Week 6

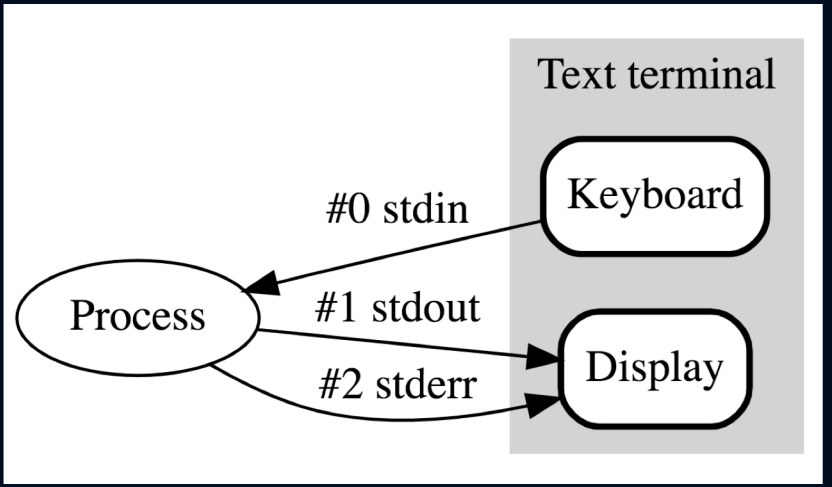
DATS 6450 – FOUNDATIONS OF COMPUTER SCIENCE

Class Overview

- Review and answer questions on Week 4 lecture
- Linux Commands continued
  - I/O & Redirection
  - Piping & Filter Commands
    - grep
    - cut

Standard Input, Output, Error

- In computer programming, **standard streams** are preconnected input and output communication channels between a computer program and its environment when it begins execution.
- The *three* input/output (I/O) connections are
  1. standard input (stdin)
  2. standard output (stdout)
  3. standard error (stderr)
- When a command is executed via an interactive shell, the streams are typically connected to the text terminal on which the shell is running, but can be changed with redirection or a pipeline.



I/O Redirection

- One of the coolest functions of the command line is I/O Redirection
  - We can redirect the input and output of commands to and from files, as well as chain multiple commands together into command pipelines
- Most of the commands we have run so far produce output of some kind
  - There are two types of output:
    1. Results - the data/output the program or command was designed to produce
    2. Status and error messages
  - By default, both standard output (stdout) and standard error (stderr) are linked to the screen (and not saved to disk)
  - Programs also take input from a stream called standard input (stdin) which is, by default, attached to the keyboard

I/O Redirection

- I/O redirection allows us to change where output goes and where input comes from.
- As previously mentioned, output normally goes to the screen and input comes from the keyboard, but with I/O redirection, we can change that.
- What is the point of redirecting output? It's often useful to store the output of a command in a file.
- To redirect standard output to another file instead of the screen, we use the ">" redirection operator followed by the name of the file.
- Syntax: **$ command > outputfile.txt**
- Example: **$ ls -l /usr/bin > binary_list.txt**

I/O Redirection

- A single “>” will always create a new file and re-write from the beginning
- If we want to append to an existing file, we use the “>>” redirection operator.
- Syntax: **$ command >> outputfile.txt**
- Example: **$ ls -l /sbin >> binary_list.txt**

I/O Redirection

- What will happen if we try redirect a command that fails?
- Example: **$ ls -l /bin/usr > binary_list.txt**
- The error is still printed to the terminal, and if we examine the file it will be empty.
- But why?

