CSE240 – Introduction to Programming Languages (online)

Lecture 10:
Programming with C++ | memory management

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Outline

- static,
- constructor and destructor,
- new and delete

static

Example


```
1.  #include <iostream>
2.  using namespace std;

3.  class Foo {
4.    public:
5.      void counting();
6.      int getCounterB();
7.      static int counterA;
8.    private:
9.      int counterB;
10. };
11.
12. // initial value to static member variable
13. int Foo::counterA = 0;


14. int counter = 0;
```

A **static variable** is **shared by all the objects** from a class. Therefore, changes made to a static variable will impact all objects from the class

Example


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```

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static versus global Variables

static variables prevents functions outside the class to access the variable. As a **global variable**, all other functions can read/write it.

Example


```
18. void Foo::counting() {  // Set a new mil Time
19.   counterA++;
20.   counterB++;
21. }
22. int Foo::getCounterB() {
23.   return counterB;
24. }
25. int main() {
26.   Foo f1, f2, f3;
27.   f1.counting();
28.   f2.counting();
29.   f2.counting();
30.   f3.counting();
31.   cout << Foo::counterA<<endl;
32.   cout << f1.getCounterB()<<endl;
33.   cout << Foo::counterA<<endl;
34.   cout << f2.getCounterB()<<endl;
35.   return 0;
36. }
```

A **static variable** go out of scope only if the program terminated. And it can be used even **without creating an object** from the class.

Constructors and destructors

Constructor and Destructor

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A **constructor** in a class:

- is a function whose name is same as the class name, and
- is used to automatically initialize objects.

A **destructor** in a class:

- is a function whose name is same as the class name (with a **~** as prefix), and
- is used to collect garbage.

Constructor and Destructor


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

class Queue {
  private:
     int queue_size;
  protected:
     int *buffer;
     int front;
     int rear;
  public:
     Queue();
     Queue(int n);
     ~Queue();
};
```

```
Queue::Queue() { // constructor
  cout << "constructor(void)"<<endl;
  // code...
}
Queue::Queue(int n) { // constructor overload
  cout << "constructor (int)"<<endl;
  // code...
}
Queue::~Queue(void) {
  cout << "destructor"<<endl;
  // code...
}

int main () {
  Queue myQueue1(500);
  Queue myQueue2;
  // more code...
  return 0;
}
```

Constructor and Destructor


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

class Queue {
  private:
     int queue_size;
  protected:
     int *buffer;
     int front;
     int rear;
  public:
     Queue();
     Queue(int n);
     ~Queue();
};
```

```
Queue::Queue() { // constructor
  cout << "constructor(void)"<<endl;
  // code...
}
Queue::Queue(int n) { // constructor overload
  cout << "constructor (int)"<<endl;
  // code...
}
Queue::~Queue(void) {
  cout << "destructor"<<endl;
  // code...
}

int main () {
  Queue myQueue1(500);
  Queue myQueue2;
  // more code...
  return 0;
}
```

```
constructor (int)
constructor(void)
destructor
destructor
```

When is a destructor called?

- When a local object (from stack) with block scope goes out of scope.
- When a program (main function) ends and global or static objects exist (OS will collect them anyway).
- When the destructor is explicitly called.
- When the **delete** keyword is called.

`new` and `delete`

new and delete

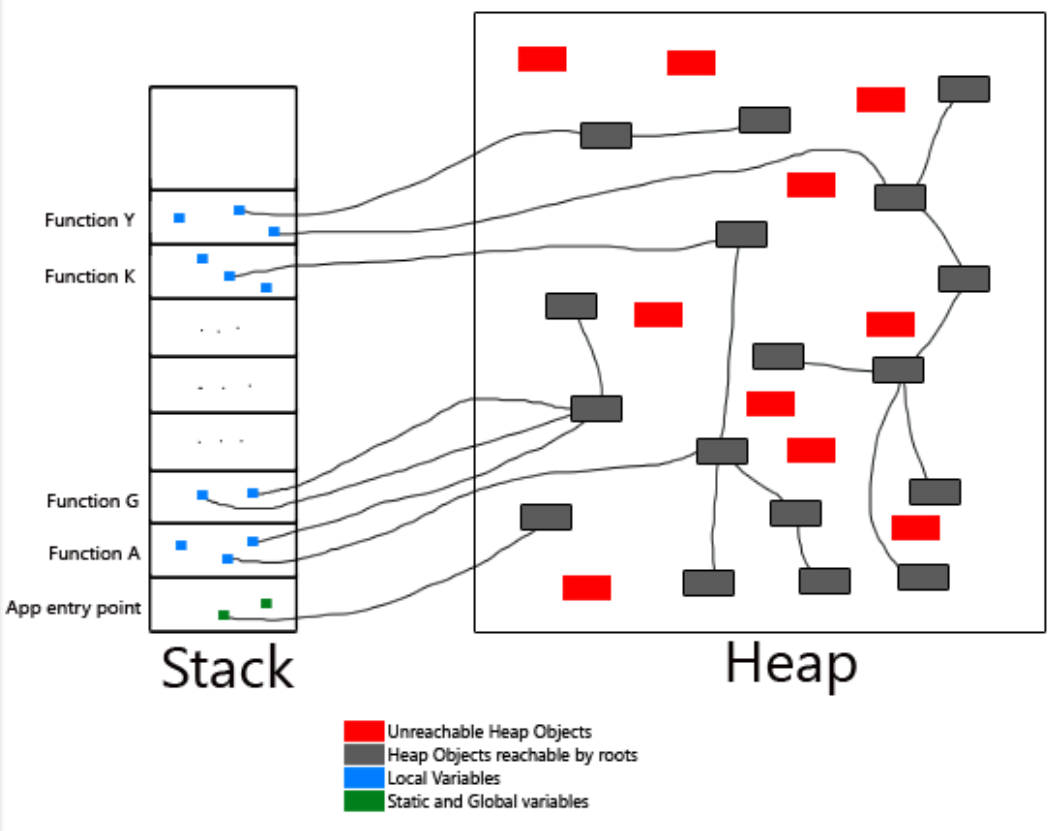
```
int main () {
  Queue myQueue2(500);

  // declare a pointer only
  Queue *myQueue;

  // reserve memory for an object
  myQueue = new Queue(500);

  // use the object
  myQueue->enqueue(23);
  myQueue2.enqueue(8);

  // delete will call ~Queue();
  delete myQueue;
  ...
  delete myQueue2;//no needed
}
```



