

Computer Systems Org - 004

Recitation

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Myself...

- Arahant (please refer to me by my 1st name :))
 - CS Grad student @ Courant.
 - Entrepreneurship, Quantum Computing, Biz analytics
 - Avid biker, traveling, writing and a dog-person
- Email: aak700@nyu.edu
- Recitation - Mondays, 8 am to 9:15 am
 - In-person (usually)
- Office hours - TBD
 - Zoom link in NYU classes
- Seating arrangements
 - Choose one and **stick to it**
- Communication - Email, NYU classes (forums)
- Let's get started...



Virtual VM (Vagrant)

- <https://github.com/arahant/nyu-cso-vm>
 - Install Vagrant (<https://www.vagrantup.com/downloads>)
 - Install Virtualbox (<https://www.virtualbox.org/wiki/Downloads>)
 - Create a Vagrantfile for your project/repo
-
- Ubuntu 20.04 (Linux)
 - GCC compiler

Basic Unix/Linux commands

- **man** - manual
- ls - list
- cd - change dir
- pwd - current dir
- mkdir - make an empty dir
- cp - copy
- mv - move
- rm - remove
- echo - write arguments to the standard output
- cat - output content of a file
- wc - word count
- grep - pattern matching
- touch - create a file

- Google/ man
- <https://github.com/jlevy/the-art-of-command-line>

Git

- Git config
 - <https://stackoverflow.com/questions/35942754/how-to-save-username-and-password-in-git-gitextension>
 - `git config -- global credential.helper store`
 - `git pull`
- Git commands
 - `git clone <url>`
 - `git status`
 - `git add`
 - `git commit -m "<your message>"`
 - `git push origin <branch>`
 - `git pull origin <branch>`

Linserv1 - Logging in

- You may program your labs on any system, but they **must** be tested on linserv1 servers, where it will be graded
- ssh <netid>@access.cims.nyu.edu
- ssh linserv1

Linserv1 - copy

- Secure copy
 - `scp -r /full/path/to/folder netid@access.cims.nyu.edu:/home/<netid>`
 - `scp /full/path/to/file netid@access.cims.nyu.edu:/home/<netid>`
- Git - copying from local machine to linserv1 (I'd recommend this)
 - local machine > `Git add` > `Git commit` > `Git push` > repo
 - repo > `git clone` > `git pull origin <branch> (master)` > cims
- Git - for each new assignment
 - `git clone <url>`
 - `git add file1.c file2.c`
 - `git commit`
 - `git push`

Linserv1 - testing

- The default gcc compiler on linserv1 is 4.8.5 (gcc —version)
- module avail gcc
- module load gcc-6.3.0 #loads gcc 6.3.0
- module unload gcc-6.3.0 #reverts back to default gcc

What is a compiler?

- C, which a high level language, is for people, not computers
 - In fact, high level languages are for **people**
 - Computer processors only understand **binary instructions**
- A compiler translates code between languages
 - In our cases, it translates from C (the source language) to machine code (the target language)

Source code - main.c

```
main.c x
1  #include <stdio.h>
2
3  int main(){
4      printf("Hello CS0!\n");
5      return 0;
6  }
```



Machine code
(binary instructions)

How to use a compiler?

- Consider a simple C program:

```
main.c
#include<stdio.h>
int main( ) {
    printf("Hello World!\n");
    return 0;
}
```

- To run this program, we must first compile it
 - Can use `gcc`: `gcc main.c` will produce a file called `a.out`
 - We can run `a.out` by issuing `./a.out`
 - You can choose the name of executable with `-o`, as in `gcc main.c -o myprogram`