I/O Redirection

- As previously mentioned, both *stdout* and *stderr* default to stream to the terminal and since calling ***ls*** on a non-existing file sends *only stderr* **(**not *stdout)* it is still displayed!
- While we have referred to the first three file streams as *stdin*, *stdout* and *stderr*, the shell references them internally as file descriptors 0, 1 and 2, respectively.
- The shell provides a notation for redirecting files using the file descriptor number, and since ***stderr*** is file descriptor number 2, we can *redirect stderr* with the following notation:
  - Syntax: **$ command 2> outputfile.txt**
  - Example: **$ ls -l /bin/usr 2> binary_list.txt**
- This time the error is not displayed to the terminal, and if we open binary_list.txt we will see the error:
  - *ls: /bin/usr: No such file or directory*

I/O Redirection

- What if we wish to capture *both stdin* and *stdout?*
- Recent versions of bash provide a streamlined method for *combined redirection:*
  - Syntax: **$ command &> outputfile.txt**
  - Example: **$ ls -l /bin/usr &> binary_list.txt**
- You can also *append both stdin and stderr* with the following:
  - Syntax: **$ command &>> outputfile.txt**
  - Example: **$ ls -l /bin/usr &>> binary_list.txt**

Pipelines

- A pipeline is a shell feature that allows *commands* to read data from *stdin* and send to *stdout*
- The *stdout* of one command can be *piped to* the *stdin* of another using the pipe operator "|"*:*
  - Syntax: **$ command1 | command2**
  - Example: **$ ls -l /usr/bin | less**
- But what is the difference between ">" and "|"?
  - Simply put, the *redirection operator* connects a command with a file while the *pipeline operator* connects the output of one command with the input of a second command

Pipelines

- A lot of people mistakenly try to just redirect a command to another command (I get it)
- This can be pretty bad….

Here is an actual example submitted by a reader who was administering a Linux-based server appliance. As the superuser, he did this:

```
# cd /usr/bin
# ls > less
```

The first command put him in the directory where most programs are stored and the second command told the shell to overwrite the file `less` with the output of the `ls` command. Since the `/usr/bin` directory already contained a file named "less" (the `less` program), the second command overwrote the `less` program file with the text from `ls` thus destroying the `less` program on his system.

The lesson here is that the redirection operator silently creates or overwrites files, so you need to treat it with a lot of respect.

Pipelines + Filters

- The real power of pipelines becomes apparent when users can perform very complex operations on data by simply stringing commands together.
- Commands that are used in this fashion are referred to as *filters.*
- Filters take input, modify it, and then output it.
  - Syntax: **$ command1 | command2 | command3**
  - Example: **$ ls /bin /usr/bin | sort | less**
- The first command specifies two lists (one for each directory) but because we piped it to *sort*, it returns a single, sorted list, and displays the results one page at a time since that list is piped to *less.*

Common Filter Commands

Program	What it does
sort	Sorts standard input then outputs the sorted result on standard output.
uniq	Given a sorted stream of data from standard input, it removes duplicate lines of data (i.e., it makes sure that every line is unique).
grep	Examines each line of data it receives from standard input and outputs every line that contains a specified pattern of characters.
fmt	Reads text from standard input, then outputs formatted text on standard output.
pr	Takes text input from standard input and splits the data into pages with page breaks, headers and footers in preparation for printing.
head	Outputs the first few lines of its input. Useful for getting the header of a file.
tail	Outputs the last few lines of its input. Useful for things like getting the most recent entries from a log file.
tr	Translates characters. Can be used to perform tasks such as upper/lowercase conversions or changing line termination characters from one type to another (for example, converting DOS text files into Unix style text files).
sed	Stream editor. Can perform more sophisticated text translations than **tr**.
awk	An entire programming language designed for constructing filters. Extremely powerful.

Wildcards

- Since the shell uses filenames so much, it provides special characters to help you rapidly specify groups of filenames.
- These special characters are called *wildcards*.
- Wildcards allow you to select filenames based on patterns of characters.

