6.087 Lecture 4 – January 14, 2010

- Review
- Control flow
- I/O
  - Standard I/O
  - String I/O
  - File I/O

Blocks

- Blocks combine multiple statements into a single unit.
- Can be used when a single statement is expected.
- Creates a local scope (variables declared inside are local to the block).
- Blocks can be nested.

```
{
  int x=0;
  {
    int y=0; /*both x and y visible*/
  }
  /*only x visible*/
}
```

Conditional blocks

if ... **else**..**else if** is used for conditional branching of execution

```
if (cond)
{
  /*code executed if cond is true*/
}
else
{
  /*code executed if cond is false*/
}
```

Conditional blocks

switch..case is used to test multiple conditions (more efficient than if else ladders).

```
switch(opt)
{
  case 'A':
    /*execute if opt=='A'*/
    break;
  case 'B':
  case 'C':
    /*execute if opt=='B' || opt=='C'*/
  default:
}
```

Iterative blocks

- **while** loop tests condition before execution of the block.
- **do**..**while** loop tests condition after execution of the block.
- **for** loop provides initialization, testing and iteration together.

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goto

- goto allows you to jump **unconditionally** to arbitrary part of your code (within the same function).
- the location is identified using a label.
- a label is a named location in the code. It has the same form as a variable followed by a ':'

```
start:
{
  if(cond)
    goto outside;
  /*some code*/
  goto start;
}
outside:
/*outside block*/
```

Spaghetti code

Dijkstra. *Go To Statement Considered Harmful*.
Communications of the ACM 11(3),1968

- Excess use of **goto** creates *sphagetti code*.
- Using **goto** makes code harder to read and debug.
- Any code that uses **goto** can be written without using one.

error handling

Language like C++ and Java provide exception mechanism to recover from errors. In C, **goto** provides a convenient way to exit from nested blocks.

```
for(..)
{
  for(..)
  {
    if(error_cond)
      goto error;
      /*skips 2 blocks*/
  }
}
error:
```

```
cont_flag=1;
for(..)
{
  for(init;cont_flag;iter)
  {
    if(error_cond)
    {
      cont_flag=0;
      break;
    }
    /*inner loop*/
  }
  if(!cont_flag) break;
  /*outer loop*/
}
```

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Preliminaries

- Input and output facilities are provided by the standard library `<stdio.h>` and not by the language itself.
- A text stream consists of a series of lines ending with `'\n'`. The standard library takes care of conversion from `'\r\n'−'\n'`
- A binary stream consists of a series of raw bytes.
- The streams provided by standard library are **buffered**.

Standard input and output

```
int putchar(int)
```

- putchar(c) puts the character c on the *standard output*.
- it returns the character printed or EOF on error.

```
int getchar()
```

- returns the next character from *standard input*.
- it returns EOF on error.

Standard input and output

What does the following code do?

```c
int main()
{
  char c;
  while((c=getchar())!=EOF)
  {
    if(c>='A' && c<='Z')
      c=c-'A'+'a';
    putchar(c);
  }
  return 0;
}
```

To use a file instead of standard input, use ’<’ operator (*nix).

- Normal invocation: ./a.out
- Input redirection: a.out < file.txt. Treats file.txt as source of standard input.This is an OS feature, not a language feature.

Standard output:formatted

```
int printf(char format[],arg1,arg2 ,...)
```

- printf() can be used for formatted output.
- It takes in a **variable** number of arguments.
- It returns the number of characters printed.
- The format can contain literal strings as well as format specifiers (starts with %).

Examples:

```
printf("hello world\n");
printf("%d\n",10);/*format: %d (integer),argument:10*/
printf("Prices:%d and %d\n",10,20);
```

printf format specification

The format specification has the following components

%[flags][width][.precision][length]<type>

type:

type	meaning	example
d,i	integer	printf ("%d",10); /*prints 10*/
x,X	integer (hex)	printf ("%x",10); /*print 0xa*/
u	unsigned integer	printf ("%u",10); /*prints 10*/
c	character	printf ("%c",'A'); /*prints A*/
s	string	printf ("%s","hello"); /*prints hello*/
f	float	printf ("%f",2.3); /* prints 2.3*/
d	double	printf ("%d",2.3); /* prints 2.3*/
e,E	float(exp)	1e3,1.2E3,1E−3
%	literal %	printf ("%d %%",10); /*prints 10%*/

printf format specification (cont.)

%[flags][width][. precision][modifier]<type>

width:

format	output
printf ("%d",10)	"10"
printf ("%4d",10)	bb10 (b:space)
printf ("%s","hello")	hello
printf ("%7s","hello")	bbhello

printf format specification (cont.)

%[flags][width][. precision][modifier]<type>

flag:

format	output
printf ("%d,%+d,%+d",10,−10)	10,+10,-10
printf ("%04d",10)	0010
printf ("%7s","hello")	bbhello
printf ("%-7s","hello")	hellobb

printf format specification (cont.)

