Data Structures in C++

Chapter 1

Tim Budd

Oregon State University
Corvallis, Oregon
USA

Language Features

The purpose of this chapter is to *quickly* review all those features of C++ that you should *already* have encountered and be familiar with.

Even if you have learned programming in another language (Pascal, for example) you should be able to quickly get up to speed with the features described here.

Comments

There are two forms of comments in C++

```
// from slashes to end of line

/*
   comments that span
   multiple lines
*/
```

Comments should be used extensively for documentation.

Constants

There are various types of constants:

- integer – 1, 12, −37
- octal integers – 014
- hexadecimal integers 0XFF 0XC
- floating point – 3.14159 2.7e14
- character – ’a’ ’\n’
- string – ”abc”

Suffixes can be applied to integer constants (U for unsigned, L for long)

Several other special backslash characters

Variables, Types, Values and Declarations

A *variable* is a named location that can hold *values* of a certain *type*.

Variables are created using a *declaration statement*, which also describes the associated type.

```
int a, b, c // declare three integer variables
```

Declarations can be combined with initialization:

```
double pi = 3.1415926;
```

Fundamental Data Types

The fundamental data types:

- integer – **`int`**
- floating point – **`double`**, **`float`**
- character – **`char`**

Modifiers that can be used with funamental types

- **`signed, unsigned`** – positive and negative, or positive only
- **`short, long`** – (possibly) shorter or longer than standard

More Data Types

Boolean (`bool`) variables are true/false.

Enumerated values are defined by providing an explicit range

```
enum months {January, February, March, April, May, June, July,
    August, September, October, November, December};


months workingMonth, vacationMonth;
months summerMonth = August;
```

Variables and Assignment

Variables are modified by assignment statments, which assign an expression to a variable.

```
double f, c;    // Fahrenheit and Celsius temperature

c = 43;
f = (c * 9.0) / 5.0 + 32;
```

Binary operators can be combined with assignment:

```
i += 5;
```

has the same meaning as the statement:

```
i = i + 5;
```

Other short-hand notations:

```
i++
```

has the effect of incrementing the variable `i` by one.

Lots of Operators

Unary Operators	
increment, decrement	i++, ++i, i−−, −−i
negation	− i
bit-wise inverse	∼ i
Arithmetic Operations	
addition, subtraction	a+b a−b
multiplication, division	a∗b a/b
remainder after division	a % b
Shift Operations (also stream I/O)	
left shift (also stream output)	a << b
right shift (also stream input)	a >> b
Relational Operations	
less than, less than or equal	< <=
equal, not equal	== ! =
greater than, greater than or equal	> >=
Logical Operations	
and	x && y
or	x || y
logical negation	! i
Miscellaneous Operations	
function call	f(a,b,c)
conditional expression	c ? a : b

Stream I/O

The left and right shift operators are given different meanings when used with *stream* values. The most common stream is associated with “console input and output”.

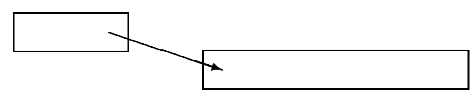
```
cout << "the Fahrenheit equivalent of " << c <<
    " is " << f << "\n";

cin >> c; // get a new value of c
cout << "the Fahrenheit equivalent of " << c <<
    " is " << f << "\n";
```

Operator >> works by side effect, changing the right hand expression. Result can be converted into a boolean, to test if input was successful.

```
int sum = 0;
int value;
while (cin >> value) {
    sum += value;
    }
cout << "sum is " << sum << "\n";
```

Pointers

A pointer is a variable that maintains the address of another location in memory.



Pointers can be used in the following ways:

- Pointers can be subscripted, (works best if they point to an array, but isn't checked).
- Pointers can be dereferenced, using the $*$ operator.
- Can combine dereference and field access, using $->$ operator.
- Can use addition, `p+i` is address of `p[i]`.

Conditional Statements

Normal sequential control can be modified using a conditional statment:

```
month aMonth;
    ...
if ((aMonth >= June) && (aMonth <= August))
    isSummer = true;
else
    isSummer = false;
```

Else part is optional.

