Structs and Classes

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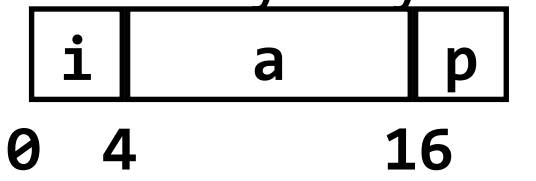
Structs in C

- Contiguously-allocated region of memory
- Members may be of different types
- No methods
- Example:

```
struct rec
{
    int i;
    int a[3];
    int *p;
};
```

Memory Layout



Structs in C++

- No need to write “struct Complex” each time even if we don’t use a typedef
- Can have methods.

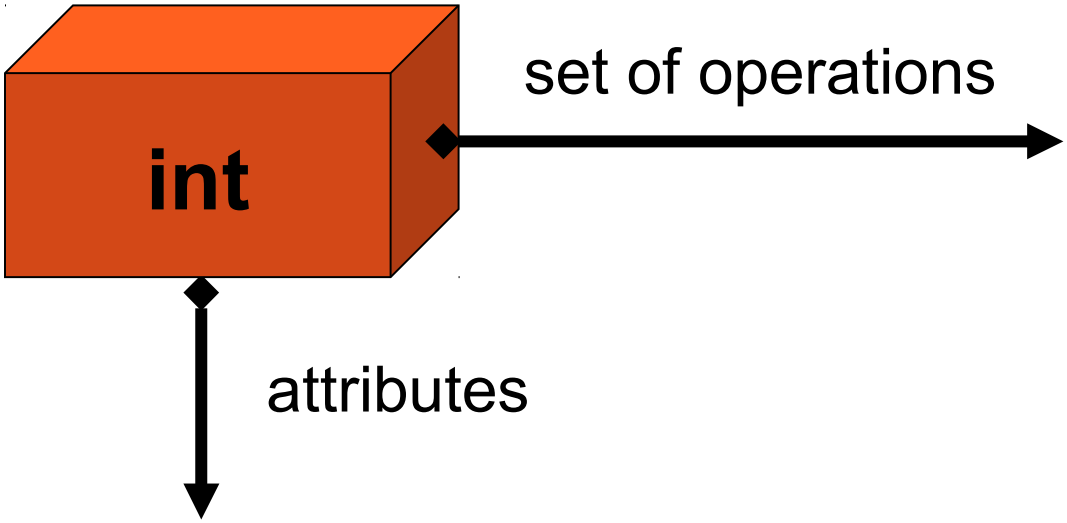
Complex.h

```
struct Complex
{
    double _real, _imag;
    Complex add(Complex other);
};

Complex subComplex(Complex, Complex);
```

Classes (C++)

Abstract Data Type (ADT)



Operations:

- numerical operators
- logical operations
- bit operations
- I/O operations

Attributes:

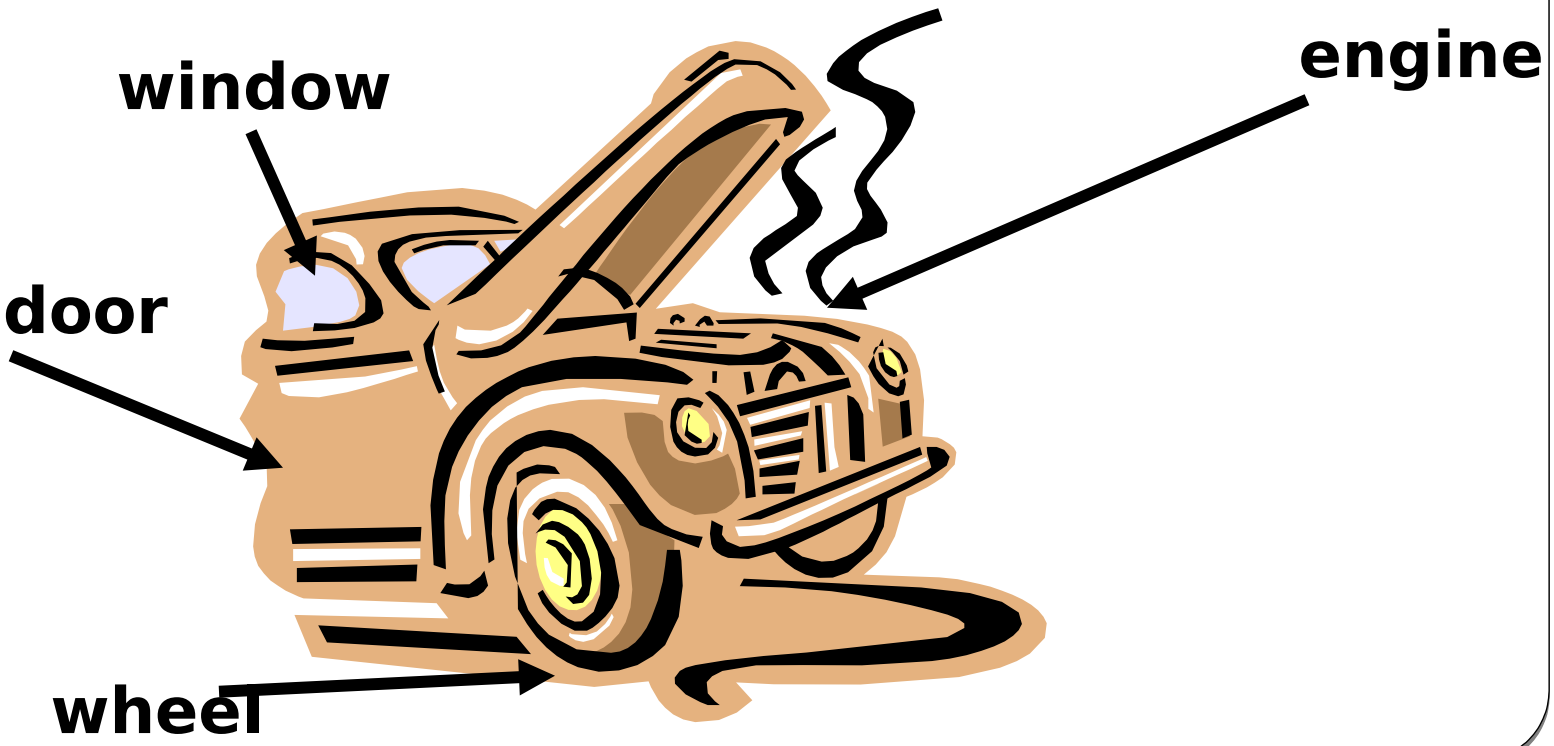
- 4 bytes.
- Integer numbers.

Data Types define the way you use storage (memory) in the .programs you write

How should we describe a car?

attributes

operations



Classes

In C++ we use **classes** for defining ADTs.

The syntax:

```
class ClassName
{
  //attributes and operations
};
```

Objects are instances of classes. That is, objects are to classes what variables are to types.

A class definition does not allocate storage for any objects.

Classes: C++ vs. Java

- In Java, there is a distinction between **primivite types** (int, char…) and **objects**.
  In C++, there is no distinction – objects are like primitive types, both in term of **usage** (e.g., a+b) and in terms of **efficiency.**
- In Java, each public class must be in a file with the same name; each package corresponds to folder with the same name.
  In C++, file and folder names are unimportant; a class can span multiple files.

Simple Class Declaration
File: Counter.hpp
It is also common to use .h for C++ headers

```
#pragma once

class Counter
{
public:
    Counter(); // Constructor
    void increment(); // A method
    int value(); // Another one
private:
    int _count;
};
```

Class Implementation: Counter.cpp

```
#include "Counter.hpp"


void Counter::increment()
{
    _count++;
}


int Counter::value()
{
    return _count;
}
```

Class Implementation: Counter.cpp

Constructor - you implement it like a function, no return type,

There might be “hidden” code inside it (more later)

```
Counter::Counter()
{
    _count = 0;
}
```

Using the class
File: app.cpp

```
#include "Counter.hpp"
#include <cstdio>
int main()
{
    Counter cnt; // Call to constructor!
    printf("Initial value= %d\n", cnt.value());
    cnt.increment();
    printf("New value = %d\n", cnt.value());
}
```