Summary of wildcards and their meanings

Wildcard	Meaning
*	Matches any characters
?	Matches any single character
[*characters*]	Matches any character that is a member of the set *characters*. The set of characters may also be expressed as a *POSIX character class* such as one of the following: POSIX Character Classes **[:alnum:]** Alphanumeric characters **[:alpha:]** Alphabetic characters **[:digit:]** Numerals **[:upper:]** Uppercase alphabetic characters **[:lower:]** Lowercase alphabetic characters
[!*characters*]	Matches any character that is not a member of the set *characters*

Wildcard Examples

Examples of wildcard matching

Pattern	Matches
`*`	All filenames
`g*`	All filenames that begin with the character "g"
`b*.txt`	All filenames that begin with the character "b" and end with the characters ".txt"
`Data???`	Any filename that begins with the characters "Data" followed by exactly 3 more characters
`[abc]*`	Any filename that begins with "a" or "b" or "c" followed by any other characters
`[[:upper:]]*`	Any filename that begins with an uppercase letter. This is an example of a character class.
`BACKUP.[[:digit:]][[:digit:]]`	Another example of character classes. This pattern matches any filename that begins with the characters "BACKUP." followed by exactly two numerals.
`*[![:lower:]]`	Any filename that does not end with a lowercase letter.

cut

- While **head** and **tail** allow you to select rows from a text file, you can use the **cut** command to select columns
- When you call the **cut** command, you need to specify the *fields* (columns) you want to extract and the *delimiter* that separates those columns
  - The *–f* flag is used to denote *fields*
  - The *–d* flag is used to denote *delimiters*
  - Example: **$ cut –f 2 –d , data.csv**
    - This will take the second column of the dataset separated by a comma

sort

- The sort program sorts the contents of standard input, or one or more files specified on the command line, and sends the results to standard output. (Typically used with pipes and usually before **uniq**)
- Prints the lines of its input or concatenation of all files listed in its argument list *in sorted order*.
- Sorting is performed on each line starting with the first character in the line.
- Blank space is the default field separator.
- A few options (there are many more):
  - -r : reverse the sort order
  - -n: sort according to numerical value
  - -f: ignore case (case insensitive)
  - -k: sort by key # (example later)
  - -b: ignore leading blanks - calculates sorting based on the first non-whitespace character on the line.

sort

- Example: sort the results of the du command to determine which packages that come with the anaconda distribution are the largest users of disk space. (Normally, the du command lists the results in pathname order).
- **$ du -s /anaconda3/pkgs/* | sort -nr | head -n 10**
- By piping the output to sort, and using the -nr options, we produce a reverse numerical sort, with the largest values appearing first in the results. This sort works because the numerical values occur at the beginning of each line.
- But what if we want to sort a list based on some value found within the line?
  - For example, the results of an **ls -l**:

sort

- I know that ls has a "-s" option for sort, but if we ignore that and look at the output of ls – l, we can pipe the output to sort to order our list by filesize as well
- **$ ls -l**

```
-rw-r--r--  1 brentskoumal  staff  3965921 Sep 24 21:47 adult.csv
-rw-r--r--  1 brentskoumal  staff  3974305 Sep 24 21:18 adult.data
-rw-r--r--  1 brentskoumal  staff  3965921 Sep 24 21:44 adult2.csv
-rw-r--r--  1 brentskoumal  staff        0 Sep 24 21:39 adult_sample.csv
-rw-r--r--  1 brentskoumal  staff      125 Sep 18 21:07 brents_text.txt
-rw-r--r--@ 1 brentskoumal  staff    90975 Sep 19 17:36 county_fips.txt
-rw-r--r--  1 brentskoumal  staff      564 Sep 24 21:07 email_list.txt
-rw-r--r--  1 brentskoumal  staff       30 Sep 25 20:26 foo.txt
-rw-r--r--@ 1 brentskoumal  staff     6246 Sep 24 21:55 group_export_7908.csv
-rw-r--r--@ 1 brentskoumal  staff    24814 Sep 24 21:55 group_export_7908_by_course.cs
-rw-r--r--  1 brentskoumal  staff      140 Sep 24 21:27 header.csv
-rw-r--r--  1 brentskoumal  staff      193 Sep 24 20:21 redirected_output.txt
```

