Smart Pointers in C++ and How to Use Them

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In this article, we will be discussing smart pointers in C++. What are Smart Pointers, why, and how to use them properly?

Pointers are used for accessing the resources which are external to the program – like heap memory. So, for accessing the heap memory (if anything is created inside heap memory), pointers are used. When accessing any external resource we just use a copy of the resource. If we make any change to it, we just change it in the copied version. But, if we use a pointer to the resource, we'll be able to change the original resource.

Problems with Normal Pointers

Take a look at the code below.

C++

```
#include <iostream>
using namespace std;

class Rectangle {
private:
};

void fun()
{
    // By taking a pointer p and
    // dynamically creating object
    // of class rectangle
    Rectangle* p = new Rectangle();
}

int main()
```

```
}
```

In function *fun*, it creates a pointer that is pointing to the *Rectangle* object. The object *Rectangle* contains two integers, *length* and *breadth*. When the function *fun* ends, p will be destroyed as it is a local variable. But, the memory it consumed won't be deallocated because we forgot to use *delete p;* at the end of the function. That means the memory won't be free to be used by other resources. But, we don't need the variable anymore, but we need the memory.

In function *main*, *fun* is called in an infinite loop. That means it'll keep creating *p*. It'll allocate more and more memory but won't free them as we didn't deallocate it. The memory that's wasted can't be used again. Which is a memory leak. The entire *heap* memory may become useless for this reason. C++11 comes up with a solution to this problem, Smart Pointer.

Introduction of Smart Pointers

As we've known unconsciously not deallocating a pointer causes a memory leak that may lead to crash of the program. Languages Java, C# has *Garbage Collection Mechanisms* to smartly deallocate unused memory to be used again. The programmer doesn't have to worry about any memory leak. C++11 comes up with its own mechanism that's *Smart Pointer*. When the object is destroyed it frees the memory as well. So, we don't need to delete it as Smart Pointer does will handle it.

A *Smart Pointer* is a wrapper class over a pointer with an operator like * and -> overloaded. The objects of the smart pointer class look like normal pointers. But, unlike *Normal Pointers* it can deallocate and free destroyed object memory.

The idea is to take a class with a pointer, destructor and overloaded operators like * and ->. Since the destructor is automatically called when an object goes out of scope, the dynamically allocated memory would automatically be deleted (or reference count can be decremented). Consider the following simple *SmartPtr* class.

```
C++
```

```
class SmartPtr {
    int* ptr; // Actual pointer
public:
    // Constructor: Refer https:// www.geeksforgeeks.org/g-fact-93/
    // for use of explicit keyword
    explicit SmartPtr(int* p = NULL) { ptr = p; }

    // Destructor
    ~SmartPtr() { delete (ptr); }

    // Overloading dereferencing operator
    int& operator*() { return *ptr; }
};

int main()
{
    SmartPtr ptr(new int());
    *ptr = 20;
    cout << *ptr;

    // We don't need to call delete ptr: when the object
    // ptr goes out of scope, the destructor for it is automatically
    // called and destructor does delete ptr.

    return 0;
}
```

Output:

```
20
```

This only works for *int*. So, we'll have to create Smart Pointer for every object? No, there's a solution, *Template*. In the code below as you can see *T* can be of any type. Read more about Template here.

C++

```
#include <iostream>
using namespace std;
```

```
    T* ptr; // Actual pointer
public:
    // Constructor
    explicit SmartPtr(T* p = NULL) { ptr = p; }

    // Destructor
    ~SmartPtr() { delete (ptr); }

    // Overloading dereferencing operator
    T& operator*() { return *ptr; }

    // Overloading arrow operator so that
    // members of T can be accessed
    // like a pointer (useful if T represents
    // a class or struct or union type)
    T* operator->() { return ptr; }
};

int main()
{
    SmartPtr<int> ptr(new int());
    *ptr = 20;
    cout << *ptr;
    return 0;
}
```

Output:

