California State University, Sacramento
College of Engineering and Computer Science

Computer Science 35: Introduction to Computer Architecture

Fall 2020 – Lab 1 – *Hello World*

Overview

It is finally time for your first lab. Woo hoo!

Anyway, it is a long-standing tradition in computer science that your first program displays “Hello World” to the screen. This dates back to the first message sent over ARPANET – the predecessor to the Internet.

This week, you will basically get your feet wet with assembly programming. On the next page of this handout, there is a very basic "Hello World" program. Essentially, your only task for this lab is to print the traditional "Hello World!" to the screen followed by some other information.

Part 1. Connecting to the Server

To do your labs, you need to use your ECS Class Account. I e-mailed the username and password last week to your Saclink account.

The three servers that we use to do our labs cannot be accessed from off campus – at least directly. To connect these computers, first connect to Athena

Step 1 – Windows

If you are using Windows, you need to download and install a copy of PuTTY. Once you have installed it, open the application and connect to the following address. The first time you connect to a server, PuTTY likes to warn you about it. Just click yes.

```
athena.ecs.csus.edu
```

Step 1 – Macintosh

Open the Terminal program. This is the same UNIX prompt that you get when you connect to Athena. Mac-OS X is a version of UNIX. Neat! Once at the prompt, type the following where ***username*** is your ECS username. You might have to manually type "yes".

```
ssh username@athena.csus.edu
```

Step 2

Once you are connected to Athena, you need to Secure Shell (SSH) to one of the SP computers. Basically, you will connect to Athena and it will connect you to the SP computer. This example uses SP2. You will have to enter your password again and (maybe) have to manually type "yes".

```
ssh sp1.ecs.csus.edu
```

Part 2. Getting the Course Library (csc35.o)

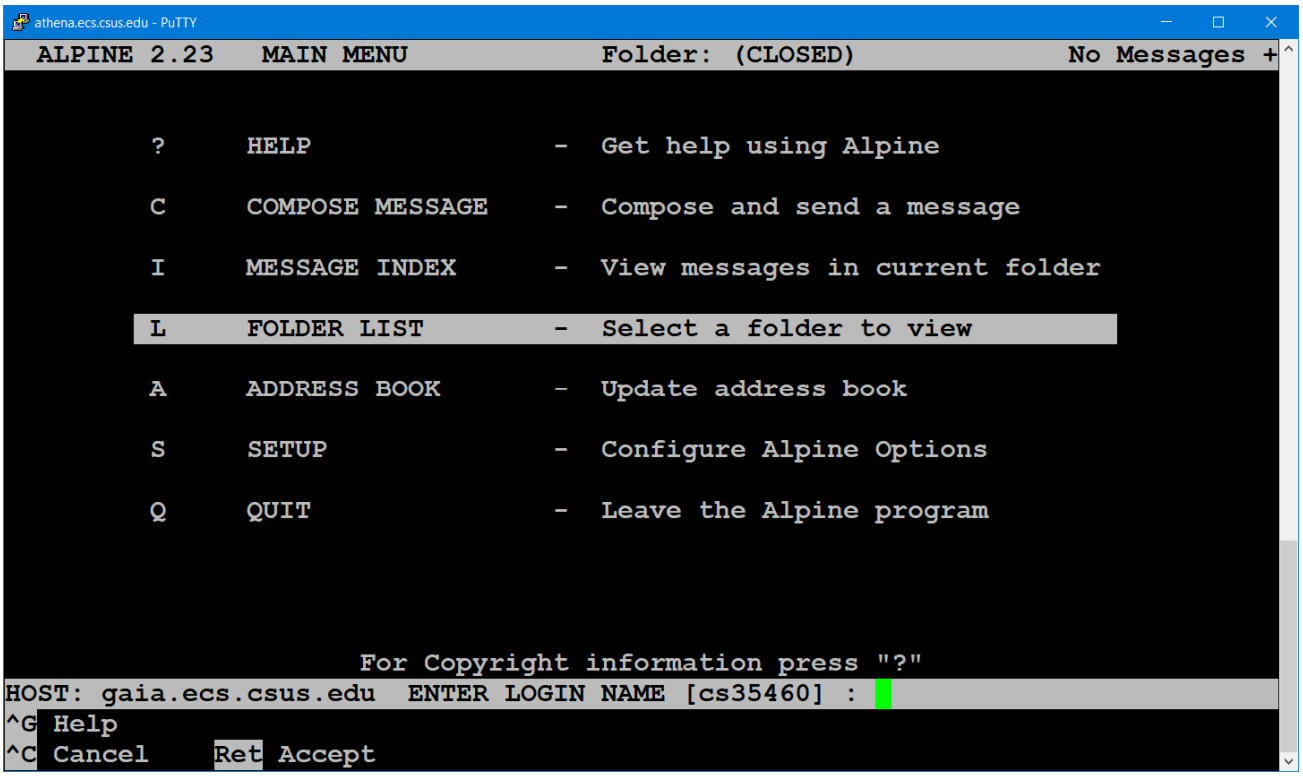
This course uses a library object file. The library contains a large number of utility functions that will allow you to easily print integers, strings, and other useful tasks. But, to use the library, you first need to obtain it.

