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C++ Programming – Classes

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Presentation Outline

- Differences between C and C++
- Object oriented programming
- Classes
- Data Abstraction

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C++ AS "BETTER" C

- More robust
  - Stronger type checking
- Hides complexity
- Enables user-extensible language

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C++ ANSI STANDARD

- Standard library
- Standard Template library
  - Wide range of collection classes
- Exception handling
- Namespaces

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STANDARD LIBRARY

- Header file names no longer maintain the **.h** extension typical of the C language and of pre-standard C++ compilers
- Header files that come from the C language now have to be preceded by a **c** character in order to distinguish them from the new C++ exclusive header files that have the same name. For example **stdio.h** becomes **cstdio**
- All classes and functions defined in standard libraries are under the **std** *namespace* instead of being global.

ANSI C LIBRARIES AND ANSI C++ EQUIVALENTS

ANSI-C++	ANSI-C
<cassert>	<assert.h>
<cctype>	<ctype.h>
<cfloat>	<float.h>
<cmath>	<math.h>
<csetjmp>	<setjmp.h>
<csignal>	<signal.h>
<cstdarg>	<stdarg.h>
<cstddef>	<stddef.h>
<cstdio>	<stdio.h>
<cstdlib>	<stdlib.h>
<cstring>	<string.h>

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FEATURES

- Comments
- Stream input and output
- Constants
  - The const keyword
- Declarations as statements
- Inline expansion
- References

MORE FEATURES

- Dynamic memory allocation (new and delete)
- Function and operator overloading
- User defined types
- Data abstraction and encapsulation
  - Use classes to incorporate new types
- Scoping and the Scope Resolution Operator
- Template

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COMMENTS

- Traditional C comment (can be used in C++)

  /*This is a traditional C comment*/

- C++ Easier comment mechanism

  //This is a C++ comment

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STREAM INPUT AND OUTPUT

- C++ Provides operators for input and output of standard data types and strings
  - Stream insertion operator <<
    - Alternative to printf
  - Stream extraction operator >>
    - Alternative to scanf
- To use C++ stream operators include the header iostream

STREAM INPUT AND OUTPUT EXAMPLES

- cout<< "Hello World\n";
  - Displays Hello World
  - Note use of the escape characters used in C
- cin>>a>>b;
  - Assigns data read from the input stream to the variables a and b
- Can still use printf and scanf but it is not good to mix usage of these with stream operators

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READING FILES USING IFSTREAM

```
#include <iostream>
#include <fstream>
using namespace std;
 int main ()
{
      ifstream infile;
      infile.open ("test.txt", ifstream::in);
      while (infile.good()) cout << (char) infile.get();
      infile.close();
      return 0;
}
```

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USING OFSTREAM TO WRITE TO FILES

```
// ofstream::open
#include <fstream>
using namespace std;
int main ()
{
      ofstream outfile;
      outfile.open ("test.txt", ofstream::out | ofstream::app); outfile << "This sentence is appended to
            the file content\n";
      outfile.close();
      return 0;
 }
```

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THE CONST KEYWORD

- In C constants normally defined using
  - #define PI 3.14159265358979323846
- In C++ use the const keyword
  - Declare any variable as const
  - const double PI = 3.14159265358979323846;
- A **const** object may be initialized, but its value may never change.

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ADVANTAGES OF USING CONST

- Allows the compiler to ensure that constant data is not modified generate more efficient code
- Allows type checking

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CLASSES

- Data Abstraction
- Data encapsulation
- Data hiding
- Objects

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ENCAPSULATION AND ABSTRACT DATA TYPES (ADT)

- Model defines an abstract view of a problem
- Represent model as a collection of abstract data types
- Abstract Data type
  - Abstract data structure
  - Operations defining an interface
- Operations of the interface are the only ones allowing access to the types data structure

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PRIMARY CHARACTERISTICS OF OBJECT ORIENTED PROGRAMS

- Encapsulation
  - Mechanism for enforcing data abstraction
- Inheritance
  - Allow objects to be derived from previously defined objects
- Polymorphism
  - Different types of objects respond to the same instruction to perform a method that is specific to the particular kind of object

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OBJECT ORIENTED PROGRAMMING (OOP)

- Successful OOP is dependent on good design, this means
  - Selecting classes that are relevant that provide the solution for the particular problem under investigation
  - Always try and get the right class structure for the application
  - In the software lifecycle sometimes necessary to refine classes and introduce new classes

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OBJECT ORIENTED DESIGN

- Use OO design techniques such as UML (Unified Modelling Language)
  - Use Case Modelling
  - Class diagrams
  - Sequence diagrams
  - Activity diagrams
- Aim to minimise the number of iterations in the development cycle

