CS3157: Advanced Programming

Lecture #6

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Shlomo Hershkop

shlomo@cs.columbia.edu

Outline

- Feedback
- Intro to C
  - – Background
  - – Compiling
  - – Basic data structures
  - – Basic I/O
  - – Types conversion
  - – Loops
  - – Branching

Feedback

- Generally good pace of labs
- Complaints about lab workload
  - 4 credit course
  - Will make homework projects / class knowledge easier in the long run
  - Am trying to balance learning and amount of effort, hard to sometime gauge effort
  - Feedback essential

Roadmap

- How this all fits together
  - We covered perl (duct-tape programming)
  - CGI programming USING perl
  - Will now move to c, which is a more low level programming language
  - Will learn to work with c, and then CGI+c
  - Then CGI+perl+c etc
  - Get the best of any programming language in a project

Why Learn C ?

- C provides stronger control of low-level mechanisms such as memory allocation, specific memory locations
- C performance is usually better than Java and usually more predictable (very task dependant)

Why Learn c continued

- Java hides many details needed for writing code, but in C you need to be careful because:
  - memory management responsibility left to you
  - explicit initialization and error detection left to you
  - generally, more lines of (your) code for the same functionality
  - more room for you to make mistakes
- most older code is written in C, will need it if upgrading or interfacing

Background

C

– Dennis Ritchie in late 1960s and early 1970s
– systems programming language
– make OS portable across hardware platforms
– not necessarily for real applications—could be written in Fortran or PL/I

Background II

C++

– Bjarne Stroustrup (Bell Labs), 1980s
– object-oriented features

Java

– James Gosling in 1990s, originally for embedded systems
– object-oriented, like C++
– ideas and some syntax from C

Background III

- C is early-70s, procedural language

- C advantages:
  - direct access to OS primitives (system calls)
  - more control over memory
  - fewer library issues— just execute

- C disadvantages:
  - language is portable, but APIs are not
  - no easy graphics interface
  - more control over memory (i.e., memory leaks)
  - pre-processor can lead to obscure errors

C vs Java

- Java program
  - collection of classes
  - class containing main method is starting class
  - running java StartClass invokes StartClass.main method
  - JVM loads other classes as required

- C program
  - collection of functions
  - one function – main() – is starting function
  - running executable (default name a.out) starts main function
  - typically, single program with all user code linked in— but can be dynamic libraries (.dll, .so)

Example

- Java

```
public class hello {
    public static void main( String[] args ) {
            System.out.println( "hello world! " );
    }
}
```

- C

```
#include <stdio.h>
    int main() {
    printf( "hello world!" );
    return 0;
    }
```

- #include <stdio.h> to include header file stdio.h
- # lines processed by pre-processor

- No semicolon at end of pre-processor lines
- Lower-case letters only— C is case-sensitive

- int main() { ... } is the only code executed

- printf(" /* message you want printed */ ");

- \n = newline, \t = tab

- \ in front of other special characters

C vs Java …Running

- Java programs are compiled and interpreted:
  - javac converts foo.java into foo.class
  - class file is not machine-specific— it is byte code
  - byte code is then interpreted by JVM
  - and each JVM is machine-specific

- C programs are compiled into object code and then linked into executables

(to allow for multiple object files and libraries to be compiled together into one program):
  - gcc compiles foo.c into foo.o and then links foo.o into a.out
  - you can skip writing foo.o if there is only one object file used to create your executable
  - a.out is executed by OS and hardware
  - the C compiler is machine-specific, creating code that executes on specific OS/hardware

Compiling c

- gcc is the C compiler we'll use in this class
- it's a free compiler from Gnu (i.e., Gnu C Compiler)
- gcc translates C program into executable for some target
- default file name a.out
- behavior of gcc is controlled by command-line switches

```
$ gcc hello.c
$ a.out
hello world!
```