new and delete with constructors and destructors


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

class Queue {
  private:
     int queue_size;
  protected:
     int *buffer;
     int front;
     int rear;
  public:
     Queue();
     Queue(int n);
     ~Queue();
};
```

```
Queue::Queue() { // constructor
  cout << "constructor(void)"<<endl;
  // code...
  buffer = NULL;
}
Queue::Queue(int n) { // constructor overload
  cout << "constructor (int)"<<endl;
  // code...
  buffer = new int[queue_size];
}
Queue::~Queue(void) {
  cout << "destructor"<<endl;
  // code...
  delete [] buffer;
}
int main () {
  Queue myQueue1(500);
  Queue myQueue2;
  Queue *myQueue3 = new Queue(100);
  // more code...
  delete myQueue3;
  return 0;
}
```

Summary

- If an object is on the **stack**, instead of on the heap, destructor will be called when the object goes out of scope. **No *delete* operation is necessary**.

- All **heap objects** must be **explicitly deleted** before leaving the function, if they are no longer needed.

- The function **delete will implicitly call the destructor** of the class, so that an object linked to a variable in the to-be-deleted object can be de-allocated too, i.e., using **delete** for variables created in the class (normally in the constructor).

delete and Array of Objects

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```
#include <iostream>
using namespace std;
#define size 4
class arrayObject {
  public:
    int x; double y;
    arrayObject()  { cout << "arrayObject's constructor called" << endl; }
    ~arrayObject() { cout << "arrayObject's destructor called"  << endl; }
};

int main() {
  arrayObject *p, *q; // declare two pointers
  p = new arrayObject[size]; // Create an array of objects
  for (q = p; q < p + size; q++) { // Initialize the objects
    q->x = 10; q->y = 1.5;
  }
  for (q = p; q < p + size; q++) {
    cout << "Element address " << q << " Element x value: " << q->x << endl;
    cout << "Element address " << q << " Element y value: " << q->y << endl;
  }
  delete[] p;
  return 0;
}
```

```
arrayObject's constructor called
arrayObject's constructor called
arrayObject's constructor called
arrayObject's constructor called
Element address 0xa40c28 Element x value: 10
Element address 0xa40c28 Element y value: 1.5
Element address 0xa40c38 Element x value: 10
Element address 0xa40c38 Element y value: 1.5
Element address 0xa40c48 Element x value: 10
Element address 0xa40c48 Element y value: 1.5
Element address 0xa40c58 Element x value: 10
Element address 0xa40c58 Element y value: 1.5
arrayObject's destructor called
arrayObject's destructor called
arrayObject's destructor called
arrayObject's destructor called
```

Summary

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- How do we delete an array of objects?

  We can use a loop to delete each element,

- However, the language provides a library function to delete all the elements **one by one** without the user to explicitly use a loop:

```
delete[] array;
```

Summary

Java

- Primitive variables (int, float, boolean) use value type.
- All other variables (string, array, user defined classes) use reference type. (Java uses automatic garbage collection).

C++

- Both value and reference types exist:
- if value semantics used then memory is allocated on *stack* or on static by compiler. Memory de-allocation is done automatically.
- if reference semantics used (e.g. variable is a **pointer to an object**), then memory must be allocated explicitly using ***new*** and explicitly de-allocated using ***delete***

Summary

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```
// in C++
  Report r; // an object is allocated to r
  Report *rp1, *rp2; // two pointers declared
  rp1 = &r;  // rp1 points to object r
  rp2 = new Report(); // an object is created, linked to rp2
  // ..
  delete rp2;

// in Java
  Report r; // an reference is allocated
  r = new Report (); // an object is created and linked to r
```

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