- **$ ls –l | sort –nr –k 5 | head**
- Many uses of sort involve the processing of tabular data, such as the results of the ls command above. If we apply database terminology to the table above, we would say that each row is a record and that each record consists of multiple fields, such as the file at-tributes, link count, filename, file size and so on. sort is able to process individual fields. In database terms, we are able to specify one or more key fields to use as sort keys. In the example above, we specify the n and r options to perform a reverse numerical sort and specify -k 5 to make sort use the fifth field as the key for sorting.

uniq

- **Finding duplicates with uniq**
- With the uniq command you can find adjacent repeated lines in a file. uniq takes several flags, the more useful ones being:
  - **uniq -c**: which adds the repetition count to each line;
  - **uniq -d**: which only outputs duplicate lines; And
  - **uniq -u**: which only outputs unique lines.
- However, uniq is not a smart command. Repeated lines will not be detected if they are not adjacent. Which means that you first need the sort the file.

grep

- The **grep** command is quite possibly the most common text processing command you will use.
- **grep** stands for *general regular expression parser.*
- It allows you to search files for characters that match a certain pattern.
- What if you wanted to know if a file existed in a certain directory or if you wanted to see if a string was found in a file?

grep

- The *grep* command takes options, a pattern to match, and files to search in:
  - Syntax: **$ grep [options] PATTERN [FILES]**
  - Example: **$grep "Falls" county_fips.txt**

Option	Meaning
`-c`	Rather than print matching lines, print a count of the number of lines that match.
`-E`	Turn on extended expressions.
`-h`	Suppress the normal prefixing of each output line with the name of the file it was found in.
`-i`	Ignore case.
`-l`	List the names of the files with matching lines; don't output the actual matched line.
`-v`	Invert the matching pattern to select nonmatching lines, rather than matching lines.

curl

- curl is a tool to transfer data from or to a server, using one of the supported protocols (DICT, FILE, FTP, FTPS, GOPHER, HTTP, HTTPS, IMAP,IMAPS, LDAP, LDAPS, POP3, POP3S, RTMP, RTSP, SCP, SFTP, SMTP, SMTPS,TELNET and TFTP). The command is designed to work without user interaction.
  - Example:
  - `$ curl https://repo.continuum.io/archive/Anaconda3-5.1.0-Linux-x86_64.sh > install.sh`
  - `$ bash install.sh`

sed

- The **sed** command is a unix utility that parses and transforms text
- At its core sed is a stream editor that operates on a line-by-line basis. It excels at substitutions, but can also be leveraged to do some very powerful stuff.
- The most basic sed command consists of s/old/new/g. This translates to search for old value, replace all occurences in-line with new. Without the /g, our command would terminate after the first occurrence on the line.
  - it reads text, line by line, from an input stream or file, into an internal buffer called the *pattern space*. Each line read starts a *cycle*. To the pattern space, sed applies one or more operations which have been specified via a *sed script*.
  - The sed script can either be specified on the command line (-e option) or read from a separate file (-f option)
  - Syntax: **$ sed "s/<string to replace>/<string to replace it with>/g" <source_file> > <target_file>**
  - Example: **$ sed -i '' 's/\([0-9]\),\([0-9]\)/\1\2/g' data.txt**

The Environment

- The shell maintains a body of information during our shell session called the *environment*.
- Data stored in the environment is used by programs to determine facts about the system's configuration.
- While most programs use *configuration* files to store program settings, some programs will also look for values stored in the environment to adjust their behavior.

What's Stored in the Environment?

- The shell stores *two* basic types of data in the environment:
  - *Environment Variables*
  - *Shell Variables*
    - Shell variables are bits of data placed there by bash and environment variables are everything else

- In addition to variables, the shell also stores *aliases* and *shell functions*.