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CLASSES

- Class is a data type
- Like a structure but includes
  - Methods i.e. functions to manipulate the members
- An object is an instantiation of a class
- Each Class instantitation i.e. each object
  - Own copy of data members
  - Share methods with objects of same type

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CLASS DECLARATION

```
class classname {
public:
        classname();
        ~classname();
        vartype m_var;
        vartype method(var list);
private:
        private members and methods here

}
```

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MEMBER FUNCTIONS

- Constructor function
  - Methods to perform when object created
  - Initializes object data
- Destructor function
  - Methods to perform when object destroyed
  - Frees any memory used by the object

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DATA MEMBER TYPES

- public (default)
  - Members declared as public can be used by any other objects
- private
  - Members declared as private can only be read, written by members of this class
- protected (see later)
  - Data members can be accessed by members of this class and classes that are derived from this class

SIMPLE CLASS DECLARATION

```
//Program8.cpp
//C++ Class example illustrating
//class constructors and destructors
#include <iostream>
#include <cstring> //strcpy and strlen
class WrgComputeNode {
    public:
        WrgComputeNode(const char *sName ); //Constructor
        ~WrgComputeNode();                  //Destructor
        char *GetName(){ return m_sName; }
    private:
        char *m_sName;
};
```

MEMBER FUNCTIONS FOR WRGCOMPUTENODE CLASS

- Function name preceeded by class name and a scope resolution operator

```
WrgComputeNode::WrgComputeNode(const char *sName )
{
        m_sName = new char [strlen(sName)];
        strcpy(m_sName, sName);
}
//Delete memory that was allocated for the
//creation of the node name
WrgComputeNode::~WrgComputeNode()
{
        delete [] m_sName;
}
```

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USING CLASSES

- Initialising an object

```
WrgComputeNode Sheffield("Titania");
WrgComputeNode Leeds1("Maxima");
WrgComputeNode York("Pascali");
```

- Accessing Members and Calling Methods

```
cout << "Sheffield grid node is " << Sheffield.GetName() <<endl;
cout << "Leeds grid node 1 is " << Leeds1.GetName() << endl;
cout << "York grid node is " << York.GetName() << endl;
```

CLASS CONSTRUCTORS AND THE NEW OPERATOR

- In C++ the new function takes the place of malloc().
- To specify how the object should be initialized, one declares a *constructor* function as a member of the class,
  - Name of the constructor function is the same as the class name
- Methods for declaring a stack class

```
stack s1(17);
stack *s2 = new stack(2);
```

DESTRUCTORS AND THE DELETE OPERATOR

- Just as new is the replacement for malloc(), the replacement for free() is delete.
- To get rid of the Stack object we allocated above with new, one can do:

  delete s2;
- This will deallocate the object, but first it will call the *destructor* for the Stack class, if there is one.
- This destructor is a member function of Stack called ~Stack()

STACK CLASS DEFINITION

```
class stack{
    public:
      stack(int sz=10);
      ~stack();
          void push(int value);
          int pop();
    public:
          int m_size;
          int m_count;
          int *m_stack
};
```

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STACK CONSTRUCTOR

```
stack::stack(int sz)
{
    m_size=(sz>0?sz:10);
    m_stack = new int[m_size];
    m_count=0;
}
```

STACK DESTRUCTOR

```
stack::~stack()
{
        delete [] m_stack;
        cout << "Stack deleted." << endl;
}
```

EXAMPLE OF USING THE STACK CLASS

```
int main()
{
        stack s1(17);
        stack *s2 = new stack(2);
        s1.push(5);
        s2->push(8);
        s2->push(7);
        //pop items from the stack
        cout << "Popping stack s1 gives " << s1.pop() << endl;
        cout << "Popping stack s2 gives " << s2->pop() << endl;
        cout << "Popping stack s2 gives " << s2->pop() << endl;

        cout << "deleting stack s2: ";
        delete s2;
        return 0;
}
```

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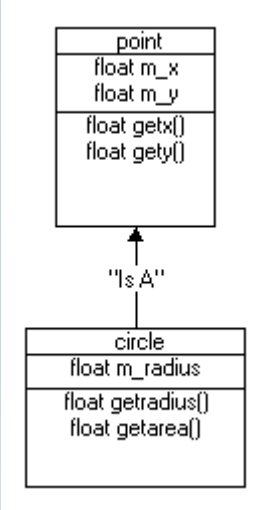
INHERITANCE

- Inheritance is a mechanism by which base classes can inherit data and methods from a base class
- The new class is called a derived class
- An object of a derived class may be treated as an object of the base class

