Introduction to Programming with C++

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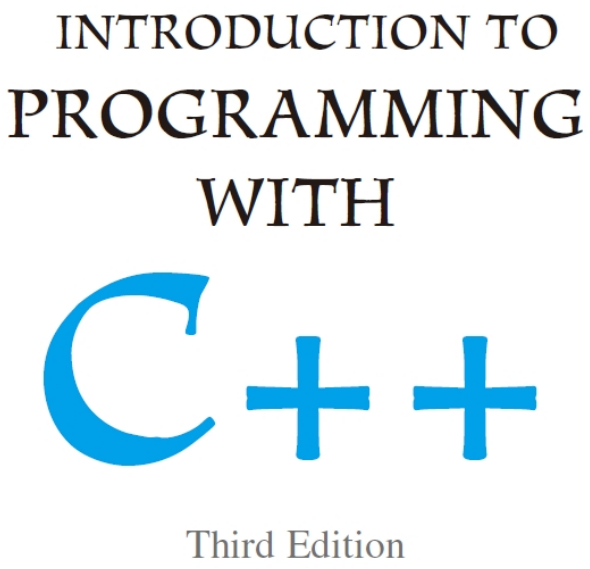


Contents are based on book by Y. Daniel Liang

Pointers

- Pointer is one of the most powerful features in C++. It is the heart and soul of the C++ programming language. Many of the C++ language features and libraries are built using pointers.

- To allocate and release the memory for variables on the fly at runtime, it could be accomplished using pointers.

- Pointer variables are also known as pointers. You can use a pointer to **reference** the address of an array, an object, or any variable.

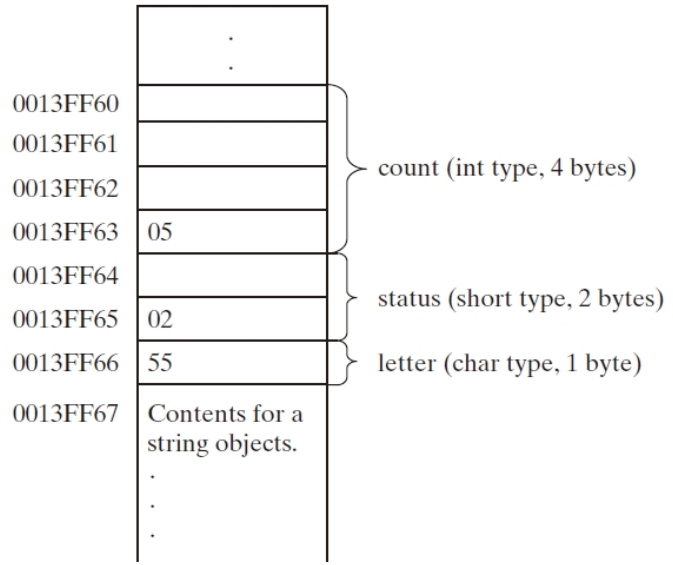
- A pointer variable holds the **memory address**. Through the pointer, you can use the **dereference operator** * to access the actual value at a specific memory location.

- Normally, a variable contains a data value e.g., an integer, a floating-point value, and a character.

- However, a pointer contains the memory address of a variable that in turn contains a data value.

Pointers

```
int count = 5;
short status = 2;
char letter = 'A';
```



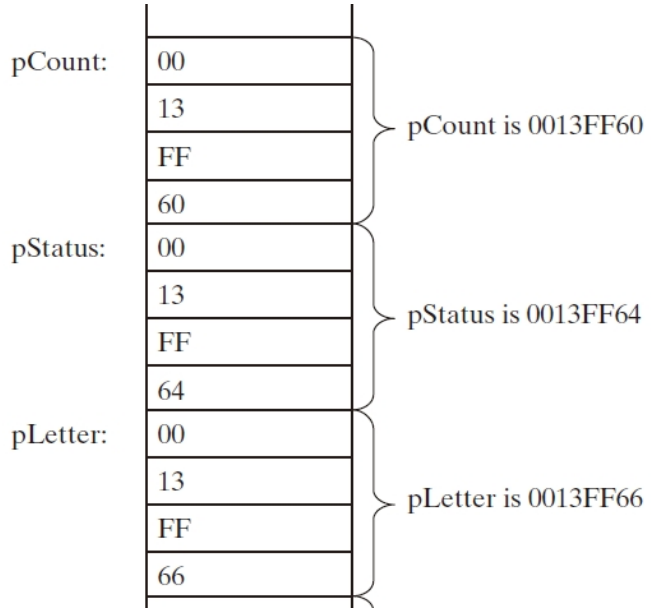
- Note that the ASCII code for 'A' is hex 55.

