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CS61C : Machine Structures

Lecture 3 – Introduction to the C Programming Language (pt 1)

2011-08-31 Get your clickers ready...

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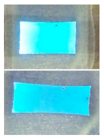
First Strechable OLED! ⇒ Still in the early research stage, but engineers at sister campus UCLA have developed an organic light-emitting diode that streches, which could lead to electronics that can be rolled up like cloth.

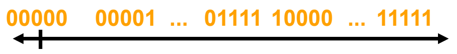


www.technologyreview.com/computing/38439/

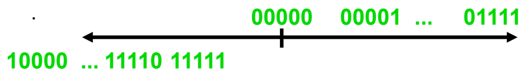
And in review...

META: We often make design decisions to make HW simple

- We represent "things" in computers as particular bit patterns: N bits ⇒ 2^N things
- These 5 integer encodings have different benefits; 1s complement and sign/mag have most problems.
- unsigned (C99's `uintN_t`) :



- 2's complement (C99's `intN_t`) universal, learn!



- Overflow: numbers ∞; computers finite,errors!

META: Ain't no free lunch

"Before this class, I (student) would say I am a solid C programmer"

a) Strongly disagree (never coded, and I *don't* know Java or C++)

b) Mildly disagree (never coded, but I *do* know Java and/or C++)

c) Neutral (I've coded *a little* in C)

d) Mildly agree (I've coded *a fair bit* in C)

e) Strongly agree (I've coded a *lot* in C)

Has there been an update to ANSI C?

- Yes! It's called the "C99" or "C9x" std
  - You need "`gcc -std=c99`" to compile
- References
  - http://en.wikipedia.org/wiki/C99
  - http://home.tiscalinet.ch/t_wolf/tw/c/c9x_changes.html
- Highlights
  - Declarations in for loops, like Java (#15)
  - Java-like `//` comments (to end of line) (#10)
  - Variable-length non-global arrays (#33)
  - `<inttypes.h>`: explicit integer types (#38)
  - `<stdbool.h>` for boolean logic def's (#35)

Disclaimer

- Important: You will not learn how to fully code in C in these lectures! You'll still need your C reference for this course.
  - K&R is a must-have reference
    - Check online for more sources
  - "JAVA in a Nutshell," O'Reilly.
    - Chapter 2, "How Java Differs from C"
    - http://oreilly.com/catalog/javanut/excerpt/
  - Brian Harvey's course notes
    - On CS61C class website

Compilation : Overview

C *compilers* take C and convert it into an architecture specific machine code (string of 1s and 0s).

- Unlike Java which converts to architecture independent bytecode.
- Unlike most Scheme environments which interpret the code.
- These differ mainly in when your program is converted to machine instructions.
- For C, generally a 2 part process of compiling .c files to .o files, then linking the .o files into executables. Assembling is also done (but is hidden, i.e., done automatically, by default)

Compilation : Advantages

- **Great run-time performance: generally much faster than Scheme or Java for comparable code (because it optimizes for a given architecture)**
- **OK compilation time: enhancements in compilation procedure (`Makefiles`) allow only modified files to be recompiled**

Compilation : Disadvantages

- **All compiled files (including the executable) are architecture specific, depending on *both* the CPU type and the operating system.**
- **Executable must be rebuilt on each new system.**
  - **Called "porting your code" to a new architecture.**
- **The "change→compile→run [repeat]" iteration cycle is slow**

C Syntax: `main`

- **To get the main function to accept arguments, use this:**

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

- **What does this mean?**
  - **`argc` will contain the number of strings on the command line (the executable counts as one, plus one for each argument). Here `argc` is 2:**

```
unix% sort myFile
```

  - **`argv` is a pointer to an array containing the arguments as strings (more on pointers later).**

C Syntax: Variable Declarations

- **Very similar to Java, but with a few minor but important differences**
- **All variable declarations must go before they are used (at the beginning of the block)***
- **A variable may be initialized in its declaration; if not, it holds garbage!**
- **Examples of declarations:**
  - **correct:** `{`

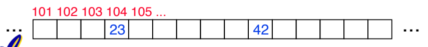
```
        int a = 0, b = 10;
        ...
```

