type that symbol.)

2.1. **Installing OCaml.** Now that you have a package manager, you can use it to install `OCaml` and its dependencies.

First, update Linux's index of available packages to make sure that everything we need can be found.

```
$ sudo apt-get update -y
```

The `git` program and several other useful tools need to be installed on Linux. You can do so with:

```
$ sudo apt-get install -y gcc make patch unzip m4 git xorg
```

Question 4. *Explain why the dependencies above might be useful.* □

Finally, run the following to install `OCaml` and `OPAM`, the `OCaml` package manager.

```
$ sudo add-apt-repository -y ppa:avsm/ppa
$ sudo apt-get update -y
$ sudo apt-get install -y ocaml
$ sudo apt-get install -y ocaml-native-compilers
$ sudo apt-get install -y camlp4-extra
$ sudo apt-get install -y opam
```

2.2. **`OCaml` versions and packages.** You may be asking yourself why we just installed a package manager specifically for `OCaml` after installing a general package manager for your system.

This is a reasonable question, and luckily it also has a reasonable answer. A software project is often developed by many different people, each of whom may be running a different operating system. Many software projects also take advantage of external libraries that have been made available to other developers. Sharing previously written libraries and packages for specific programming languages across multiple operating system package managers (note that there are 4 different version of this document), and keeping all of the different listings in sync with each other, would be a true challenge of coordination. This complexity arises before considering the fact that several different projects that one developer is working on may each require a different version of the same programming language.

To solve this problem, the developer communities for most popular programming languages have built ABSTRACTIONS between the libraries for and versions of their language and the operating system in the form of language-specific package managers. Each system's version of a language-specific package manager knows how to install libraries on that system, so that the authors of a library need only describe how the single manager should install the library.

ABSTRACTIONS

`OPAM` is the package manager for `OCaml`. Some other examples of language-specific package managers are `pip` for Python, `npm` for Node.js, and `gem` for Ruby.

Question 5. *What's the benefit of language-specific package managers? In what way do they serve as abstractions?* □

To set up `OPAM`, run:

```
$ opam init -a
```

The official version of OCaml used in CS 51 this year is `4.02.3`. This is most likely not the version installed by default by the system package manager. In addition to managing `OCaml` packages, `OPAM` can also manage `OCaml` versions. To install the correct version, run:

```
$ opam switch 4.02.3
```

Now that you have the right version, you can install some packages that you will need during the course.

```
$ opam install -y ocamlbuild
$ opam install -y ocamlfind
$ opam install -y ocamlnet
$ opam install -y yojson
$ opam install -y merlin
$ opam install -y utop
```

After all of this is done, you should finish the process by running

```
$ eval `opam config env`
```

N.B. the command above should have no output. If you see output, the ` character was likely not copied correctly. Type the command manually, including that character. Note that ` is the character at the upper left, below the escape key, and not a single quote.

At this point, close anything you are working on and restart your computer.

3. Verification

Now that you have OCaml installed, to verify that everything went well, open your system's Terminal and type:

```
$ ocaml
```

You should see the following:

```
OCaml version 4.02.3

#
```

READ-EVAL-PRINT LOOP

This is the OCaml READ-EVAL-PRINT LOOP (REPL), where you can type or paste `OCaml` code and see the output evaluated. To quit the REPL, press `Ctrl + D` to send an `EOF` character, or `#quit;;` to call the REPL's quit command.

You also installed a more-fully featured OCaml REPL, called `utop`. It has useful features like auto-completion built-in. To make sure that is working, type:

```
$ utop
```

It should also identify `4.02.3` as the version of `OCaml` it is running. It can be quit in the same way as the `ocaml` REPL. Then verify that typing the string `"are we there yet?"` (including quotes) followed by two semicolons and pressing enter results in something like this.

```
# "are we there yet?";;
- : string = "are we there yet?"
```

(The '#' character represents the `OCaml` prompt; you don't need to type it.) You just wrote your first piece of `OCaml`.

4. Setting up `git`

Before reading this section, you should watch this video about the version control system `git`.

4.1. **Sign up for GitHub.** We will be using `git`, a popular source control system, to distribute problem sets to you, and you will likewise use `git` to submit your work. The `git` repositories we will work with will be remotely hosted on GitHub, a `git` service offering remote repositories hosted in the cloud.

If you don't already have a GitHub account, follow these instructions to create one.

4.2. **Adding an SSH key.** Use SSH to let GitHub identify you and your computer. This lets you avoid having to type in your GitHub password every time you push to save your code remotely (which you should do often). To set up SSH authentication, follow these articles from GitHub:

(1) Checking for existing keys
(2) Generating a new key (if necessary)
(3) Telling GitHub about your key.

`git` should now be fully configured!

5. Getting the Source Code

We hand out problem set distribution code using GitHub Classroom. Every problem set specification will contain a link to the distribution code. When you click the link, GitHub will create a repository for you to use, and, if applicable, for you to share with your problem set partner.

5.1. **Creating the remote repository.** To create your repository for this homework, go to http://tiny.cc/cs51ps0 and follow the directions about GitHub.