Seeing What's in the Environment

- To see environment variables:
  - `$ printenv | less`
- To see environment and shell variables:
  - `$ set | less`
- To list the value of a specific variable:
  - `$ printenv USER`
- To see the contents of a variable:
  - `$ echo $HOME`
- To list all aliases:
  - `$ alias`

Expansion – How the Shell Sees Things

- Did you notice how we had to use **$USER** to be able to print the value of the **USER** variable?
  - This is an example of *expansion*.
- Expansion is a process where we enter a command and it is actually *expanded* into something else before the shell acts on it
  - Example: `$ echo this is a test`
  - Example: `$ echo *`
    - Why didn't *echo* print "*"?
      - The simple answer is that the shell expands the "*" into something else (in this instance, the names of the files in the current working directory) before the *echo* command is executed

Expansion – How the Shell Sees Things

- Pathname Expansion
  - The mechanism by which *wildcards* work is called *pathname* expansion
  - This is what we saw on the previous slide with "*"
- Tilde Expansion
  - This is why when used at the beginning of a word, the tilde expands into the name of the home directory of the named user, or if no user is named, the home directory of the current user
- Brace Expansion
  - Allows us to create multiple text strings from a pattern containing braces
  - Example: `$ echo Number_{1..5}`
    - Number_1 Number_2 Number_3 Number_4 Number_5

Expansion – How the Shell Sees Things

- When might this be helpful?

```
[me@linuxbox ~]$ mkdir Photos
[me@linuxbox ~]$ cd Photos
[me@linuxbox Photos]$ mkdir {2007..2009}-{01..12}
[me@linuxbox Photos]$ ls
2007-01  2007-07  2008-01  2008-07  2009-01  2009-07
2007-02  2007-08  2008-02  2008-08  2009-02  2009-08
2007-03  2007-09  2008-03  2008-09  2009-03  2009-09
2007-04  2007-10  2008-04  2008-10  2009-04  2009-10
2007-05  2007-11  2008-05  2008-11  2009-05  2009-11
2007-06  2007-12  2008-06  2008-12  2009-06  2009-12
```

Expansion – How the Shell Sees Things

- Parameter Expansion
  - This is the type of expansion associated with having to put a **$** in front of **USER** earlier to extract the value of the variable.
  - The shell uses parameter expansion so it knows whether you want a filename, value of a variable, etc.

Environment Variables

- Environment variables are usually stored as upper case
- A few of the most important ones to know are:

Variable	Contents
HOME	The path of the user's home directory
PWD	Present working directory; same value returned by pwd command
USER	Your username
OLDPWD	The previous working directory
SHELL	The name of the shell program being used
PATH	A colon-separated list of directories that are searched when you enter the name of a executable program.

- Try running: **$ echo $PATH**

How is the Environment Established?

- When we log on to the system, the *bash* program starts, and reads a series of configuration scripts called *startup files*, which define the default environment shared by all users.
- This is followed by more startup files in our home directory that define our personal environment.
- The exact sequence depends on the type of shell session being started. There are two kinds:
  - login shell session
    - One in which the user is prompted for username and password
  - non-login shell session
    - Typically occurs when we launch a terminal session in the GUI

Startup Files

- Login shells read:

File	Contents
/etc/profile	Global configuration script that applies to all users
~/.bash_profile	User's personal startup file. Extend or override global settings
~/.bash_login	If ~/.bash_profile isn't found, then bash tries to read this
~/.profile	If ~/.bash_profile and ~/.bash_login aren't found, then bash tries to read this

- Non-login shells read:

File	Contents
/etc/bash.bashrc	Global configuration script that applies to all users.
~/.bashrc	User's personal startup file. Extend or override global settings

How does the shell find commands?