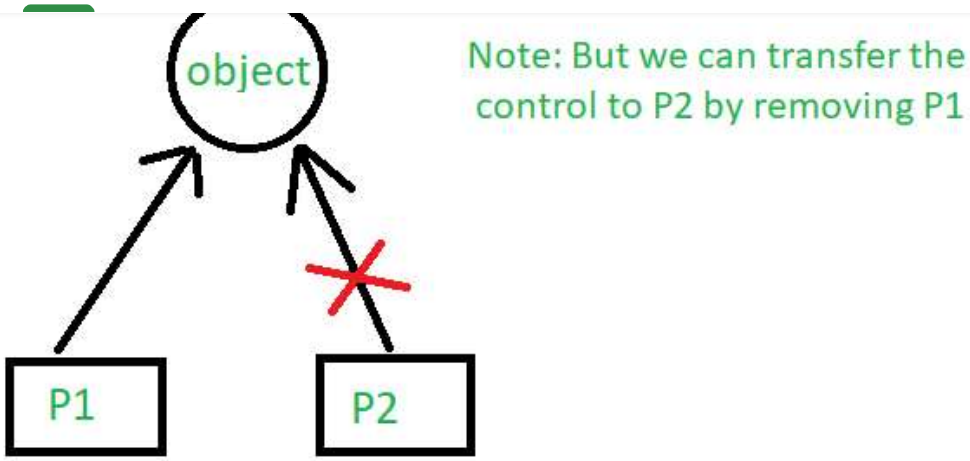
```
20
```

Note: Smart pointers are also useful in the management of resources, such as file handles or network sockets.

Types of Smart Pointers

1. unique_ptr

unique_ptr stores one pointer only. We can assign a different object by removing the current object from the pointer. Notice the code below. First, the *unique_pointer* is



C++14

```
#include <iostream>
using namespace std;
#include <memory>

class Rectangle {
    int length;
    int breadth;

public:
    Rectangle(int l, int b){
        length = l;
        breadth = b;
    }

    int area(){
        return length * breadth;
    }
};

int main(){

    unique_ptr<Rectangle> P1(new Rectangle(10, 5));
    cout << P1->area() << endl; // This'll print 50

    // unique_ptr<Rectangle> P2(P1);
    unique_ptr<Rectangle> P2;
    P2 = move(P1);
```

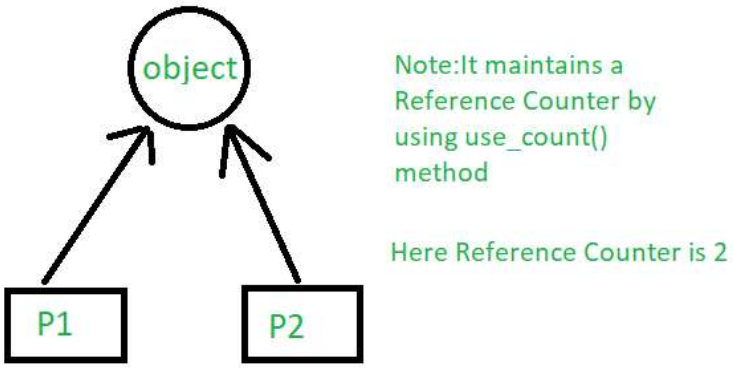
```
    return 0;
}
```

Output:

```
50
50
```

2. shared_ptr

By using *shared_ptr* more than one pointer can point to this one object at a time and it'll maintain a **Reference Counter** using ***use_count()* method.**



C++14

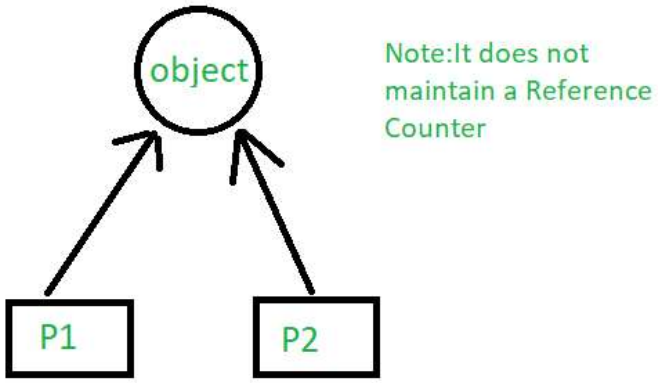
```
#include <iostream>
using namespace std;
#include <memory>

class Rectangle {
```

```
    Rectangle(int l, int b)
    {
        length = l;
        breadth = b;
    }

    int area()
    {
        return length * breadth;
    }
};

int main()
{

    shared_ptr<Rectangle> P1(new Rectangle(10, 5));
    // This'll print 50
    cout << P1->area() << endl;

    shared_ptr<Rectangle> P2;
    P2 = P1;

    // This'll print 50
    cout << P2->area() << endl;

    // This'll now not give an error,
    cout << P1->area() << endl;

    // This'll also print 50 now
    // This'll print 2 as Reference Counter is 2
    cout << P1.use_count() << endl;
    return 0;
}
```

Output:

```
50
50
50
2
```

case, a pointer will not have a stronghold on the object. The reason is if suppose pointers are holding the object and requesting for other objects then they may form a **Deadlock.**



C++ libraries provide implementations of smart pointers in the form of auto_ptr, unique_ptr, shared_ptr and weak_ptr

References:

http://en.wikipedia.org/wiki/Smart_pointer

This article is improved by AmiyaRanjanRout. Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.

It had been improved again by AAShakil50.

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