inst.eecs.berkeley.edu/~cs61c

CS61C : Machine Structures

Lecture 2 – Introduction to the C Programming Language (pt 1)

2010-06-22

There is a handout at the front of the room! Please pick one up each day!

Instructor Paul Pearce

MIPS Supercomputer ⇒ China's next supercomputer (the Dawning 6000) will be built using the Loongson (MIPS) processor and run Linux. Currently, the top 500 supercomputers are mostly x86 chips. You'll learn MIPS in CS61C!

www.technologyreview.com/computing/24374/

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`) :

00000 00001 ... 01111 10000 ... 11111

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

00000 00001 ... 01111

10000 ... 11110 11111

- Overflow: numbers ∞; computers finite,errors!

META: Ain't no free lunch

Clarification from last lecture

- Subtraction on UNSIGNED integers can be done using traditional methods

(+13) – (+3) = 10

```
      0 1
    1 1 0 1
  - 0 0 1 1
  -----------
    1 0 1 0
```

- Subtraction on SIGNED integers is done as follows:
  - A – B becomes A + (-B), which we can do

Peer Instruction

Which of the following are TRUE

I: One of the advantages of 2's compliment is it provides symmetry in the number of positive and negative #'s

II: In 2's compliment, each number has only one unique representation (for a given number of bits).

	I	II
a)	F	F
b)	F	T
c)	T	F
d)	T	T
e)	No idea	

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 (`Makefile`s) 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++)`

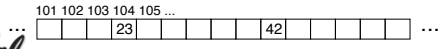
*C99 overcomes these limitations

Actual C Code

```
#include <stdio.h>
int main(int argc, char *argv[]) {
   int i;
   int n = 5;
   for (i = 0; i < n; i = i + 1) {
       printf("hello, world\n");
   }
   return 0;
}
```

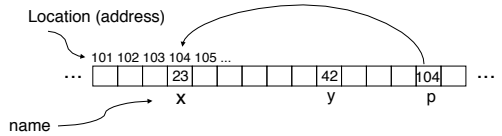
Address vs. Value

- 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.

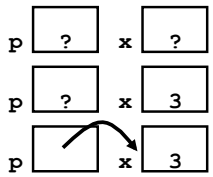


Pointers

- How to create a pointer:

  `&` operator: get address of a variable

```
int *p;
int 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`.

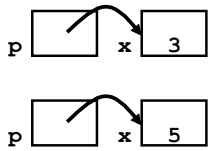
- How get a value pointed to?

  `*` "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;
```

```
printf("what is x? %d\n", x);
```

```
x is 5
```


Common Pitfall

- In variable declarations, does * associate with the type, or the variable?

```
int *x;      // This is legal
int* y;      // Is this legal?
int* z, q;   // Uh oh!
```

Yes, all legal code. What is the type of q?

q is an int, not a pointer!

* associates with variables in declarations, so we suggest you use the first style!

Administrivia!

- New class mailing list!
  - We will go over how to sign up in lab!
- Labs start today. Be there!
  - You should have cardkey access to the room, if not, send Noah an email!
- HW1 online now! (Dun dun dunnnnn.. =)
- C Help session!
  - Wednesday June 23rd, 7-9pm, 306 Soda
- Check back of yesterday's handout!
  - Illistrated study guide for number rep!

More Administrivia!

- Final will be on Thursday, August 12th
  - Time TBA
- Let's see what you guys think about midterm times
  - A) I'd like the midterm to be during class time, 9:30am-12:30pm.
  - B) I'd like the midterm to be during class time, 8:00am-11am.
  - C) I'd like the midterm to be in the evening during a day we have lecture (M-Th)
  - D) I'd like the midterm to be on Friday

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);
printf("What is y? %d\n", 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);

printf("What is y? %d\n", 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!

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`

Peer Instruction Question

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

And in conclusion…

- All declarations go at the beginning of each function except if you use C99.
- Only 0 and NULL evaluate to FALSE.
- 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