University at Buffalo
Department of Computer Science and Engineering
School of Engineering and Applied Sciences

CSE 220: Systems Programming

2 – *Introduction to C*

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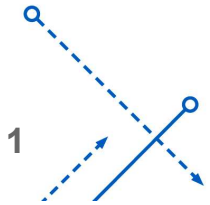
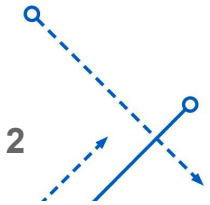


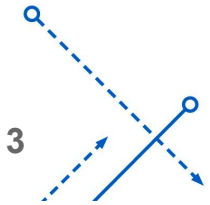
Why C?

- Dozens of programming languages – why C?
  - C is “high level” – but not very
  - C provides functions, structured programming, complex data types and many other powerful abstractions
- It also exposes many architectural details
- Most system software including OS kernels are written in C/C++
- C influences many other languages



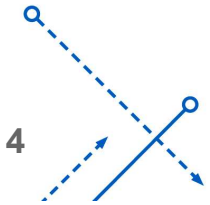
Effective C

- Effective programming in C requires that you master the machine
- You must be aware of the system architecture and details of operation
- We will be using C in Linux on x86-64
- The compiler we will use is `gcc`
- The dialect of C we will use is C99



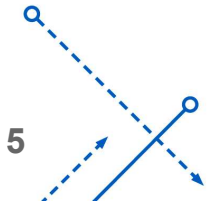
CSE 220 and C

- That said, CSE 220 is not about learning C (only)
- CSE 220 teaches you systems concepts, and you will learn to implement them in C
- We will not cover all details of C syntax
- We will cover ideas, and some syntax when we feel necessary
- You should consult:
  - K&R book
  - Unix man pages
  - Given code



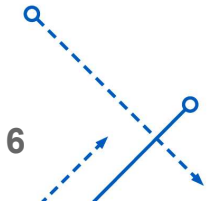
A Simple Computer Model

- Data in memory is stored at accessible addresses
- CPU is able to manipulate data stored in memory and access I/O
- Program code is executed as a series of instructions
  - That manipulate memory
  - Interact with input/output devices
  - Display results to the user
- Program code is also stored in memory – possibly not accessible



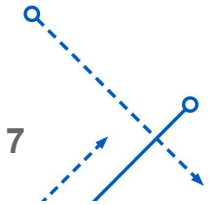
Modern Multi-Tasking OS

- Most modern OSes (including *NIX) provide a particular model
- Each process has its own dedicated resources, i.e., each process appears to have:
  - A dedicated CPU
  - Private, dedicated memory
  - Private I/O
- OS provides mechanisms to share existing resources among all active processes



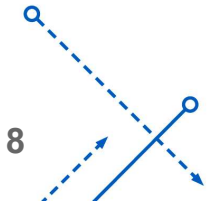
Program Execution

- C programs (all programs) are translated into machine instructions
- Computer executes these instructions in order
- Instructions are things like:
  - Add two numbers together (and other arithmetic operations)
  - Store a number to a location in memory
  - Retrieve a sensor reading
  - Display a result
- Its all numbers!



Imperative Programming

- C is an imperative language
- It consists of a list of statements
- Each statement is an instruction to the computer to do something
- Statements can be grouped into functions
- The computer executes the program from beginning to end (roughly) – i.e., imperative
- Modern systems (especially interactive systems such as smartphones/robots) allow for event-driven programming



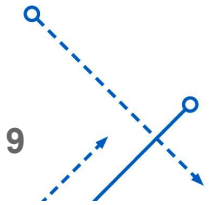
Let Us C

- Every C program starts with the function `main()`

```
int main()  {
  return 0;
}
```

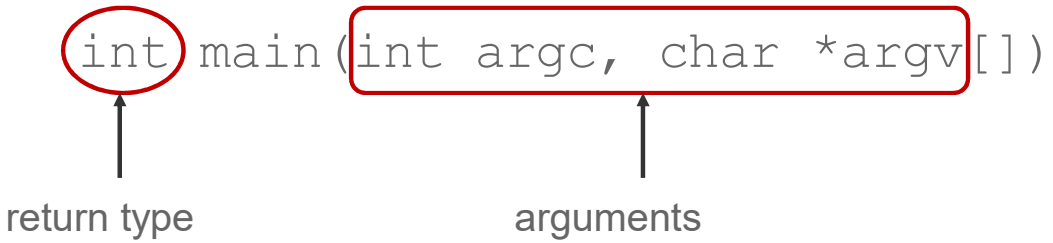
- Every C function takes zero or more arguments
- Every C function can return a single value
- Every statement ends with a semi-colon (;)
- C programs are stored in files that end with .c extension

