The Edit-Compile-Run Cycle

EECS 211

Winter 2019
So you’ve written a C program:

```c
#include <stdio.h>

int main()
{
    printf("Hello, EECS 211!\n");
}
```

What now?
Compilation

We need to translate our program from

- source code (e.g., C, human readable)

to

- machine code (machine executable).
What does machine code look like?

55
48 89 e5
48 83 ec 10
48 8d 3d 37 00 00 00
b0 00
e8 0e 00 00 00
31 c9
89 45 fc
89 c8
48 83 c4 10
5d
c3
What does machine code look like?

```
55  pushq %rbp
48 89 e5  movq %rsp, %rbp
48 83 ec 10  subq $16, %rsp
48 8d 3d 37 00 00 00  leaq 55(%rip), %rdi
b0 00  movb $0, %al
e8 0e 00 00 00  callq 14
31 c9  xorl %ecx, %ecx
89 45 fc  movl %eax, -4(%rbp)
89 c8  movl %ecx, %eax
48 83 c4 10  addq $16, %rsp
5d  popq %rbp
c3  retq
```
Using Unix

For the first few weeks of class, we are going to develop and test our programs under Unix.
For the first few weeks of class, we are going to develop and test our programs under Unix.

Unix  A style of multi-user operating system invented 50 years ago. (Modern variants include Linux and Mac OS X.)
Using Unix

For the first few weeks of class, we are going to develop and test our programs under Unix.

Unix  A style of multi-user operating system invented 50 years ago. (Modern variants include Linux and Mac OS X.)

shell The main program for controlling a Unix computer, using textual commands.
For the first few weeks of class, we are going to develop and test our programs under Unix.

**Unix** A style of multi-user operating system invented 50 years ago. (Modern variants include Linux and Mac OS X.)

**shell** The main program for controlling a Unix computer, using textual commands.

**terminal** A program (or historically, device) for displaying textual interactions, often remote, with a Unix computer.
Advantages of the Unix shell (1/2)

Compared to point-and-click, you can say more with less:

```
$ mkdir backup
$ cp *.docx backup
```
Advantages of the Unix shell (1/2)

Compared to point-and-click, you can say more with less:

$ mkdir backup
$ cp *.docx backup

$ mkdir thumbs
$ foreach i ( *.png )
   convert -geometry 128x128 "$i" "thumbs/$i"
end
Advantages of the Unix shell (2/2)

You can automate repeated tasks by putting common sequences of commands in *shell scripts*:

```
#!/bin/sh

for dir in "*$"; do
    ( cd "$dir"
      mkdir -p thumbs
      for file in *.png; do
          convert -geometry 128x128 "$file" "thumbs/$file"
      done
    )
done
```
Compilation in the Unix shell

```
$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
$./hello
Hello, EECS 211!
```
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$

$
Compilation in the Unix shell

```bash
$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
```
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211

$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
$ ./hello
Hello, EECS 211!
Compilation in the Unix shell

```bash
$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
$ ./hello
Hello, EECS 211!
```
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls

$ cc hello.c -o hello
$ ls

Hello, EECS 211!
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ ls
hello.c
$ cc hello.c -o hello
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello  hello.c
$
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ ls
hello hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
$ ./hello

Hello, EECS 211!
Compilation in the Unix shell

$ exec scl enable devtoolset-6 tcsh
$ mkdir eecs211
$ cd eecs211
$ emacs -nw hello.c
$ ls
hello.c
$ cc hello.c -o hello
$ ls
hello hello.c
$ ./hello
Hello, EECS 211!
$
As programs get larger, builds get more complicated:

- More files to compile, in complex combinations
- Want to just recompile the changed files
- Different compilers/machines want different options and work differently
Build management

As programs get larger, builds get more complicated:

- More files to compile, in complex combinations
- Want to just recompile the changed files
- Different compilers/machines want different options and work differently

We’ll use a software building system called Make to automate builds for us.
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
cc -o hello hello.c
```

(Meaning: To build `hello` from `hello.c`, run the command `cc -o hello hello.c`.)

Using Make:

```
$ make hello
cc -o hello hello.c
$ make hello
make: `build/hello' is up to date.
```

Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)

Using Make:

```
$ make hello
```
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)

Using Make:

```
$ make hello
```
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)

Using Make:

```
$ make hello
cc -o hello hello.c
$
```
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)

Using Make:

```
$ make hello
cc -o hello helloc
$ make hello
```
Introduction to Make

Make is configured using a file called Makefile, which is a set of rules that say what you can build, what it’s built from, and how.

The simplest possible Makefile:

```
hello: hello.c
    cc -o hello hello.c
```

(Meaning: To build hello from hello.c, run the command cc -o hello hello.c.)

Using Make:

```bash
$ make hello
cc -o hello hello.c
$ make hello
make: `build/hello' is up to date.
$
Cleaning up

```
$ cd
$ rm -Rf eecs211
$ mkdir eecs211
```
Cleaning up

$ cd
Cleaning up

$ cd

$
Cleaning up

$ cd
$ rm -Rf eecs211
Cleaning up

$ cd
$ rm -Rf eecs211
$
Cleaning up

$ cd
$ rm -Rf eecs211
$ mkdir eecs211
Cleaning up

$ cd
$ rm -Rf eecs211
$ mkdir eecs211
$
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
$ unzip 01compile.zip
$ cd 01compile
$ ls Makefile src
$ ls src
hello.c
```

Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```bash
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eeecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
$
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```bash
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
$ ls
```
Getting a Make project onto EECS

You can download an example Make project from the course website:

```
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
$ ls
Makefile src
$`

Getting a Make project onto EECS

You can download an example Make project from the course website:

```bash
$ cd eecs211
# All on one line:
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
$ ls
Makefile src
$ ls src
```
You can download an example Make project from the course website:

```
$ cd eecs211  
# All on one line:  
$ wget http://users.eecs.northwestern.edu/~jesse/course/eecs211/lec/01compile.zip
...
$ unzip 01compile.zip
...
$ cd 01compile
$ ls
Makefile  src
$ ls src
hello.c
$ 
```
Another Makefile
$ cat Makefile
Another Makefile

$ cat Makefile
CFLAGS = -std=c11 -pedantic -Wall

all: build/hello

build/hello: src/hello.c
    mkdir -p build
    cc -o $@ $< $(CFLAGS)

clean:
    rm -Rf build

.PHONY: all clean
$
Building the project using Make

$ make

$ mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall

$ build/hello
Hello, EECS 211!

$ sed -i 's/EECS 211/everyone/' src/hello.c

$ build/hello
Hello, everyone!

$ make

$ mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall

$ build/hello
Hello, everyone!
Building the project using Make

$ make

$ make

$ make
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$
$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
Building the project using Make

```
$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$  
```
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$ build/hello
Building the project using Make

$ make
mkdir -p build
c -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$ build/hello
Hello, EECS 211!
$
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$ build/hello
Hello, EECS 211!
$ make
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$ build/hello
Hello, EECS 211!
$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/\' src/hello.c
$ build/hello
Hello, EECS 211!
$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Building the project using Make

$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, EECS 211!
$ sed -i 's/EECS 211/everyone/' src/hello.c
$ build/hello
Hello, EECS 211!
$ make
mkdir -p build
cc -o build/hello src/hello.c -std=c11 -pedantic -Wall
$ build/hello
Hello, everyone!
$