I e-mailed a copy of the csc35.o file to your class account last week. You need to put the library into your class account folder (call your "root" folder). So, you need to open that e-mail and save the attachment.

The e-mail software, that we are using, is called Alpine – which was created by the University of Washington. To open the software, type "alpine" at the command line and press Enter.

```
alpine
```

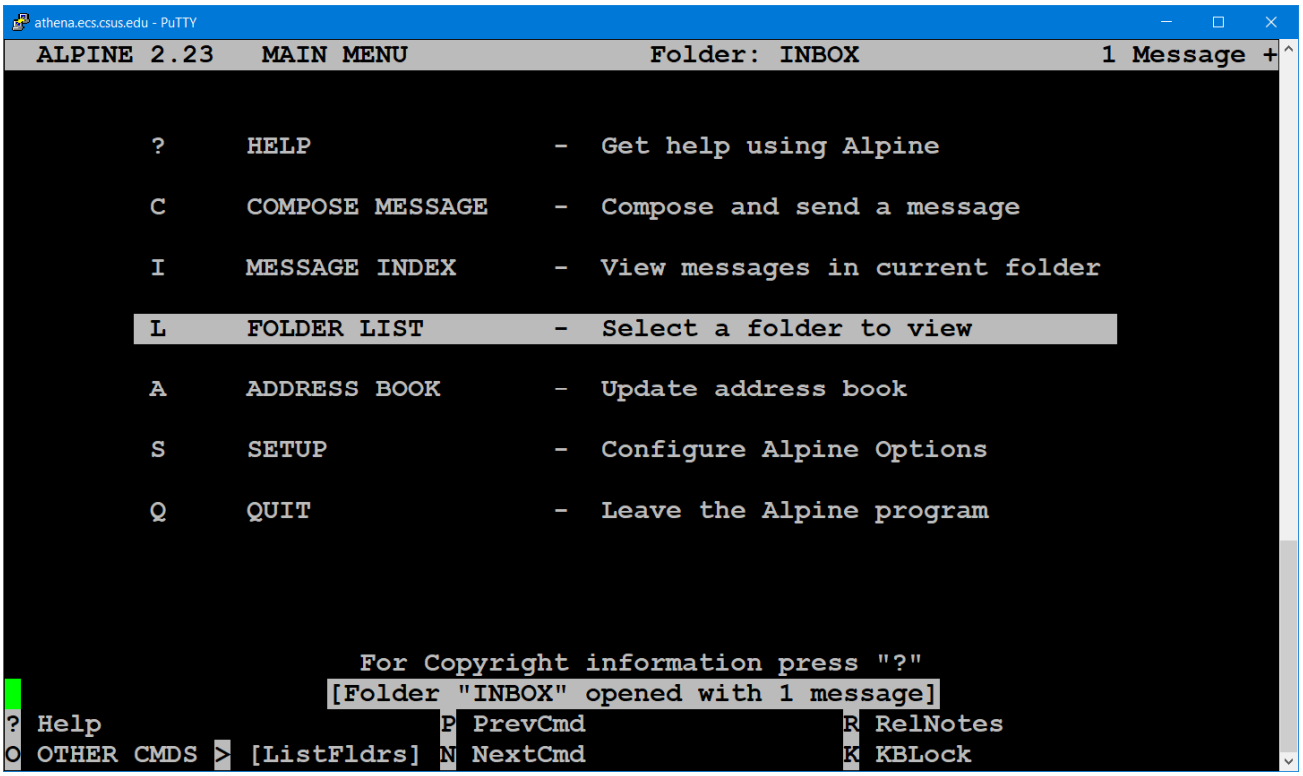
The first time you open the software, it displays a very annoying "welcome" screen. Just press **E** to exit it. Once you do, you will be greeted with the main menu, but you still need to log in.



