12.010 Computational Methods of Scientific Programming Lecture 8

Today's lecture

- Start C/C++
- Basic language features

C History and Background

- Origins 1973, Bell Labs
- Public K&R C "The C Programming Language", [Kernighan 1978]
- ANSI C – standardized 1989, X3.159-1989
- Ritchie "C is quirky, flawed and an enormous success"
  - http://cm.bell-labs.com/cm/cs/who/dmr/chist.html
- Compiled language (gcc, cc)
  - Good runtime performance, more control e.g memory utilisation
  - Portability, licensing, versatility
  - C apps: Matlab, Mathematica, + Linux netscape, IE, …
- C++ superset of C i.e. C plus some additional concepts – more on these later

C Variables (and C++)

- Variable names
  - Lower or upper case + lower, upper, digit, _ …
  - e.g. x, CO2, DENSITY, area_of_polygon
  - Names ARE case sensitive: CO2 and co2 not same
  - Keywords are reserved (also case sensitive)
    - if, for, while, return, int, float ……..

Data types and basic arrays

- int, float, double, char, short, uint, long int
- int – 4 byte integer (long = 8 byte), short – 2 byte integer, float 32-bit, double 64-bit, char – 1 byte
- [] for arrays
- Examples
  - int a [10], b[10][10];
  - char c[20];
  - double x, area_of_circle, radius;
- Also macros
  - #define PI 3.14159
- Everything must be declared
- /* */ comments

Executable Statements 1

- Statement terminator is the ;. All C-statements end with this character (common compile error is to forget to put ; at end of a statement.
- Assignment
  - #define PI 3.14159
    double x, radius, area_of_circle;
    radius=2.;
    area_of_circle = PI*radius*radius;
- Assignment operators:
  variable op= expression is equivalent to
  Variable = variable op epression
- Operators are: = += -= *= /= %/ >>= <<= &= ^= |=
- Example: k *= 3+x is the same as k=k*(3+x)
- Some of the operators above (>> << & | are bit operators and rarely seen. % is the modulus operator (a%b is a modulus b; remainder after removing as many b's are possible from a e.g. 7%3 = 1)
- Multiple = and be used on a line e.g., a=b=c-0; right to left evaluation

Executables: Conditionals

- Conditional statements are like fortran except no endif statement. The code to be executed in contained in {}' s unless it is just one statement.
  - if (radius == 0.) {
    inv_radius = 0.;
    } else {
    inv_radius = 1./radius;
    }
  - We could above used '} else inv_radius = 1./radius; '
  - If(radius == 0.) { code }
    else if (condition) { code }
  - It is allowed to have to an empty statement by just having ; after the if or in a sequence of if else if statements.

Executable Statements 2

- Increment int type by 1 methods in c:
  - Postfix evaluated after expression
  - Prefix evaluated before expression

```
int i;
i = i+1.;
++i;   /* prefix mode */
i++;  /* postfix mode */
```

  - When used in an expression prefix mode increments first e.g., c = ++a + ++b; gives difference answer to c = a++ + b++;
  - These commands are used because increment by 1 is a machine instruction (faster than load 1 to register and add to another register)
- Changing variable type: cast
  - double x; int i;
  - x = (double) i; /* changes integer i to double type)

Executable Statements 3

- Loops using the “for” construction.

```
int i,j,k;
double b[10][10];
k=0;
for (j=0;j<10;++j) {
 for (i=0;i<10;++i) {
   b[j][i] = (double) k++;
 }
}
```

- Fortran style “do while structure” but the while appears at the end of the construction

```
do { statements;} while (condition);
```

Standard libraries

- no math functions, no I/O functions etc are included in standard code. Header files are need to define constants and functions.

```
#include <math.h>
x = cos(y);
z = cos(PI);

#include <stdio.h>
printf("Hello\n");
fprintf(stdout,"Hello\n");
```