How do we compile it?

```
g++ -Wall -Wvla -Werror -g -D_GLIBCXX_DEBUG -std=c++11 –c Counter.cpp –o Counter.o
g++ -Wall -Wvla -Werror -g -D_GLIBCXX_DEBUG -std=c++11 –c app.cpp –o app.o

g++ -Wvla -Werror -g -D_GLIBCXX_DEBUG -std=c++11 -Wall Counter.o app.o –o app
```

Declaration + implementation

```
#pragma once

class Counter
{
public:
    Counter(); // Constructor
    // A method with inline (we will learn about
this later) implementation :
    void increment(){ _count++; }
private:
    int _count;
};
```

Class Basics: Public/Private

Declare which parts of the class are accessible outside the class

```
class Foo
{
public:
    // accessible from outside
private:
// private - not accessible from outside //
(compilation error)
// but visible to user!
};
```

Example

```
class MyClass
{
public:
    int a();
    double _x;
private:
    int b();
    double _y;
};
```

```
int main()
{
    MyClass foo;
    // legal:
    foo._x = 1.0;
    foo.a();
    //compile error:

    foo._y = 2.0;
    foo.b();
}
```

Example

```
class MyClass
{
public:
    int a();
    double _x;
private:
    int b();
    double _y;
};
```

```
int MyClass::a()
{
    // legal
    _x = 1.0;
    // also legal
    _y = 2.0;
    b();
}
```

Example – Point

```
class Point
{
   public:
      Point(int x, int y);
      int getX();
      int getY();
private:
      int _x, _y;
};
```

this

The address of the instance for which the member method was invoked

this

The address of the instance for which the member method was invoked

```
class Node
{
   Node* next;
public:
   bool isChild(const Node*);
   // ...
;}
```

```
bool Node::isChild(const Node* other)
{
   for (const Node* curr=this; curr; curr=curr->next)
   {
      if (curr==other) return true;
   }
   return false;
}
```

this

The address of the instance for which the member method was invoked

```
class Node
{
   Node* next;
public:
   bool isChild(const Node*);
   // ...
;}
```

```
bool Node::isChild(const Node* other)
{
   for (const Node* curr=this; curr; curr=curr->next)
   {
      if (curr==other) return true;
   }
   return false;
}
```

Type of “this”: Node*

structs and classes

Where did `structs` go?

- In C++ `class`==`struct`, except that by default `struct` members are **public** and `class` members are **private** (also inheritance diff later):

```
struct MyStruct
{
    int x;
};
class MyClass
{
    int x;
};
```

```
int main()
{
    MyStruct s;
    s.x = 1; // ok
    MyClass c;
    c.x = 1; // error
}
```

structs & classes

All of these are the same:

```
struct A
{
   int x;
};

struct A
{
   public:
   int x;
};

class A
{
   public:
   int x;
};
```

structs & classes

All of these are the same (and useless):

```
class A
{
   int x;
};

class A
{
   private:
   int x;
};

struct A
{
   private:
   int x;
};
```

Class Basics - member/static

```
class List
{
public:
   static int getMaxSize();
   int getSize();
   static int max_size=1000; //error! (only outside, below)
   int size=0; //error! (only in ctor, coming slides)
};

int List::max_size=1000; //ok, in one cpp file

int main()
{
   List l;
   l.getSize();
   List::getMaxSize();
   l.getMaxSize(); //compiles ok, but bad style
}
```

this

```
static int List::getMaxSize() //no this!
{
   return this->size; // compile error!
   return max_size; // ok
}
int List::getSize()
{
   return this->size; //ok
}
```

Class Basics: Constructors

Initialize the class object upon construction

```
class MyClass
{
public:
1   MyClass();
2   MyClass( int i );
3   MyClass( double x, double y );
    ...
};

MyClass a; // Calls 1
MyClass b(5); // Calls 2
MyClass c( 1.0, 0.0 ); // Calls 3
```

Constructors – parameterless ctor

```
class MyClass {
public:
    MyClass(); // parameterless ctor.
    //...
};
//...
int main() {
    MyClass a; // parameterless ctor called
    // …
}
```

Constructors – default parameterless ctor

```
class MyClass {
public:
    // No ctors
    //...
};
//...
int main() {
    MyClass a; // default ctor called
    // …
}
```