Notice that, at the bottom of the screen, Alpine is asking for your username and password. This is because you are connecting to "Gaia" and this server also wants you to show your credentials.

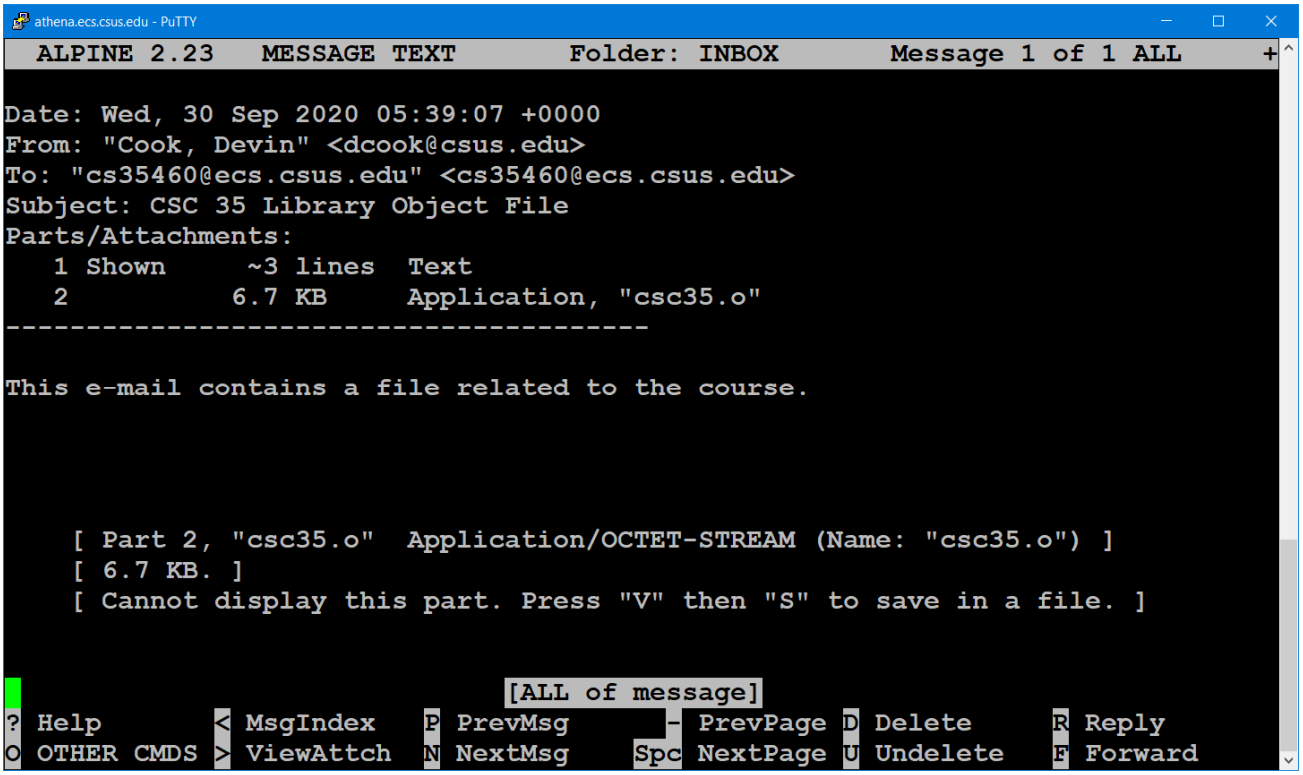
- Enter your username and password. Notice that Alpine "echos" password characters. How nice!

If you entered your credentials correctly it will display a message on the screen indicating your Inbox is opened.