<math.h> == /usr/include/math.h – C source files

<stdio.h> == /usr/include/stdio.h

A C Program

```
#include <stdio.h>
#include <math.h>
int i=1;
main()
{
 int j;
 j = 2;
 printf("Hello\n");
 fprintf(stdout,"Hello\n");
 fprintf(stdout,"pi ==
  %f\n",M_PI);
 fprintf(stdout,"i == %d\n",i);
 fprintf(stdout,"j == %d\n",j);
}
```

Header files

Global constants and types

Program heading

Local declarations

Executable statements

Functions

- Definition method. All modules are functions in c and may or may not return a result (type void if no return).

```
type fname(type arg1, type arg2)
{
 /* Local variables and executable code */
}
```

- Calling a function

```
fname(arg1, arg2); /* type void call */
result = fname( arg1, arg2); /* result and fname same type*/
```

- Prototype defines how a function should be called

```
type fname(type, type);
```

- In C, none of the arguments passed to a functions can be changed -- call by value. Addresses can be passed and the values stored at these addresses can be changed.

Function Example

```
int mymax(float, float);     /* Prototype */
main ()
{
   float a,b; int ans;
   a=b=2.;
   ans= mymax(a,b) /* returns 1 if a > b, 2 if b > a, 0 otherwise */
}
int mymax(float a, float b)
{
   if ( a > b ) return 1;
   if ( b > a ) return 2;
   return 0;
}
```

Call by reference

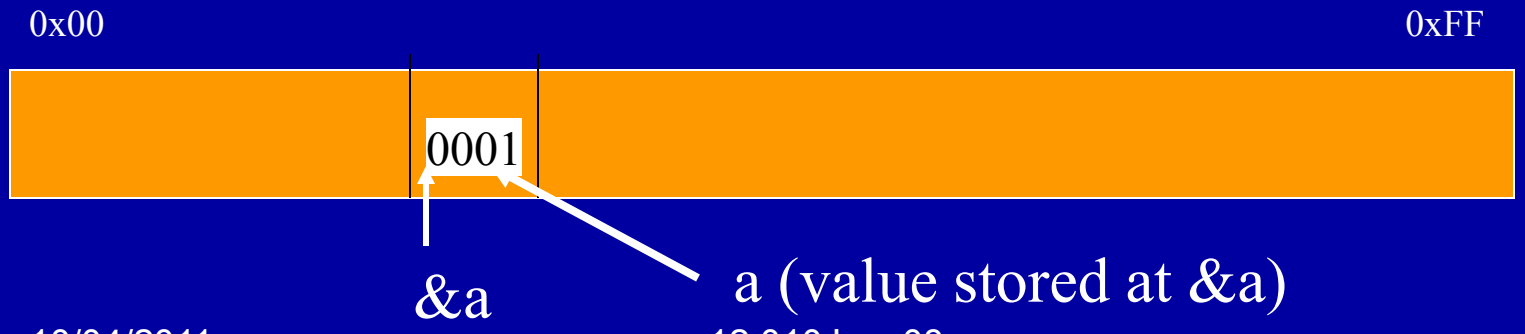
```
int mymax(*float, *float);     /* Prototype.  The *float is a pointer to
    (address of) a floating point number */
main ()
{
   float a,b; int ans;
   a=b=2.;
   ans= mymax(&a,&b); /* 1 if a > b, 2 if b > a, 0 otherwise */
                                /* set a and b = to max. value          */
 }
int mymax(float *a, float *b)
{
   if ( *a > *b ) {*b=*a;return 1;}
   if ( *b > *a ) {*a=*b;return 2;}
   return 0;
}
```

Addresses - *, &

- C allows very explicit addressing of memory locations with the concept of “pointers” (points to memory location)

```
short a; short *ptr_to_a;
a = 1;
ptr_to_a = &a;
```

Computer Memory



Summary

- C programming language. Similar to fortran in many ways but with:
  - Somewhat less rigid syntax
  - More explicit memory addressing methods
  - “short-cut” ways of doing operations that can be very fast on some CPU’s.
- Next lecture we go into more detail in pointers and call by reference and call by value.

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Fall 2011