Constructors – no default parameterless ctor

```
class MyClass {
public:
    MyClass(int x); // no parameterless ctor.
};

int main() {
    MyClass a; // complier error –
               // no parameterless ctor.
}
```

Destructors

1. Ensure propose “cleanup” when the object is destructed
2. Use for freeing memory, notifying related objects, etc.

Class Basics: Destructors

```
#include <cstdlib>
class MyClass
{
public:
   MyClass();
   ~MyClass(); // destructor
private:
   char* _mem;
};
MyClass::MyClass()
{
   _mem=(char*)malloc(1000);
}
MyClass::~MyClass()
{
   free(_mem);
}
```

```
int main()
{
   MyClass a;
   if( ... )
   {
      MyClass b;

   }

}
```




C struct and functions

```
struct IntList;
typedef struct IntList IntList;
IntList* intListNew();
void intListFree(       IntList* List );
void intListPushFront( IntList* List, int x);
void intListPushBack(  IntList* List, int x);
int  intListPopFront(  IntList* List );
int  intListPopBack(   IntList* List );
int  intListIsEmpty(   IntList const* List);

typedef void (*funcInt)( int x, void* Data );
void intListMAPCAR(    IntList* List,
                       funcInt Func, void* Data );
```

C++ Class

In header file:

```
class IntList
{
public:
  IntList();
  ~IntList();
  void pushFront(int x);

  void pushBack(int x);
  int popFront();
  int popBack();
  bool isEmpty() const;
private:
  struct Node
  {
      int value;
      Node *next;
      Node *prev;
  };
  Node* m_start;
  Node* m_end;
};
```

Classes & Memory allocation

Consider this C++ code

```
main()
{
    IntList L;
    …
}
```

Compare to C style:

```
main()
{
    IntList* L =
    intListNew()
    …
    intListFree(L)
}
```

What is the difference?

Classes & Memory allocation

```
IntList* L =
(IntList*)malloc(sizeof(IntList));
```

Does not call constructor!

Internal data members are not initialized

```
free(L);
```

Does not call destructor!

Internal data members are not freed

new & delete

Special operators:

```
IntList *L = new IntList;
```

1. Allocate memory
2. Call constructor
3. Return pointer to the constructed object

```
delete L;
```

4. Call destructor
5. Free memory

new

Can be used with any type:

```
int *i = new int;
char **p = new (char *);
```

- new is a global operator
- new ***expression*** invokes the new ***operator*** to allocate memory, and then calls ctor
- Can be overloaded (or *replaced*)
- By default, failure throws exception. Can be changed.
- See <new> header

Global ***operator*** new (simplified)

```
void *operator new(size_t size)
{
   void *p;
   if((p = malloc(size)) == 0)
   {
      throw std::bad_alloc;
   }
   return p;
}
```

New & Constructors

```
class MyClass
{
public:
 (1) MyClass();
 (2) MyClass( int i );
 (3) MyClass( double x, double y );

};

MyClass* a;
a = new MyClass; // Calls (1)
a = new MyClass(5); // Calls (2)
a = new MyClass( 1.0, 0.0 ); // Calls (3)
```

New & arrays

To allocate arrays, use

```
int *a = new int[10]; // array of 10
                      //ints
size_t n = 4;
IntList *b = new IntList[n];
             // array of n IntLists
```

Objects in allocated array must have an

Delete & arrays

Special operation to delete arrays

```
int *a = new int[10];
int *b = new int[10];

delete [] a; // proper delete command

delete b;    // may work, but may
             // cause memory leak!
```

Allocate array of objects w/o def. cons.

```
size_t n = 4;
MyClass **arr = new MyClass *[n];
// array of n pointers to MyClass (no
// cons. is invoked)

for (size_t i=0; i<n; ++i)
{
    arr[i] = new MyClass (i);
    // each pointer points to a MyClass
    // object allocated on the heap, and
    // the cons. is invoked.
}
```

Free an allocated array of pointers to objects on the heap

```
size_t n = 4;
for (size_t i=0; i<n; ++i)
{
   delete (arr[i]);
   // invoked the dest. of each MyClass
   // object allocated on the heap, and
   // free the memory.
}
delete [] arr;
// free the memory allocated for the
// array of pointers. No dest. is invoked
```

We will see different (and in many cases better) alternatives to directly using new!