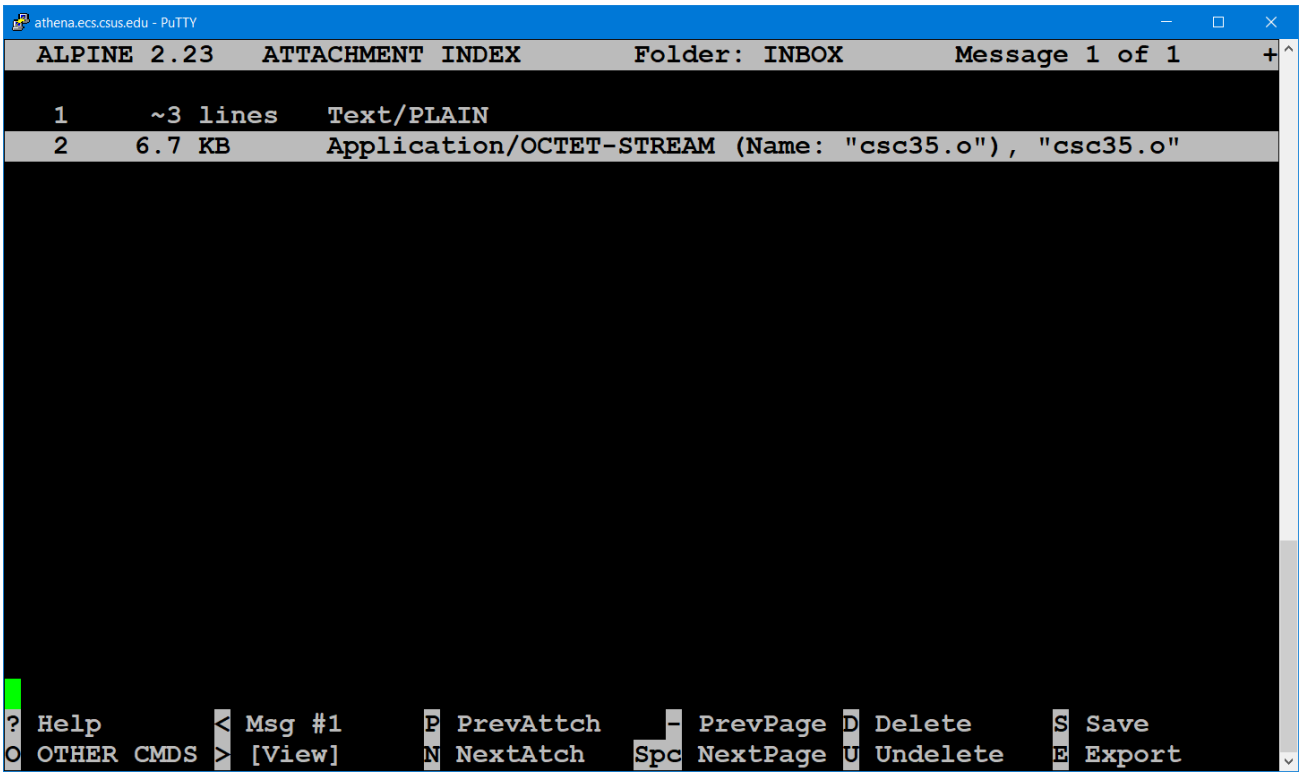
Now, you need to open the e-mail that I send you last week. You can use the arrows on your keyboard to navigate this menu (this is so easy!).

- Highlight "Folder List" and it press **Enter**.
- You will then see a folder called "Inbox". This will be the only folder – unless you create more. Press **Enter** again.
- Now, you will see a list of e-mails, select the one I sent you (which might be the only one), and, again, press **Enter**.



This looks a tad different from e-mail software you have used in the past. Notice the bottom lines of the screenshot above. Alpine displays all the common options and their associated key. In this case, we want to view the attachment "csc35.o".

- So, press **>** on the keyboard to View Attachment (yes, the menu label was abbreviated).



We aren't really "viewing" it since, well, it's a binary object file. Now we can save the attachment. Notice that the bottom of screen now lists an option to save.

- Press **S** on the keyboard
- Alpine then gives you a chance to rename it. Nah! Just press **Enter**.

You're done!

Now it's time to that back out of the program. Notice, that at the bottom of the screen, it states you can press **<** to go to "Msg #1".

- Keep pressing **<** until you get to the main menu.
- Once you have reached the main menu, press **Q** to quit.
- Excellent! Now type **`ls`** and press **Enter** to confirm you have the library file.

Part 3. Creating / Editing a File

Now that you have the library, it's time to write your first assembly program. First, you need to create your source code. In UNIX, there a number of excellent text editors. We are going to use an application called *Nano* – which is easy-to-use and quite user-friendly.

To create a new file (or edit an existing file), type "nano" followed by the filename and press the Enter Key.

```
nano lab1.asm
```

Once it opens, notice that all the options are listed on the bottom of the screen. In UNIX, the carrot symbol **^** represents pressing *and holding* the **Control** key. So, for example, to exit your program you will press **Control** and **X**.

The following is the solution for the classic "Hello, World' program. This solution makes use of the CSC 35 library. Please type it verbatim into the text editor. Pay very close attention where there are spaces.

You don't have to type the comments, but it might be good idea. You need to understand what each line does.