Compiling your program

two-stage compilation
1. pre-process and compile: gcc -c hello.c
2. link: gcc -o hello hello.o

linking several modules:
>gcc -c a.c -> a.o
>gcc -c b.c -> b.o
>gcc -o hello a.o b.o

using a library, for example the "math" library (libm):
>gcc -o calc calc.c -lm

Compiling problems

- errors can come from multiple sources:
  - *pre-processor*: missing include files
  - *parser*: syntax errors
  - *assembler*: rare
  - *linker*: missing libraries and references
  - e.g., undefined names will be reported when linking:

```
undefined symbol first referenced in file
_print program.o
ld fatal: Symbol referencing errors
No output written to file.
```

- if gcc gets confused, there can be hundreds of messages!
  - fix first message first, and then retry— ignore the rest
- gcc will produce an executable with warnings
- gcc is more forgiving than javac!

c pre-processor

- the C pre-processor (cpp) is a macro-processor which
  - manages a collection of macro definitions
  - reads a C program and transforms it
  - pre-processor directives start with # at beginning of line
- used to:
  - include files with C code (typically, “header” files containing definitions; file names end with .h)
  - define new macros (later – not today)
  - conditionally compile parts of file (later – not today)
- gcc -E shows output of pre-processor
- can be used independently of compiler

pre-processor II

- file inclusion

```
#include "filename.h"
#include <filename>
```

- inserts contents of filename into file to be compiled
- "filename.h" relative to current directory
- <filename> relative to /usr/include or in default path (specified by -I compiler directive); note that file is named verb+filename.h+

- import function prototypes (in contrast with Java import) (more about function prototypes later)
- examples:

```
#include <stdio.h>
#include "mydefs.h"
#include "/home/shlomo/programs/defs.h"
```

Comments

1. /* any text until this */
2. // until end of line

- convention for longer comments:

```
/*
* AverageGrade()
* Given an array of grades, compute the average.
*/
```

- avoid **** boxes - hard to edit, usually look ragged.

Data Types

- Very important when trying to resource memory/cpu
- float has 6 bits precision
- double has 15 bits precision
- Range can change depending on machine type, generally int is native to the machine type