- Remember when we showed that the **ls** program was located at **/bin/ls** by running **which ls**?
  - So how does the computer know how to find the **ls** command when we don't supply the path?
  - The computer searches a list of directories that are contained in the **PATH** variable
- Did you get asked when downloading Anaconda if you wanted to add it to your PATH variable?
  - Saying "yes" adds the following to your *~/.bash_profile*:
    - **$ export PATH="/Users/michaelarango/anaconda3/bin:$PATH"**
    - Note: the *export* command tells the shell to make the contents of PATH available to child processes of this shell.

Week 6

DATS 6450 – FOUNDATIONS OF COMPUTER SCIENCE

Shell Scripts

- A *shell script* is a file containing a series of commands (just like a Python script)
- There are three things we need to do to create and run shell scripts:
  1. Write the script
     - Shell scripts are text files, so you're going to want a good text editor.
  2. Make the script executable
     - You need to tell the computer that the text file is a program and change the permissions to allow execution
  3. Put the script somewhere the shell can find it
     - Add it to a directory in your PATH

Basic Text Editors

Editor	Type	Cmd	Notes
• VI • VIM	System Default (Text Only)	vi vim	• The default for Unix systems, vi and vim are universally available (vi is the grandpa of text editors) • Supports syntax highlighting • Powerful, lightweight, and fast • Famous for its difficult, non-intuitive command structure w/ different "modes" • Nice once you learn the shortcuts • VIM is an extended version of the vi, with additional features
EMACS	System Default (Text Only)	emacs	• A screen-based editor with an embedded computer language (EMACS LISP) • Similar to VI in that it has many programmable features/shortcuts • Emacs vs VI is a famous battle among nerds
NANO	System Default (Text Only)	nano	• Very simple and easy to use but short on features • One B&W mode only • Recommended for first-time users who need a simple command line editor
gedit	Basic GUI	gedit	• Designed as a general-purpose text editor • Emphasizes ease of use, Supports syntax highlighting • Clean/simple GUI • Available for Windows/Mac as well as Linux
notepad	Basic GUI	?	• Simple text editor for Windows one of the first GUI text editors • It was first released as a mouse-based MS-DOS program in 1983, and has been included in all versions of Microsoft Windows since Windows 1.0 in 1985. • "Historically, Notepad did not treat newlines in unix- or classic MacOS-style text files correctly…However, on 8th May 2018, Microsoft announced that they had fixed this issue"

Fancy Text Editors

Editor	Type	Cmd	Notes
Sublime	GUI	subl	• Many themes/color options • Autocompletion and Find/Replace are supported • Auto-indentation/Brace-Matching • Integrated Git Functionality • Supports add-ons/extension/packages + Build Environments • Snippets - allows users to save blocks of frequently used code and assign keywords to them • Somewhat lightweight compared to other fancy editors
Atom	GUI	atom	• Same as Sublime
Notepad++	GUI	notepad++	• Same as Sublime/Atom, slightly less add-ons/extensions • No "Build" • Windows only (used by many engineers and lots of C/C++ Users) • In 2015 Stack Overflow conducted a worldwide Developer Survey, and Notepad++ was voted as the most used text editor worldwide with 34.7% of the 26,086 respondents claiming to use it daily. The 2016 survey had NotePad++ at 35.6%.

Wikipedia List

VI Basics

Modes & Controls

Command Mode	ESC (commands preceded by :)
Insertion Mode	Entered on insertion or change

Starting VI (command line)

vi <filename>	Edit *filename*
vi -r <filename>	Edit last version of *filename* after crash
vi + *n* <filename>	Edit *filename* at line *n*
vi + <filename>	Edit *filename* at end of file
vi +/*str* <filename>	Edit *filename* at first occurance of *str*

In insertion mode the following should be preceded by ESC:

:w	Save
:x	Save & Exit
:q	Exit if no changes made
:q!	Exit & discard any changes

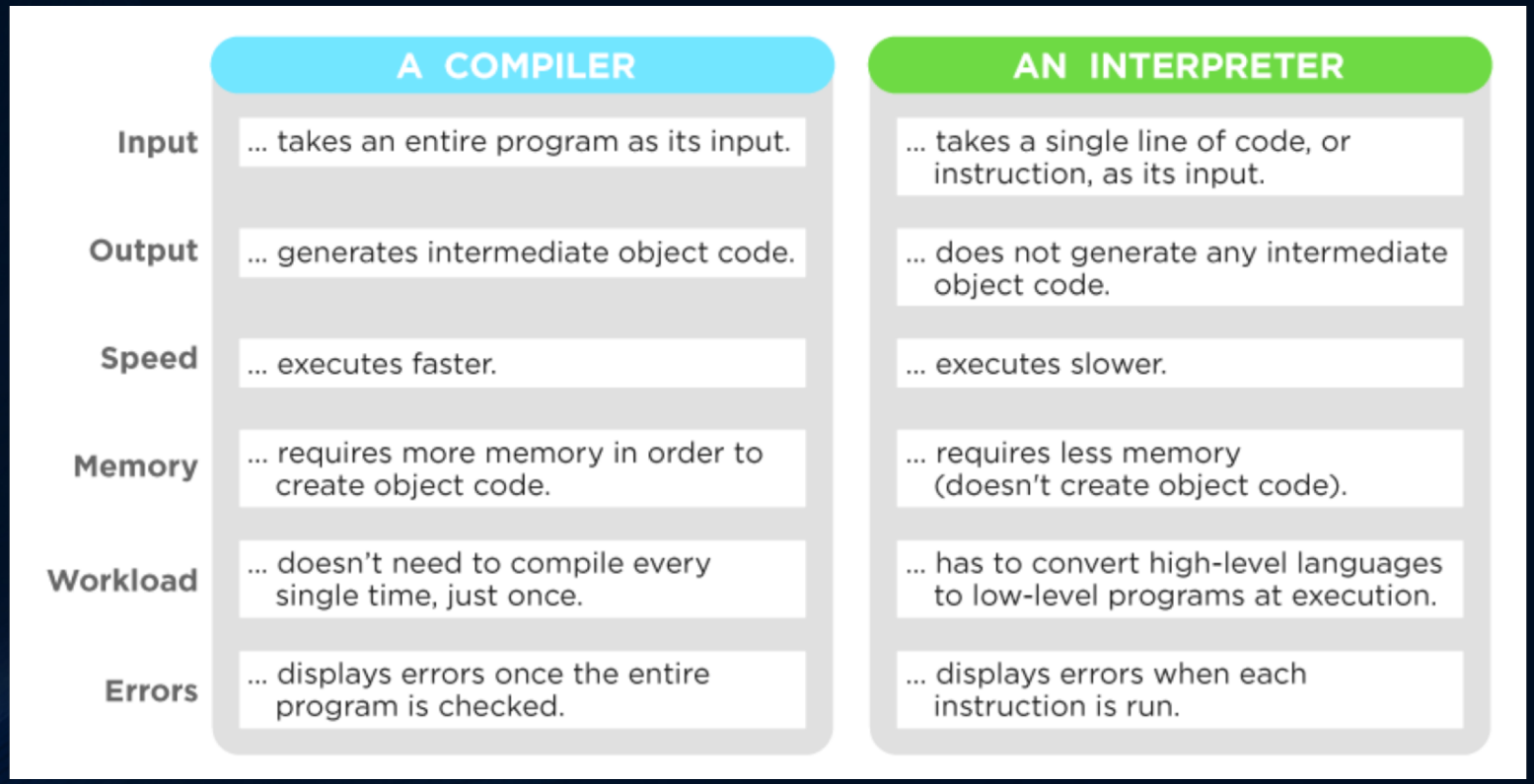
Compilers and Interpreters

- We generally write a computer program using a high-level language. A high-level language is one which is understandable by us humans. It contains words and phrases from the English (or other) language.
- A computer does not understand high-level language. It only understands program written in 0's and 1's in binary, called “machine code”.
- A program written in high-level language is called a *source code*.
- We need to convert the source code into machine code and this is accomplished by compilers and interpreters. Hence, a compiler or an interpreter is a program that converts program written in high-level language into machine code understood by the computer.