Switch Statements

Switch statements can select one of many alternatives:

```
switch (aMonth) {
    case January:
        highTemp = 20;
        lowTemp = 0;
        break;
    case February:
        highTemp = 30;
        lowTemp = 10;
        break;
    ...
    case July:
        highTemp = 120;
        lowTemp = 50;
        break;
    default:
        highTemp = 60;
        lowTemp = 20;
};
```

Loops

Loops are used to execute statements repeatedly until a condition is satisfied.

```
c = 0;
while (c <= 100) {
    cout << "Celsius " << c << " is Fahrenheit " <<
        ((9.0 * c) / 5.0 + 32) << "\n";
    c += 10;
    }
```

For statements

For statements combine in one statement initialization, termination test, and update.

```
for (c = 0; c <= 100; c += 10) {
  cout << "Celsius " << c << " is Fahrenheit " <<
    ((9.0 * c) / 5.0 + 32) << "\n";
  }
```

Declaration of new variables can be combined with loop.

```
for (int i = 0; i < 12; i++) {
  cout << "i: " << i << " i squared " << i*i << "\n";
  }
```

Array

An array is a fixed sized collection of similarly-typed values. Array elements are accessed using subscripts, range is zero to one less than array size.

```
    // declare an array of twelve integer values
int Temperatures[12];
    // now assign all values
Temperatures[0] = 0;
Temperatures[1] = 10;
Temperatures[2] = Temperatures[1] + 15;
...
```

Arrays can be initialized:

```
string MonthNames[12] = {"January", "February",
    "March", "April", "may", "June",
    "July", "August", "September", "October",
    "November", "December" };
```

Multidimensional Arrays

Arrays of more than one dimension can be created by giving the extent along each axis.

```
double matrix[10][20];
```

Creates a double precision array of ten rows and twenty columns. Elements accessed by giving subscript for each dimension:

```
matrix [i][j] = matrix [i-1][j+1] + 1;
```

Arrays and Pointers

Close relationship between arrays and pointers.

Array name is in fact treated just like a pointer.

Pointers can be subscripted, as if they were arrays (even if they aren't!)

`MonthNames + 3` is legal, means address of `MonthNames[3]`.

Arrays as Arguments

When used as an argument, size need not be specified:

```
int arraySum (int values[ ], int n)
    // compute sum of array values[0] .. values[n-1]
{
    int result = 0;
    for (int i = 0; i < n; i++) {
        result += values[i]
        }
    return result;
}
```

Structures

A structure is a collection of fields, which need not have the same type.

```
struct person {
    string name;
    int age;
    enum {male, female} sex;
    };
```

Fields are accessed using dot notation.

```
person employee;
employee.name = "sam smith";
employee.age++;
if (employee.sex == male)
    ...
```

We actually won't use structures, will use more general mechanism called *class* (Described in chapter 2).

Functions

Functions encapsulate a set of actions, so that later we can refer to the sequence of actions by name alone:

```
int Fahrenheit(int cTemp)
{
    return (cTemp * 9.0) / 5.0 + 32;
}
```

Parts:

- Header – with return type, name, and arguments
- Body – with statements to execute. Can have *return* statement to end execution.

Return type can be `void` – no value.

A function *prototype* is a declaration but not a definition, just gives name, arguments and return type.

```
    // prototype for Fahrenheit – definition occurs later
int Fahrenheit (int);
```

Local Variables

Variables within a function come into existance when the function is entered, disappear when the function exits. Execute in stack-like fashion. Assume function A calls function B which calls function C – can imagine variables as follows:

local variables for C
local variables for B
local variables for A

Will eventually encounter *recursive* functions, functions that can call themselves. Imagine B is recursive, and has called itself once before calling C, can envision the following:

local variables for C
local variables for B
local variables for B
local variables for A

The Main Event

A program must always include a procedure named **main**, which is the starting point for execution.

```
# include <iostream>

void main() {
   // program to write table of squares
   cout << "Table of Squares\n";

   for (int i = 0; i < 12; i++) {
      cout << "i: " << i << " i squared " << i*i << "\n";
      }
}
```

Include Files

Many data structures require one to define an include file before they can be processed.

purpose	*name*
stream input/output	iostream
math functions	math.h
complex numbers	complex
Boolean values	bool.h
generic algorithms	algorithm