%[flags][width][.precision][modifier]<type>

precision:

format	output
printf ("%.2f,%.0f,1.141,1.141)	1.14,1
printf ("%.2e,%.0e,1.141,100.00)	1.14e+00,1e+02
printf ("%.4s","hello")	hell
printf ("%.1s","hello")	h

printf format specification (cont.)

%[flags][width][.precision][modifier]<type>

modifier:

modifier	meaning
h	interpreted as short. Use with i,d,o,u,x
l	interpreted as long. Use with i,d,o,u,x
L	interpreted as double. Use with e,f,g

Digression: character arrays

Since we will be reading and writing strings, here is a brief digression

- strings are represented as an array of characters
- C does not restrict the length of the string. The end of the string is specified using 0.

For instance, "hello" is represented using the array `{'h','e','l','l','\0'}`.
Declaration examples:

- `char str[]="hello"; /*compiler takes care of size*/`
- `char str[10]="hello"; /*make sure the array is large enough*/`
- `char str[]={'h','e','l','l',0};`

Note: use \" if you want the string to contain ".

Digression: character arrays

Comparing strings: the header file <string.h> provides the function **int** strcmp(**char** s[],**char** t []) that compares two strings in dictionary order (lower case letters come **after** capital case).

- the function returns a value <0 if s comes before t
- the function return a value 0 if s is the same as t
- the function return a value >0 if s comes after t
- strcmp is case sensitive

Examples

- strcmp("A","a") /*<0*/
- strcmp("IRONMAN","BATMAN") /*>0*/
- strcmp("aA","aA") /*==0*/
- strcmp("aA","a") /*>0*/

Formatted input

int scanf(**char*** format ,...) is the input analog of printf.

- scanf reads characters from standard input, interpreting them according to format specification
- Similar to printf , scanf also takes variable number of arguments.
- The format specification is the same as that for printf
- When multiple items are to be read, each item is assumed to be separated by white space.
- It returns the number of **items** read or EOF.
- **Important:** scanf ignores white spaces.
- **Important:** Arguments have to be address of variables (pointers).

Formatted input

int scanf(char∗ format ,...) is the input analog of printf.

Examples:

printf ("%d",x)	scanf("%d",&x)
printf ("%10d",x)	scanf("%d",&x)
printf ("%f",f)	scanf("%f",&f)
printf ("%s",str)	scanf("%s",str) /∗note no & required∗/
printf ("%s",str)	scanf("%20s",str) /∗note no & required∗/
printf ("%s %s",fname,lname)	scanf("%20s %20s",fname,lname)

String input/output

Instead of writing to the standard output, the formatted data can be written to or read from character arrays.

```
int  sprintf (char string [], char format[],arg1,arg2)
```

- The format specification is the same as printf.
- The output is written to string (does not check size).
- Returns the number of character written or negative value on error.

```
int  sscanf(char str [], char format[],arg1,arg2)
```

- The format specification is the same as scanf;
- The input is read from str variable.
- Returns the number of items read or negative value on error.

File I/O

So far, we have read from the standard input and written to the standard output. C allows us to read data from text/binary files using fopen().

```
FILE* fopen(char name[],char mode[])
```

- mode can be "r" (read only),"w" (write only),"a" (append) among other options. "b" can be appended for binary files.
- fopen returns a **pointer** to the file stream if it exists or NULL otherwise.
- We don't need to know the details of the FILE data type.
- **Important:** The standard input and output are also FILE* datatypes (stdin,stdout).
- **Important:** stderr corresponds to standard error output(different from stdout).

File I/O(cont.)

```
int fclose(FILE* fp)
```

- closes the stream (releases OS resources).
- fclose() is automatically called on all open files when program terminates.

File input

```
int getc(FILE∗ fp)
```

- reads a single character from the stream.
- returns the character read or EOF on error/end of file.

Note: getchar simply uses the standard input to read a character. We can implement it as follows:

```
#define getchar() getc(stdin)
```

```
char[] fgets(char line [], int maxlen,FILE∗ fp)
```

- reads a single line (upto maxlen characters) from the input stream (including linebreak).
- returns a pointer to the character array that stores the line (read-only)
- return NULL if end of stream.

File output

```
int putc(int c,FILE* fp)
```

- writes a single character c to the output stream.
- returns the character written or EOF on error.

Note: putchar simply uses the standard output to write a character. We can implement it as follows:

```
#define putchar(c) putc(c,stdout)
```

```
int fputs(char line [], FILE* fp)
```

- writes a single line to the output stream.
- returns zero on success, EOF otherwise.

```
int fscanf(FILE* fp,char format[],arg1,arg2)
```

- similar to scanf,sscanf
- reads items from input stream fp.

Command line input

- In addition to taking input from standard input and files, you can also pass input while invoking the program.
- *Command line parameters* are very common in *nix environment.
- So far, we have used `int main()` as to invoke the main function. However, main function can take arguments that are populated when the program is invoked.

Command line input (cont.)

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

- argc: count of arguments.
- argv[]: an array of pointers to each of the arguments
- note: the arguments include the name of the program as well.

Examples:

- ./cat a.txt b.txt (argc=3,argv[0]="cat" argv[1]="a.txt" argv[2]="b.txt"
- ./cat (argc=1,argv[0]="cat")