- Each variable being declared as a pointer must be preceded by an **asterisk (*)**.

- Syntax

```
dataType* pVarName;

int* pCount; //pointer to an i
short* pStatus;
char* pLetter;
```

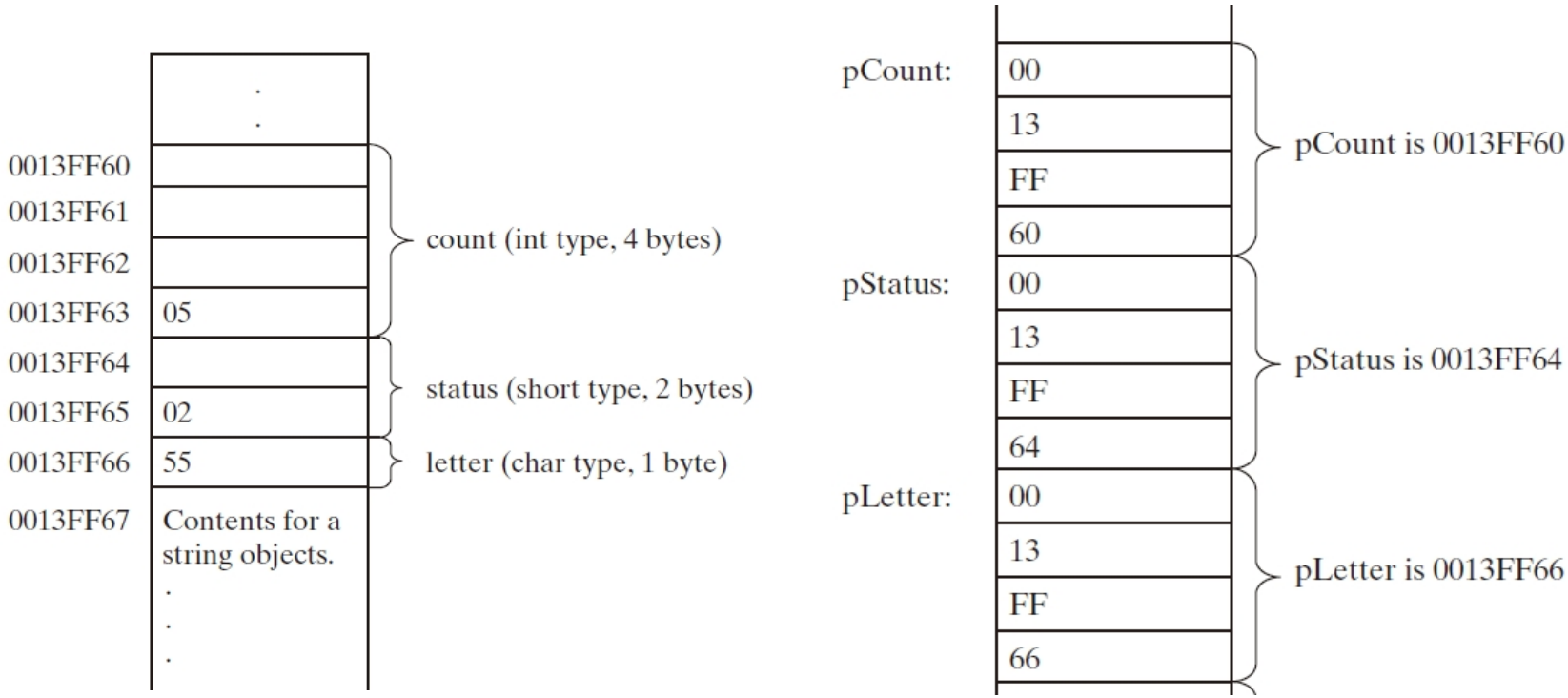


Pointers

- We assign the address of a variable to a pointer as following
  `pCount = &count;`

- The **ampersand (&)** symbol is called the **address operator** when placed in front of a variable. It is a unary operator that returns the **variable's address**.