Type	Bytes
char	8
short	16
int	32
long	32
float	32
double	64

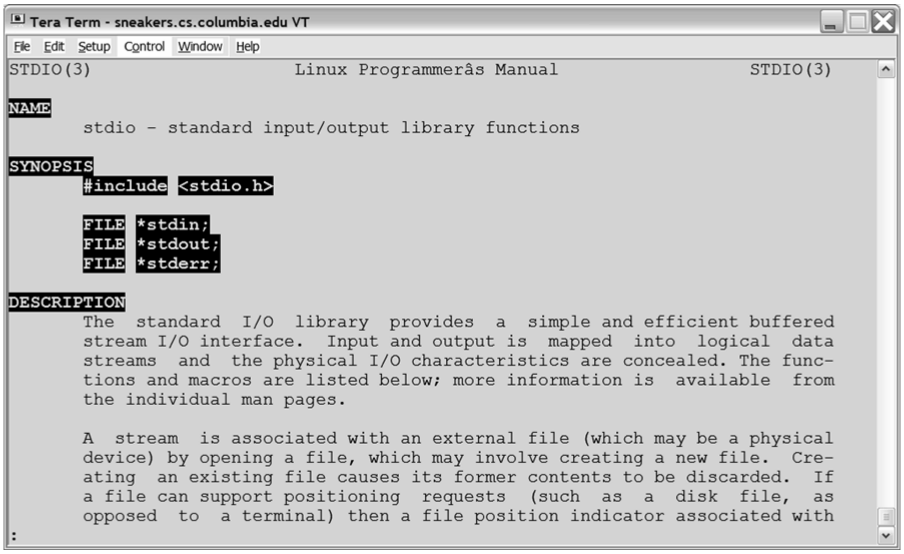
Types II

- unsigned char
- unsigned short
- unsigned int
- unsigned long

- Byte size is the same, but can now have greater range
- /usr/include/limits.h

Library

- Access libraries using the include statement
- Generally include the header file
- Compiler links them automatically
- Example:
  - stdio.h
  - Try:
    man stdio




```
STDIO(3)                   Linux Programmerâs Manual                STDIO(3)

NAME
       stdio - standard input/output library functions

SYNOPSIS
       #include <stdio.h>

       FILE *stdin;
       FILE *stdout;
       FILE *stderr;

DESCRIPTION
       The  standard  I/O  library  provides  a  simple and efficient buffered
       stream I/O interface.  Input and output is  mapped  into  logical  data
       streams  and  the physical I/O characteristics are concealed. The func-
       tions and macros are listed below; more information is  available  from
       the individual man pages.

       A  stream  is associated with an external file (which may be a physical
       device) by opening a file, which may involve creating a new file.  Cre-
       ating  an existing file causes its former contents to be discarded.  If
       a file can support positioning  requests  (such  as  a  disk  file,  as
       opposed  to  a terminal) then a file position indicator associated with
:
```

stdio.h

- Access stdio functions by
  - using #include <stdio.h>
  - compiler links it automatically

- defines stdin, stdout, stderr
- use for character, string and file I/O (later)

- printf
  - %[flags][width][.precision][modifiers]type

stdio.h : printf, type specifier

- int printf(const char *format, ...) formatted output to stdout

c	Character	a
d or i	Signed decimal integer	392
e	Scientific notation (mantise/exponent) using e character	3.9265e2
E	Scientific notation (mantise/exponent) using E character	3.9265E2
f	Decimal floating point	392.65
g	Use shorter %e or %f	392.65
G	Use shorter %E or %f	392.65
o	Signed octal	610
s	String of characters	sample
u	Unsigned decimal integer	7235
x	Unsigned hexadecimal integer	7fa
X	Unsigned hexadecimal integer (capital letters)	7FA
p	Address pointed by the argument	B800:0000
n	Nothing printed. The argument must be a pointer to integer where the number of characters written so far will be stored.	

printf flags

- %[flags][width][.precision][modifiers]type

-	Left align within the given width. (right align is the default).
+	Forces to preceed the result with a sign (+ or -) if signed type. (by default only - (minus) is printed).
Blank	If the argument is a positive signed value, a blank is inserted before the number.
#	Used with o, x or X type the value is preceeded with 0, 0x or 0X respectively if non-zero.
	Used with e, E or f forces the output value to contain a decimal point even if only zeros follow.
	Used with g or G the result is the same as e or E but trailing zeros are not removed.

example

```
int class_size = 35;
char *class_name = “3157 adv prog”;

printf(“Welcome to our test program\n”);


printf( “the %s class size is %d”,
        class_name, class_size);
```

stdio.h: scanf

- int scanf(const char *format, ...) formatted output to stdout

Example: scanf/printf

```
#include <stdio.h>
void main( void ) {
int n = 0; /* initialization required */
printf( "how much wood could a woodchuck chuck\n" );
printf( "if a woodchuck could chuck wood?" ); /* prompt user
   */
scanf( "%d",&n ); /* read input */
printf( "the woodchuck can chuck %d pieces of wood!\n",n
   );
return;
}
```

output

```
$ a.out
how much wood could a woodchuck chuck
if a woodchuck could chuck wood? 12345
the woodchuck can chuck 12345 pieces of
   wood!
```

Loops

- loops in C are just like in Java
- there are 2 methods for looping:
  - counter-controlled (loop for a fixed number of times)
  - sentinal-controlled (loop while a condition is true)
- there are 3 statements for implementing the 2 methodologies:
  - for
  - while
  - do...while
- as always: beware the infinite loop!
- Ctrl-C interrupts your executing C program
- exercise: can you write 6 loops, one for each method-statement combination?

Branching

- branching in C is just like in Java
- there are 2 ways to do branching:
  - if/else
  - switch
- questions:
  - which is more flexible and powerful?
  - one can always be translated into the other, but not the other way around— which is which?

For next time:

- Lab on Wednesday
- For anyone observing Jewish new year, I will have extra lab hours Thursday 2-4.