Compilers and Interpreters

Compiler	Interpreter
Scans the entire program and translates it as a whole into machine code. Examples include C, C++, C#, Java, Lua, VisualBasic , .NET	Translates program one statement at a time. Examples include Perl, Python, Matlab, R, Javascript, PHP
It takes large amount of time to analyze the source code but the overall execution time is comparatively faster.	It takes less amount of time to analyze the source code but the overall execution time is slower.
Generates intermediate object code which further requires linking, hence requires more memory.	No intermediate object code is generated, hence are memory efficient.
It generates the error message only after scanning the whole program. Hence debugging is comparatively hard.	Continues translating the program until the first error is met, in which case it stops. Hence debugging is easy.

Compilers and Interpreters



	A COMPILER	AN INTERPRETER
Input	... takes an entire program as its input.	... takes a single line of code, or instruction, as its input.
Output	... generates intermediate object code.	... does not generate any intermediate object code.
Speed	... executes faster.	... executes slower.
Memory	... requires more memory in order to create object code.	... requires less memory (doesn't create object code).
Workload	... doesn't need to compile every single time, just once.	... has to convert high-level languages to low-level programs at execution.
Errors	... displays errors once the entire program is checked.	... displays errors when each instruction is run.

Hello World

- Open up the text editor of your choice and type what you see in the box below.
- Save it as *hello_world*.

```
#!/bin/bash

# This is our first script.

echo 'Hello World!'
```

- Comments in the shell are made with "#"
- The first line is a special sequence
  - **#!** is called *shebang* and it tells the system what interpreter to use when executing the script.
    - Every shell script should include this
    - Have you ever seen a python script with **#! usr/bin/python** at the top?

Hello World

- We saw last week that default permissions are *rw-r--r--*, so we will need to use *chmod* to make it executable:
  - **$ chmod 700 hello_world** makes it executable for just the owner (you)
  - **$ chmod 755 hello_world** makes it executable for everyone

- We can execute the script with **$ ./hello_world**
  - Why can't we just type **$ hello_world**?
    - If the PATH variable doesn't contain the current working directory, then we need to provide the path to the script at the front.

Demo

WRITING YOUR FIRST SHELL SCRIPT!

Control Flow: Branching with *if*

- Often we need to have our code *branch* off in a different direction based on whether or not a certain condition is met.
- Using the shell, we can do this very similarly to how we do it in Python:

```
x=5

if [ "$x" -eq 5 ]; then
    echo "x equals 5."
else
    echo "x does not equal 5."
fi
```

Control Flow: Branching with *if*

- The *if* statement has the following syntax

```
if commands; then
     commands
[elif commands; then
     commands...]
[else
     commands]
fi
```

- where *commands* is just a list of commands like we showed on the previous slide

Positional Parameters

- One feature that was missing from our simple program was the ability to process command line options and arguments.
- The shell provides a set of variables called positional parameters that contain the individual words on the command line. The variables are named *0* through *9*.
- Even when no arguments are provided, **$0** will always contain the first item appearing on the command line, which is the pathname of the program being executed

Positional Parameters

- Sometimes, we may want to deal with all positional parameters at once in our script
- There's a special parameter, @, that allows us to do this:
- **$@** expands into the list of positional parameters, starting with 1.
  - When surrounded by double quotes, it expands each positional parameter into a separate word surrounded by double quotes.

Demo

POSITIONAL PARAMETERS

Control Flow: Looping with *for*

- There are 2 versions of *for* loops available in the shell
  - Traditional form
  - C form
- We are only going to cover the traditional form
- Syntax:

```
for variable [in words]; do
        commands
done
```

Demo and In-class example

PUTTING IT ALL TOGETHER