- You may pronounce **&count** as **the address of count**.



Pointers

```
\\List11_1.cpp
int count = 5;          \\ declare variable
int* pCount = &count; \\ declare pointer, assign &count to pCount
                        \\ i.e. we point pCount to count
cout << "The value of count is "   << count << endl;
cout << "The address of count is " << &count << endl;
cout << "The value of pCount is "  << pCount << endl;
cout << "The address of pCount is "<< &pCount << endl;
cout << "The value of pCount pointed is "
                                   << *pCount << endl;
-------------------------------------------------
The value of count is 5
The address of count is 0013FF60
The value of pCount is 0013FF60
The address of pCount is 0019CF12  \\ other location
The value of pCount pointed is 5
```

- Referencing a value through a pointer is often called **indirection**.
  `*pointer`

Pointers

- The **asterisk (*)** used in the preceding statement is known as the **indirection operator** or **dereference operator** (dereference means indirect reference).

- When a pointer is dereferenced, the value at the address stored in the pointer is retrieved.

- You may pronounce ***pCount** as the **value indirectly pointed by pCount**, or simply **value pointed by pCount**.

- Pointers are variables. So, the naming conventions for variables are applied to pointers.

- We have named pointers with prefix p, such as pCount and pArea. However, it is impossible to enforce this convention.

- **An array name is actually a pointer**.

Pointers

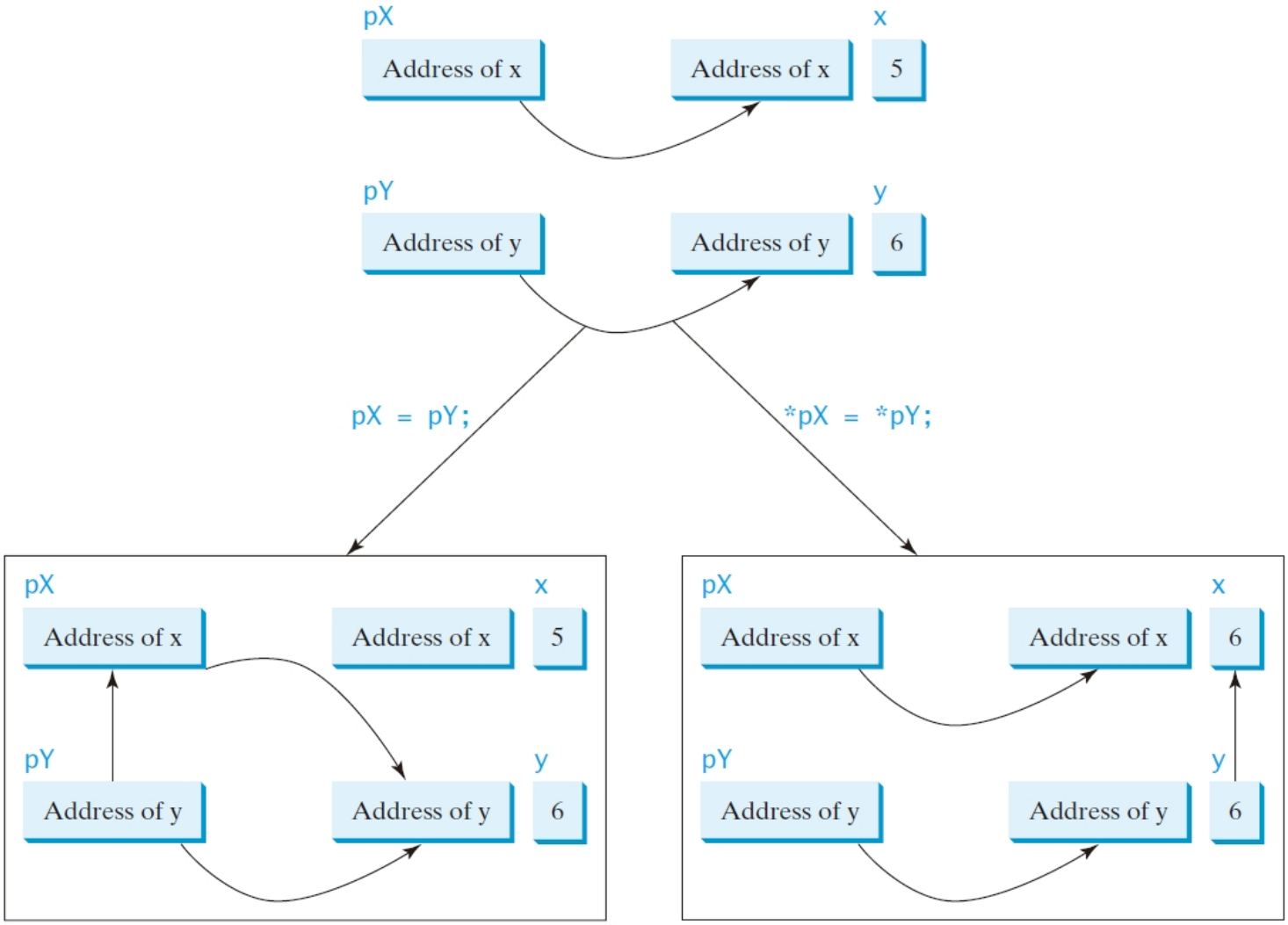
- Like a local variable, a local pointer is assigned an arbitrary value if you don't initialize it.
- A pointer may be initialized to 0, which is a special value to indicate that the pointer points to nothing.
- To prevent errors, you should always initialize pointers.
- A number of C++ libraries including <iostream> define **NULL** as a constant with value 0. It is more descriptive to use NULL than 0.
- You can declare an int pointer using the following syntax

```
int* p; // p is an integer pointer

int *p; // p is a pointer pointed to integer

int * p;// Well, I can't explain this!!
```

