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CS61C : Machine Structures

Lecture 3 – Introduction to the C Programming Language

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Princeton cracks down! ⇒ Previously, nearly half the grades given out were {A-,A,A+}…not unusual; other Ivys 44-55%. New cap is 35%. EECS policy is 17% (Lower div) and 23% (upper), though not strict.

www.ledger-enquirer.com/mld/mercurynews/news/world/10713562.htm

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".

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.
- Generally a 2 part process of compiling .c files to .o files, then linking the .o files into executables

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 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 */` `printf`

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.
- Examples of declarations:
  - correct: `{`
    ```
        int a = 0, b = 10;
          ...
    ```
  - incorrect: `for (int i = 0; i < 10; i++)`

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!)

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`

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).
    - Example: `unix% sort myFile`
  - `argv` is a pointer to an array containing the arguments as strings (more on pointers later).

Administrivia : You have a question?

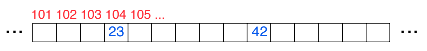
- Do not email Dan (& expect response)
  - Hundreds of emails in inbox
  - Email doesn't scale to classes with 200+ students!
- Tips on getting an answer to your question:
  - Ask a classmate
  - Ask Dan after or before lecture
  - The newsgroup, ucb.class.cs61c
    - Read it : Has your Q been answered already?
    - If not, ask it and check back
  - Ask TA in section, lab or OH
  - Ask Dan in OH
  - Ask Dan in lecture (if relevant to lecture)
  - Send your TA email
  - Send one of the two Head TAs email
  - Send Dan email

Administrivia : Near term

- Upcoming lectures
  - C pointers and arrays in detail
- HW
  - HW0 due in discussion tomorrow
  - HW1 due this Wed @ 23:59 PST
  - HW2 due next Wed @ 23:59 PST
- Reading
  - K&R Chapters 1-5 (lots, get started now!)
  - First quiz due Friday
- Get cardkeys from CS main office Soda Hall 3rd floor if you need/want them
  - Soda locks doors @ 6:30pm & on weekends

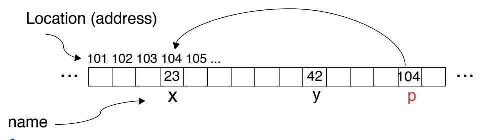
Address vs. Value

- 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.
- 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 points to a memory location.
- **Pointer**: A variable that contains the address of a variable.



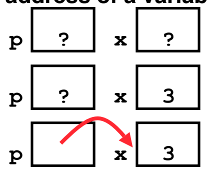
Pointers

- 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`.

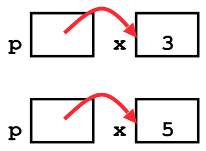
- How get a value pointed to?
  - `*` "dereference operator": get value pointed to

```
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 a parameter "by value"
  - procedure/function 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

- 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!

Peer Instruction Question

```
void main(); {
  int *p, x=5, y; // init
  y = *(p = &x) + 10;
  int z;
  flip-sign(p);
  printf("x=%d,y=%d,p=%d\n",x,y,p);
}
flip-sign(int *n){*n = -(*n)}
```

How many errors?

```
#Errors
      1
      2
      3
      4
      5
      6
      7
      8
      9
  (1) 0
```

And in conclusion…

- All declarations go at the beginning of each function.
- 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