- Lets examine `main()` in more detail



main()

- The main function takes two arguments:



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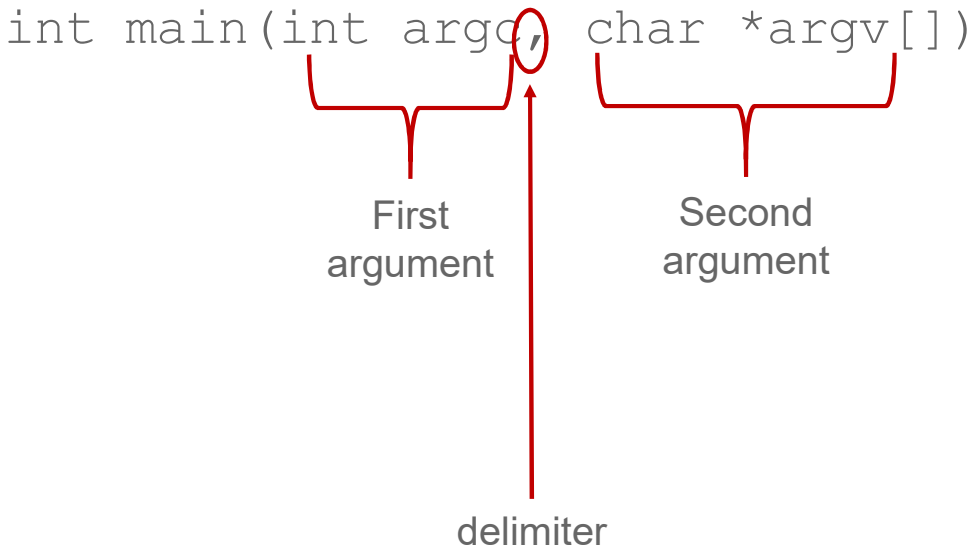

main()

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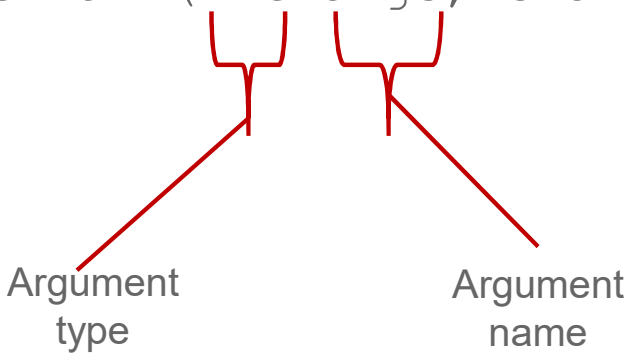
```
int main(int argc, char *argv[])
```



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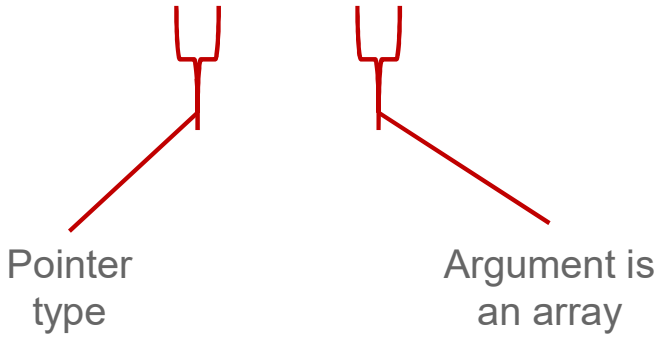


Aside on slide syntax

```
$ gcc program.c -o program
```

Terminal prompt

- `$` sign indicates the terminal prompt
- Please do not type this – you will get an error
- You should type everything that follows the `$` sign
- Good time to brush up on Linux basics

[1] Quick tutorial: https://www.digitalocean.com/community/tutorials/an-introduction-to-linux-basics

[2] Comprehensive set: https://ryanstutorials.net/linuxtutorial/

Compiling a C Program

- Assume you saved our earlier program as trivial.c:

```
int main()  {
  return 0;
}
```

- We can compile it into an executable program as follows:

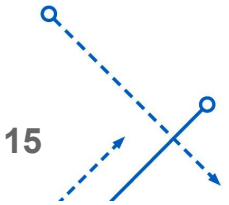
```
$ gcc trivial.c
```

- This produces a file a.out, which is a native binary

```
$ ls
a.out                trivial.c
```

- You can run the binary as follows:

```
$ ./a.out
$
```

First Real Program

- “Hello World” is a classic first program when learning a language
- Objective is to print “Hello, world!” in the terminal