Pointers


pX
Address of x
Address of x
x
5
pY
Address of y
Address of y
y
6
pX = pY;
*pX = *pY;
pX
Address of x
Address of x
x
5
pY
Address of y
Address of y
y
6
pX
Address of x
Address of x
x
6
pY
Address of y
Address of y
y
6

Dynamical Array

- C++ supports dynamic memory allocation, which enables you to allocate persistent storage dynamically.

- The memory is created using the **new operator**.

```
int* p = new int(4);
```

```
cout << "Enter the size of the array: ";
int asize;
cin >> asize;
int* a = new int[asize];
```

- **new int(size)** tells the computer to allocate memory space for an int array with the specified number of elements.

- The address of the array is assigned to list.

- The array created using the new operator is also known as a dynamic array.

- Note that when you create a regular array, its size must be known at compile time.

Dynamical Array

```
  cout << " Enter the size of the array: "
  cin >> asize; \\List11_1a.cpp
  a = new int[asize];

  for(i = 0; i < asize; i++)
    a[i] = i;

  for(i=0; i<asize; i++)
    cout<<" a["<< i <<"] = "<< a[i] <<'\n';

  delete[] a;
-------------------------------------------
 Enter the size of the array: 5
 a[0] = 0
 a[1] = 1
 a[2] = 2
 a[3] = 3
 a[4] = 4
```

Dynamical Array

- The word **delete** is a keyword in C++. If the memory is allocated for an array, the () symbol must be placed between the delete keyword and the pointer to the array to release the memory properly.

- Use the delete keyword only with the pointer that points to the memory created by the new operator.

```
int* p = &x;
delete p; // This is wrong
```

  Homework: 11.1, 11.5.

- Goto Chapter 8.