Once you have typed out the program, press **Control** and **X** to exit Nano. Remember to select "yes" to save the buffer (that's the memory which is storing the text of your program).

```
# lab1.s
# YOUR NAME HERE
#
# 1. Assemble : as -o lab1.o lab1.asm
# 2. Link     : ld -o a.out lab1.o csc35.o
# 3. Execute  : a.out

.intel_syntax noprefix              #Use Intel formatting
.data                               #Start the data section
Greeting:                           #Message is an address
    .ascii "Hello, world!\n\0"      #Create a buffer of ASCII

.text                               #Start the text section
.global _start                      #Make the _start label public

_start:                             #UNIX starts here
    lea  rbx, Greeting              #Put address into rbx
    call PrintCString               #Execute the csc35.o subroutine

    call EndProgram                 #Execute the csc35.o subroutine
```

Part 4. Assemble the Program

If you type **ls** and press Enter, you should be able to see your new file listed. Now that it is created, let's assemble it into an object file. Type the following and, then, press the Enter Key. Don't forgot the **-o**. It specifies that the filename listed – after it – is the output.

Warning: If you list your **.asm** file after the **-o**, it will be destroyed.

```
as -o lab1.o lab1.asm
```

If you have any typos in your program, the assembler will list the errors. If that happens, open your existing program (type **nano lab1.asm**) and fix them.

Part 5. Link the Objects

If you didn't receive any error messages from Step 3, then the object file was created. Now let's link your object file to the CSC 35 library and create a program. Let's use a default program name of "a.out".

Type the following. Don't forget to type **a.out** after **-o**.

```
ld -o a.out lab1.o csc35.o
```

If you have any mistakes with your labels, you will receive an error. Often, this is the result of a simple typo.

Part 6. Execute

You can execute your new program by simply typing its name and pressing the Enter Key.

```
a.out
```

If UNIX cannot find your program, you might have to type **./a.out** instead.

Requirements

Now work on each of the requirements below one at a time. You will turn in the final program, but incremental design is best for labs. You must think of a solution on your own. The requirements are as follows:

1. Put your name and section # in a comment at the very top of your program. We are using class accounts, and I need to be able to identify you.

2. Print "hello world" to the screen. You can make it "howdy" or any type of greeting you like. This was pretty much done for you already in the sample code.

3. Print the text "My name is" and your full name to the screen.
   Do **not** use the same string as in #1. Create a new label and ASCII text.

4. Print a quote from someone. It can be funny or inspirational.
   Do **not** use the same string as in #1 or #2. Create a new label and ASCII text.

5. Print off a historical year that is interesting to you. For example: "In the year 1947 Sacramento State was founded!" The sentence must have text before and after the year.

   Here's the tricky part: the year must be printed using the **PrintInt** subroutine. So, put the immediate value (the year) into **rbx**. Make sure to use `mov` rather than `lea`.

   There is no concatenation in assembly. For the final sentence, you will need three prints – two PrintCString and one PrintInt.

Submitting Your Lab

This activity may only be submitted in Intel Format.
Using AT&T format will result in a zero. Any work from a prior semester will receive a zero.

Afterwards, run Alpine by typing the following and, then, enter your username and password.

```
alpine
```

Please send an e-mail to yourself (on your Outlook, Google account) to check if Alpine is working. To submit your lab, send the assembly file (not a.out or the object file) to:

```
dcook@csus.edu
```

UNIX Commands

Editing

Action	Command	Notes
Edit File	**nano** *filename*	"Nano" is an easy to use text editor.
E-Mail	**alpine**	"Alpine" is text-based e-mail application. You will e-mail your assignments it.
Assemble File	**as -o** *object source*	Don't mix up the *objectfile* and *asmfile* fields. It will destroy your program!
Link File	**ld -o** *exe object(s)*	Link and create an executable file from one (or more) object files

Folder Navigation

Action	Command	Description
Change current folder	**cd** *foldername*	"Changes Directory"
Go to parent folder	**cd ..**	Think of it as the "back button".
Show current folder	**pwd**	Gives the current a file path
List files	**ls**	Lists the files in current directory.

File Organization

Action	Command	Description
Create folder	**mkdir** *foldername*	Folders are called directories in UNIX.
Copy file	**cp** *oldfile newfile*	Make a copy of an existing file
Move file	**mv** *filename foldername*	Moves a file to a destination folder
Rename file	**mv** *oldname newname*	Note: same command as "move".
Delete file	**rm** *filename*	Remove (delete) a file. There is **no** undo.