A SHAPE DEFINED BY A OBJECT DEFINING ITS POSITION



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BASE CLASS DEFINITION

```
class point {
public:
        point(float x=0, float y=0);  //Default constructor
        void setpoint(float x, float y);
        float getx() const {return m_x;}
        float gety() const {return m_y;}
protected:   //accessible only by derived classes
        float m_x;
        float m_y;
};
```

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DERIVED CLASS DEFINITION

```
class circle : public point {   //circle inherits from point
public:
        circle(float r, float x, float y); //default constructor
        void setradius(float r);
        float getradius() const;
        float getarea() const;
protected:
      float m_r;
};
```

CREATING INSTANCES

```
point *pointPtr;
point p(2.1, 3.2);
circle *circlePtr;
circle c(3.2, 1.7, 3.9);

pointPtr = (point *) &c;
circlePtr = &c;
```

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CALLING OBJECT METHODS AND MEMBERS

```
cout << "Point p: x=" << p.getx() << " y=" << p.gety() << endl;
cout << "Circle c: radius=" << c.getradius() <<" x=" << c.getx()
        << " y=" << c.gety() << " area=" << c.getarea() << endl << endl;
```

TREATING A CIRCLE OBJECT AS A POINT OBJECT

```
cout << "Using point pointer to access circle base class information"
        << endl;
cout << "Circle c: x=" << pointPtr->getx()
        << " y=" << pointPtr->gety() << endl;
```

TREATING A CIRCLE OBJECT AS A CIRCLE BASE CLASS

```
cout << "Using circle pointer to access circle base class information"
        << endl;
cout << "Circle c: x=" << circlePtr->getx()
        << " y=" << circlePtr->gety() << endl;
```

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VIRTUAL FUNCTIONS AND POLYMORPHISM

- Through virtual functions and polymorphism it is easier to extend systems and to reuse objects
- programs take on a simplified appearance with less branching logic
- Easier to maintain applications

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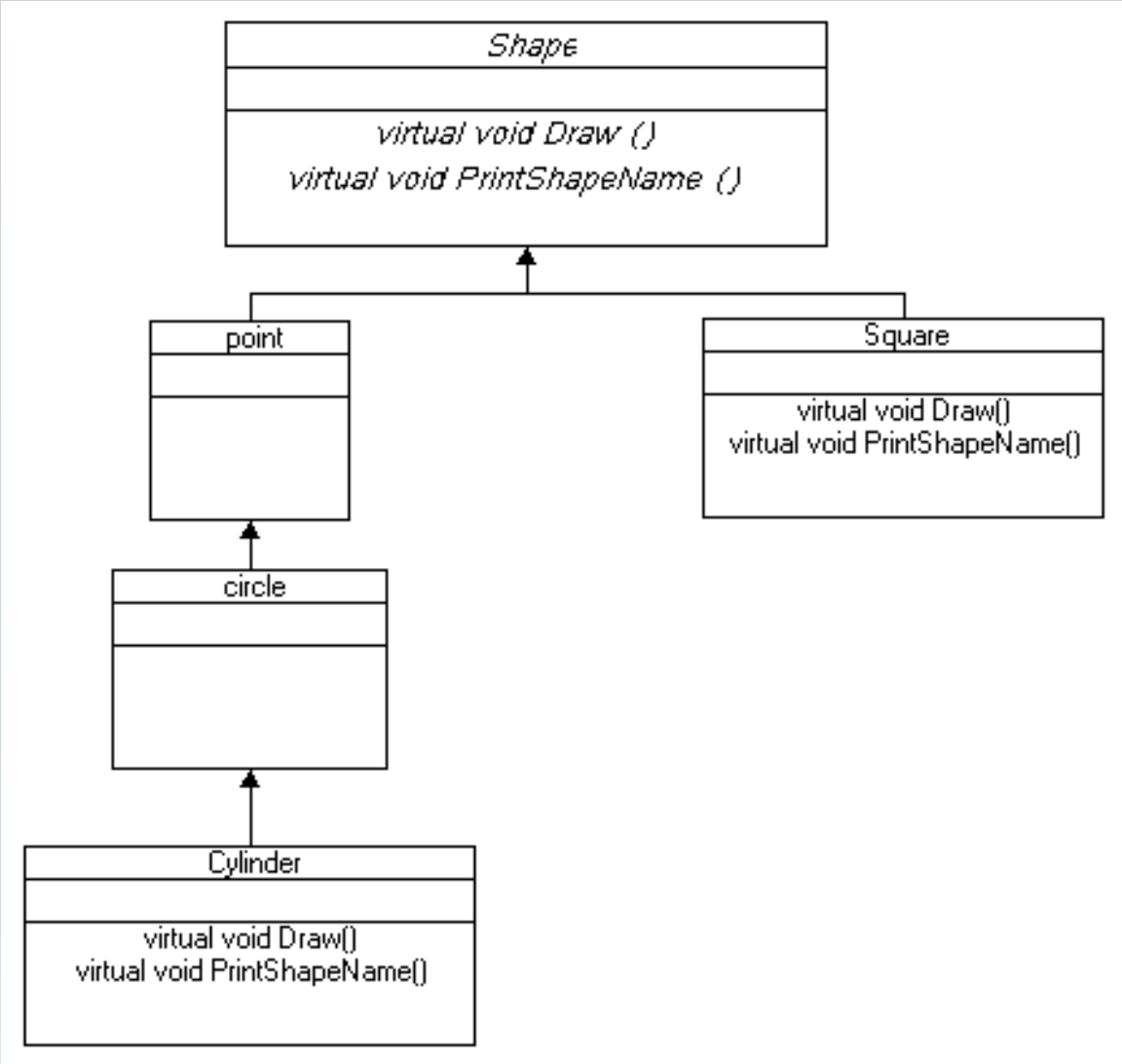
THE SHAPES EXAMPLE