Creating and Accessing Dynamic Objects

- To create an object dynamically, invoke the constructor for the object using the syntax `new ClassName(arguments)`

```
ClassName* pObject = new ClassName;
```

creates an object using the no-arg constructor and assigns the object address to the pointer.

```
ClassName* pObject = new ClassName(arguments);
```

creates an object using the constructor with arguments and assigns the object address to the pointer.

Creating and Accessing Dynamic Objects

- To access object members via a pointer, you must dereference the pointer and use the dot (.) operator to object's members.

```
string* p = new string("abcdefg");
cout << "The first three characters in the string are "
     << (*p).substr(0, 3) << endl;
cout << "The length of the string is "
     << (*p).length() << endl;
```

- To accesse object members from a pointer:
arrow operator (->), which is a dash (-) immediately followed by the greater than (>) symbol.

```
cout << "The first three characters in the string are "
     << p->substr(0, 3) << endl;
cout << "The length of the string is "
     << p->length() << endl;
```

The this Pointer

- The **this** pointer points to the calling object itself.

- A hidden data field can be accessed by using the this keyword, which is a special built-in pointer that references the calling object.

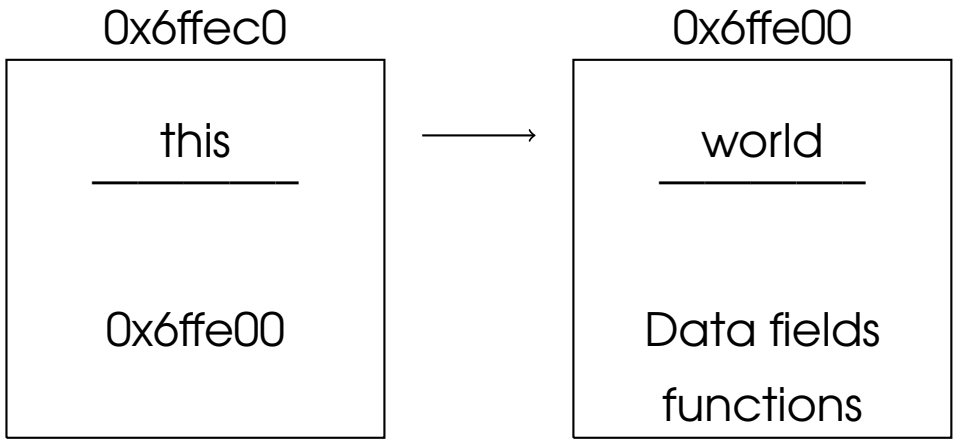
```
Circle::Circle(double radius)
{                              // CircleWithThisPointer.cpp
  this->radius = radius; // or (*this).radius = radius;
}
void Circle::setRadius(double radius)
{
  this->radius = (radius >= 0) ? radius : 0;
}
```

- The parameter name radius in the constructor is a local variable. To reference the data field radius in the object, you have to use this->radius.

The this Pointer

```
class Str {     \\ List11_2a.cpp
public:
  void show() { cout << str << endl; }
  void set(char * ptr) { str = ptr; }
  void showthis() { cout << this << endl; }
  void showaddressthis() {
          Str * const &add = this;
          cout << &add << endl;}
private:
  char * str;
};

int main()
{
  Str hello, world;
  hello.set("Hello");
  world.set("World!");
  cout << "The address of hello object "
       << &hello << endl;
  cout << "The address of world object "
       << &world << endl;;
  world.showthis();
  world.showaddressthis();
}
-------------------------------------------------
The address of hello object 0x6ffe10
The address of world object 0x6ffe00
0x6ffe00
0x6ffec0
```



Destructors

- Every class has a destructor, which is called automatically when an object is deleted.
- Destructors are the opposite of constructors.
- Destructors are named the same as constructors, but you must put a tilde character ($\sim$).
- See List11_12.cpp

Copy Constructors

- every class has a copy constructor, which can be used to create an object initialized with the data of another object of the same class.

```
ClassName(const ClassName&)
Circle(const Circle&)
```

- A default copy constructor is provided for each class implicitly, if it is not defined explicitly. The default copy constructor simply copies each data field in one object to its counterpart in the other object.

```
Circle circle1(5);
Circle circle2(circle1); // Use copy constructor
```