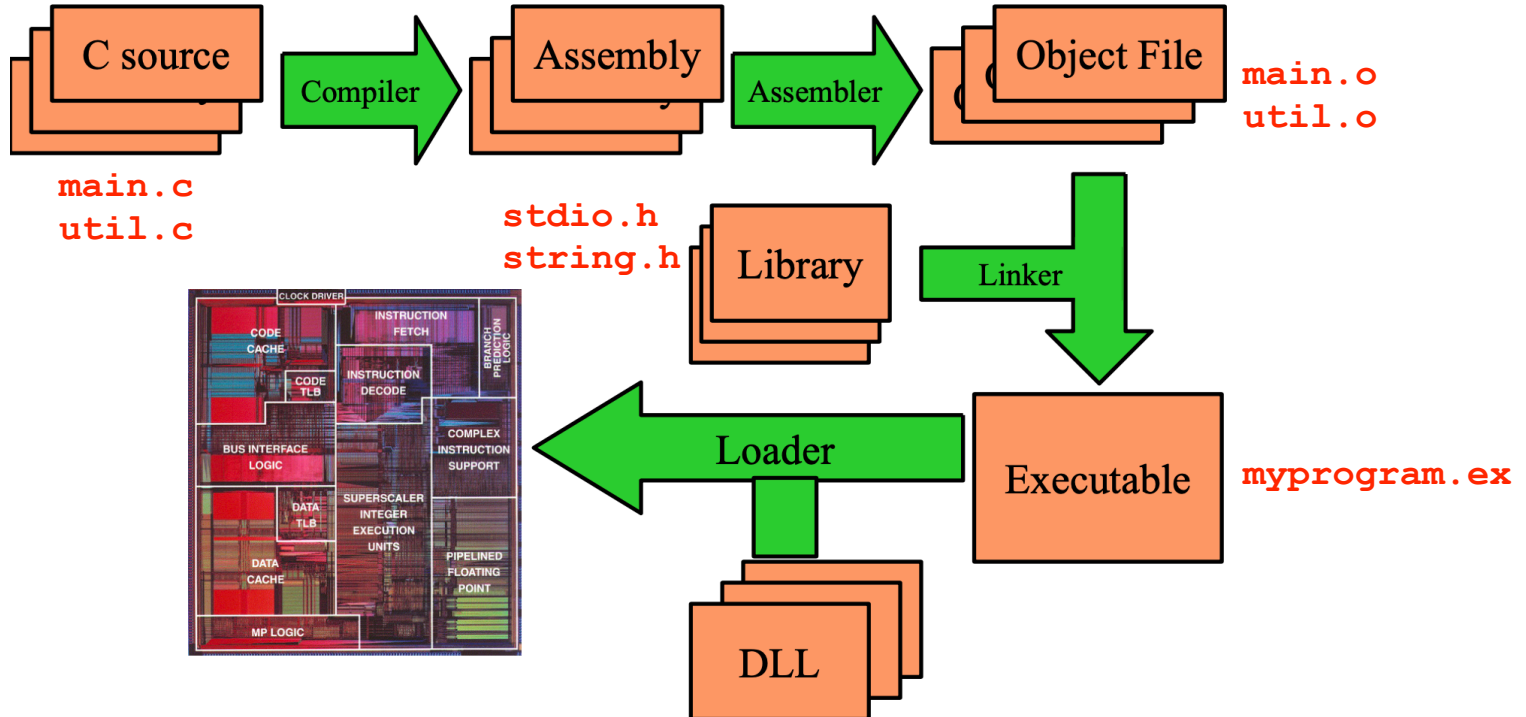
Potential challenge

- For large projects, recompiling everything can be slow
- To avoid this, we can compile files separately, **without linking** using the `-c` flag
 1. Ordinarily, the compiler compiles each source file into object code
 2. Then links them and
 3. Deletes the intermediate object code
- `gcc -c main.c util.c`
 - Will create `main.o` and `util.o`
 - Then we can add to `main.c` and `util.c` and not have to recompile the other
 - We can later do link by running `gcc main.o util.o -o myprogram`

Compiling and Linking

- Compiling isn't quite the same as creating an executable file!
- Instead, creating an executable is a multistage process divided into two components: compilation and linking
- Compilation:
 - Refers to the processing of source code files and the creation of an 'object' file
 - Merely produces the machine language instructions
- Linking:
 - Refers to the creation of a single executable file from multiple object files
- .c is the source code
- .o extension is for an object file - this is a binary file generated by compilation unit
- executable files should have no extension (by default a.out, which has the .out extension)

Source code to execution - stages



Makefile

- In the real world, things are so elaborate and complicated...
 - The Linux kernel has over 45,000 files of C code - it uses almost 2700 Makefiles
- Make will also know when we need to recompile different sources
- Make builds projects for us, keeping track of when it needs to recompile or not
 - When make recompiles, each modified C source file must be recompiled
 - If any source file has been recompiled, all the object files must be linked together to produce the new executable
- We tell make about the dependencies in our code in the Makefile
- Makefile consists of a number of 'rules':

Makefile

- Rules specify:
 - A target, which is usually the name of a file that is generated by a program
 - Targets include main.o or myprogram
 - Dependencies, which are files that are used as input to create the target
 - main.o needs main.c
 - myprogram needs main.o and util.o
 - Commands, which are actions that make carries out
 - gcc -c main.c -o main.o
- Rules look like this:

```
myprogram: main.o util.o
    gcc main.o util.o -o myprogram
```
- However, the rule that specifies commands for the target need not have dependencies, for example “clean”
 - make clean
- A clumsy Makefile...

```
myprogram: main.c util.c
    gcc main.c util.c -o myprogram
```

Makefile

A good Makefile:

```
myprogram: main.o util.o
    gcc main.o util.o -o myprogram
main.o: main.c
    gcc -c main.c -o main.o
util.o: util.c
    gcc -c util.c -o util.o
clean:
    rm -f main.o util.o myprogram
```

- Make supports pattern matching with the %
 - %.c means all .c files
- Make has “automatic variables”
 - The meaning of variables within a rule is contextual
 - \$@ is the name of the rule
 - \$^ is the list of dependencies
- Example:

```
%.o: %.c
    gcc -c $^ -o $@
```