5.2. **Cloning the code.** You now have a remote repository to store your homework. In addition, you'll also need a local repository so that you can make changes and then `git push` them to GitHub.

Following the directions listed here, clone the remote repository that was just created for you above. We recommend creating a folder to hold all of your problem sets (using `mkdir`).

If all went well, you should have seen something like this:

```
Cloning into 'cs51/ps0-student'...
remote: Counting objects: 51, done.
remote: Compressing objects: 100% (51/51), done.
remote: Total 51 (delta 51), reused 51 (delta 51)
Receiving objects: 100% (51/51), 51 MiB | 51 MiB/s, done.
Resolving deltas: 100% (51/51), done.
```

Using `cd`, change into the directory that was just cloned. When you run `ls`, you should see `ps0.ml`, `ps0_tests.ml`, `makefile`, and `_tags`, as well as several versions of this document.

5.3. **Checking for Updates.** We may occasionally publish changes to the distribution code after a problem set has already been released. If they occur, the changes will be small, and we may not notify you. If they are large, we will send an email to the course and post on Piazza.

`git` should make it painless to keep up the distribution code up-to-date. At the beginning of each assignment, we will ask you to add an extra `REMOTE`, which is a connection between a local repository and a remote repository, where we will upload the distribution code.

REMOTE

To add this week's extra remote, run

```
$ git remote add distribution git@github.com:cs51/ps0.git
```

This tells `git` to track the remote repository and gives the remote repository the name "distribution".

To check for updates, run:

```
$ git pull distribution master
```

This command checks the remote repository for changes and merges them in, if possible, or alerts you to conflicts if manual merges are required.

6. Writing your First OCaml Program

Good job making it this far. We know that getting your setup ready can be frustrating, but it's an important part of the process.

It's time to write and submit your first OCaml program. **Your job is to edit `ps0.ml`. The directions are inside.**

First, however, check that everything is working. Type:

```
$ make all
$ ./ps0.byte
```

You should see:

```
----------------------------------------
Name: FIRST LAST

Year: Other: I haven't filled it in yet

50?: Other: I haven't filled it out yet

I'm excited about ....!

----------------------------------------
```

If that worked, **open up `ps0.ml` in your favorite text editor**. (Members of the staff recommend Sublime Text 3, and Prof. Shieber recommends Emacs.) **Follow the directions inside.**

7. Submitting your problem set

Submitting homework happens in two phases. First, you'll commit your changes to your local `git` repository and push those changes to the remote GitHub repository. Second, you'll log in to `Gradescope` and tell us that you want to submit; `Gradescope` will then retrieve your submission from GitHub so that we can grade it.

7.1. **Using git.** When you modify some code, reach a good checkpoint in your coding (e.g., "fixed that bug!"), or finish your work, you can and should "commit" these changes by executing

```
$ git commit -am "some message here"
```

at the terminal from the directory in which you're working. **You should commit early and often, and push whenever you finish something important, so that your work is backed up on GitHub in the event of a computing emergency (like a spilled cup of coffee).** The `-a` flag ("a" stands for "all") here specifies that `git` should take note of *all* changes made in files that you have previously told `git` to track.

- You can tell `git` to track a file named `filename` by `add`ing it, as in:
  ```
  $ git add filename
  ```
- Since ps0.ml was already `add`ed, you don't have to `add` it again. However, if you were to make a new file, you would have to `add` it.
- You can `add` all of the files in your current directory (and subdirectories) to your repository by running
  ```
  $ git add -all
  ```
  This is probably the safest thing to do (to ensure you're tracking everything), but you'll probably not want to track the compiled binaries (like the `_build` directory and `ps0.byte` that you'll shortly be generating).

The `-m` flag ("m" for "message"), followed by some string, specifies a *commit message*, which is a short string describing the changes that have been made since the last commit. This can be useful in keeping track of exactly what changes you make throughout the development process. If you work on projects with other people, they can see what other changes you've made by reading these commit messages, which they (and you) can see by running `git log`.

Merely committing will store these changes in your computer's local copy of the repository. To "push" this repository's changes online to GitHub, execute:

```
$ git push
```

This will allow you to submit your work to `Gradescope` (though it doesn't perform the submission process itself; see below). **Equally important: it will also create a remote backup of your work so that, in the event of your losing access to your computer, you'll still have something to work with and submit. Again, commit and push early and often.**

7.2. **Submitting on `Gradescope`.** We'll be using `Gradescope`, an online coding course management platform, to manage CS51 labs and problem sets this year.

After enrollments have been submitted, you will have received an email from `team@Gradescope.com` with a link to sign up for an account.

Once you have signed in, select CS 51 as the course and look for the appropriate assignment. Choose it and then click "Submit from GitHub."

After `Gradescope` receives your submission, it double checks that your code compiles against our unit testing framework. After this test is complete (it usually takes about 10 seconds), you will receive confirmation that your submission succeeded. Code submissions that do not compile are rejected by the system and count for no credit.

Remember, pushing to GitHub does not complete your submission. You must submit inside `Gradescope` to complete the homework.

You can make sure that the right files were submitted by clicking on the "code" tab on the assignment page after you have submitted.