- treat all shapes as a generic instances of the base class shape
- When a shape is drawn we then simply call the Draw method of the shape base class
- program determines dynamically at execution time which Draw method should be used
- Extend our circle class by introducing different shapes and a base class called shape

POLYMORPHISM – ABSTRACT CLASSES



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ABSTRACT SHAPE CLASS

```
class shape {
public:
        virtual float area() const {return 0.0;}
        virtual float volume() const {return 0.0;}
        virtual void printShapeName()=0;  //pure virtual
};
```

A CONCRETE CLASS

```
class square : public shape{
public:
        square(float x=0);  //Default constructor
        void setside(float x);
        float getside() const {return m_side;}
        virtual void printShapeName(){cout << "Square: ";}
        virtual float area() const {return(m_side*m_side);}
protected:   //accessible only by derived classes
        float m_side;
};
```

CODE FRAGMENT ILLUSTRATING POLYMORPHISM

```
void main()
{
        int i;
        shape *shapearray[3];
        point p(2.1, 3.2);
        circle c(3.2, 1.7, 3.9);
        square s(4.5);
        shapearray [0] = (shape *)&p;
        shapearray [1] = (shape *)&c;
        shapearray [2] = (shape *)&s;
        for(i=0; i<3; i++)
        {
          cout << "Area of ";
          shapearray[i]->printShapeName();
           cout << shapearray[i]->area() << endl;
        }
}
```

ABSTRACT CLASSES AND VIRTUAL FUNCTIONS

- abstract class called shape which is inherited by two new shapes cylinder and square
- since shape is abstract and it does not express a concrete realisation of a shape we cannot define the Draw method
  - Draw function of the shape base class is said to be vitual

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POLYMORPHIC BEHAVIOUR THROUGH ABSTRACTION

- Virtual functions in an abstract base class.
    - Desired behaviour obtained dyamically by selecting the correct methods for concrete realisations of a class
- Method is defined in each of the derived classes.
- In this sense a collection of objects referenced using the shape class exhibit polymorphic behaviour
    - behaviour dependent on the specific methods defined for the derived classes.

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RECOMMENDATION

- Do not mix C and C++ Programming Styles
  - External c libraries can still be called
- For C++ programs use the ANSI C++ header nad not the ANSI C headers standard libraries
- Keep things simple
  - Build Create new classes when necessary
  - Take care when using inheritance
- Avoid re-inveting the wheel, use SDK's
  - See the code repository references below

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CONCLUSION

- Advantages
  - Powerful development language for HPC applications
  - Portable
  - Reusable
  - Requires careful design
  - Wide range of libraries enabling high performance and rapid development.
- Disadvantage
  - Very easy to develop sloppy and inefficient code!!!!!!!!

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REFERENCES

- http://www.cplusplus.com
- Standard template libraries
  - http://www.sgi.com/tech/stl/table_of_contents.html
- Bjarn Stroustrups homepage
  - http://www.research.att.com/~bs/homepage.html
- Documentation for Sun Compilers
  - http://developers.sun.com/prodtech/cc/compilers_index.html

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CODE RESPOSITORIES

- Github
- http://sourceforge.net/
- http://www.netlib.org/
- http://archive.devx.com/sourcebank/
- http://www.boost.org/