  - **Incorrect:*** `for (int i = 0; i < 10; i++)`

***C99 overcomes these limitations**

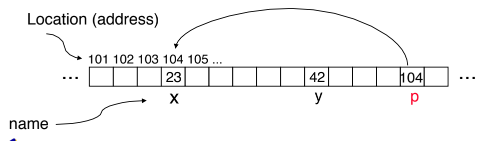
Address vs. Value

- **Consider memory to be a single huge array:**
  - **Each cell of the array has an address associated with it.**
  - **Each cell also stores some value.**
  - **Do you think they use signed or unsigned numbers? Negative address?!**
- **Don't confuse the address referring to a memory location with the value stored in that location.**



Pointers

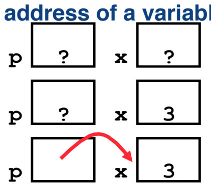
- **An address refers to a particular memory location. In other words, it <u>points</u> to a memory location.**
- **Pointer: A variable that contains the <u>address</u> of a variable.**



Pointers

- How to create a pointer:
  - `&` operator: get address of a variable

```
int *p, x;
  x = 3;
  p =&x;
```



Note the "*" gets used 2 different ways in this example. In the declaration to indicate that `p` is going to be a pointer, and in the `printf` to get the value pointed to by `p`.

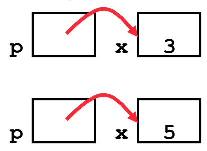
- How get a value pointed to?
  - `*` "dereference operator": get value pointed to

```
printf("p points to %d\n",*p);
```

Pointers

- How to change a variable pointed to?
  - Use dereference `*` operator on left of =

```
*p = 5;
```



Pointers and Parameter Passing

- Java and C pass parameters "by value"
  - procedure/function/method gets a copy of the parameter, so changing the copy cannot change the original

```
void addOne (int x) {
   x = x + 1;
}
int y = 3;
addOne(y);
```

`y` is still = 3

Pointers and Parameter Passing

- How to get a function to change a value?

```
void addOne (int *p) {
  *p = *p + 1;
}
int y = 3;

addOne(&y);
```

`y` is now = 4

Pointers

- Pointers are used to point to any data type (`int`, `char`, a `struct`, etc.).
- Normally a pointer can only point to one type (`int`, `char`, a `struct`, etc.).
  - `void *` is a type that can point to anything (generic pointer)
  - Use sparingly to help avoid program bugs… and security issues… and a lot of other bad things!

Peer Instruction Question

```
void main(); {
  int *p, x=5, y; // init
  y = *(p = &x) + 1;
  int z;
  flip-sign(p);
  printf("x=%d,y=%d,p=%d\n",x,y,p);
}
flip-sign(int *n){*n = -(*n)}
```

How many syntax+logic errors in this C99 code?

#Errors
a) 1
b) 2
c) 3
d) 4
e) 5

Peer Instruction Answer

```
void main(); {
  int *p, x=5, y; // init
  y = *(p = &x) + 1;
  int z;
  flip-sign(p);
  printf("x=%d,y=%d,p=%d\n",x,y,*p);
}
flip-sign(int *n){*n = -(*n);}
```

How many syntax+logic errors in this C99 code?

I get 5…
(signed ptr print is logical err)

#Errors
a) 1
b) 2
c) 3
d) 4
e) 5

And in conclusion…

- All declarations go at the beginning of each function except if you use C99.
- All data is in memory. Each memory location has an address to use to refer to it and a value stored in it.
- A pointer is a C version of the address.
  - `*` "follows" a pointer to its value
  - `&` gets the address of a value

C vs. Java™ Overview (1/2)

Java	C
• Object-oriented (OOP)	• No built-in object abstraction. Data separate from methods.
• "Methods"	• "Functions"
• Class libraries of data structures	• C libraries are lower-level
• Automatic memory management	• Manual memory management
	• Pointers

C vs. Java™ Overview (2/2)

Java	C
• High memory overhead from class libraries	• Low memory overhead
• Relatively Slow	• Relatively Fast
• Arrays initialize to zero	• Arrays initialize to garbage
• Syntax: `/* comment */` `// comment` `System.out.print`	• Syntax: * `/* comment */` `// comment` `printf`

* You need newer C compilers to allow Java style comments, or just use C99

C Syntax: True or False?

- What evaluates to FALSE in C?
  - 0 (integer)
  - NULL (pointer: more on this later)
  - no such thing as a Boolean*
- What evaluates to TRUE in C?
  - everything else…
  - (same idea as in scheme: only `#f` is false, everything else is true!)

*Boolean types provided by C99's `stdbool.h`

C syntax : flow control

- Within a function, remarkably close to Java constructs in methods (shows its legacy) in terms of flow control
  - `if-else`
  - `switch`
  - `while` and `for`
  - `do-while`