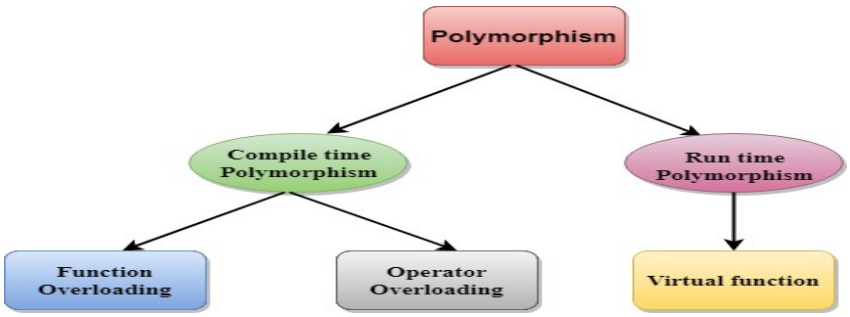
Polymorphism

Polymorphism is a feature of OOPs that allows the object to behave differently in different conditions. In C++ we have two types of polymorphism:
1) **Compile time Polymorphism** – This is also known as **static (or early) binding**.
2) **Runtime Polymorphism** – This is also known as **dynamic (or late) binding**.



1) Compile time Polymorphism

Function overloading and Operator overloading are perfect example of Compile time polymorphism.

Compile time Polymorphism Example

In this example, we have two functions with same name but different number of arguments. Based on how many parameters we pass during function call determines which function is to be called, this is why it is considered as an example of polymorphism because in different conditions the output is different. Since, the call is determined during compile time that's why it is called compile time polymorphism.

```
#include <iostream>
using namespace std;
class Add {
public:
  int sum(int num1, int num2){
     return num1+num2;
  }
  int sum(int num1, int num2, int num3){
     return num1+num2+num3;
  }
};
int main() {
  Add obj;
  //This will call the first function
  cout<<"Output: "<<obj.sum(10, 20)<<endl;
  //This will call the second function
  cout<<"Output: "<<obj.sum(11, 22, 33);
  return 0;
}

Output:
```

```
Output: 30
Output: 66
```

2) Runtime Polymorphism

Function overriding is an example of Runtime polymorphism.
Function Overriding: When child class declares a method, which is already present in the parent class then this is called function overriding, here child class overrides the parent class.

In case of function overriding we have two definitions of the same function, one is parent class and one in child class. The call to the function is determined at **runtime** to decide which definition of the function is to be called, that's the reason it is called runtime polymorphism.

Example of Runtime Polymorphism

```
#include <iostream>
using namespace std;
class A {
public:
  void disp(){
     cout<<"Super Class Function"<<endl;
  }
};
class B: public A{
public:
  void disp(){
     cout<<"Sub Class Function";
  }
};
int main() {
  //Parent class object
  A obj;
  obj.disp();
  //Child class object
  B obj2;
  obj2.disp();
  return 0;
}
```

Output:

```
Super Class Function
Sub Class Function
```

Virtual Function

A **virtual** function is a function in a base class that is declared using the keyword **virtual**. Defining in a base class a virtual function, with another version in a derived class, signals to the compiler that we don't want static linkage for this function.

What we do want is the selection of the function to be called at any given point in the program to be based on the kind of object for which it is called. This sort of operation is referred to as **dynamic linkage**, or **late binding**.

Pure Virtual Functions

It is possible that you want to include a virtual function in a base class so that it may be redefined in a derived class to suit the objects of that class, but that there is no meaningful definition you could give for the function in the base class.

We can change the virtual function area() in the base class to the following –

```
class Shape {
  protected:
    int width, height;

  public:
    Shape(int a = 0, int b = 0) {
      width = a;
      height = b;
    }

    // pure virtual function
    virtual int area() = 0;
};
```

The = 0 tells the compiler that the function has no body and above virtual function will be called **pure virtual function**.

Interfaces in C++ (Abstract Classes)

An interface describes the behavior or capabilities of a C++ class without committing to a particular implementation of that class.

The C++ interfaces are implemented using abstract classes and these abstract classes should not be confused with data abstraction which is a concept of keeping implementation details separate from associated data.

A class is made abstract by declaring at least one of its functions as pure virtual function. A pure virtual function is specified by placing "= 0" in its declaration as follows –

```
class Box {
   public:
      // pure virtual function
      virtual double getVolume() = 0;

   private:
```

```
        double length;      // Length of a box
        double breadth;     // Breadth of a box
        double height;      // Height of a box
    };
```

The purpose of an abstract class (often referred to as an ABC) is to provide an appropriate base class from which other classes can inherit. Abstract classes cannot be used to instantiate objects and serves only as an interface. Attempting to instantiate an object of an abstract class causes a compilation error.

Thus, if a subclass of an ABC needs to be instantiated, it has to implement each of the virtual functions, which means that it supports the interface declared by the ABC. Failure to override a pure virtual function in a derived class, then attempting to instantiate objects of that class, is a compilation error.

Classes that can be used to instantiate objects are called concrete classes.

Abstract Class Example

Consider the following example where parent class provides an interface to the base class to implement a function called **getArea()** –

```
#include <iostream>

using namespace std;

// Base class
class Shape {
   public:
      // pure virtual function providing interface framework.
      virtual int getArea() = 0;
      void setWidth(int w) {
         width = w;
      }

      void setHeight(int h) {
         height = h;
      }

   protected:
      int width;
      int height;
};

// Derived classes
class Rectangle: public Shape {
   public:
      int getArea() {
         return (width * height);
      }
};

class Triangle: public Shape {
   public:
      int getArea() {
         return (width * height)/2;
      }
```

```
};

int main(void) {
   Rectangle Rect;
   Triangle  Tri;

   Rect.setWidth(5);
   Rect.setHeight(7);

   // Print the area of the object.
   cout << "Total Rectangle area: " << Rect.getArea() << endl;

   Tri.setWidth(5);
   Tri.setHeight(7);

   // Print the area of the object.
   cout << "Total Triangle area: " << Tri.getArea() << endl;

   return 0;
}
```

```
Total Rectangle area: 35
Total Triangle area: 17
```

C++ Exception Handling

An exception is a problem that arises during the execution of a program. A C++ exception is a response to an exceptional circumstance that arises while a program is running, such as an attempt to divide by zero.
Exceptions provide a way to transfer control from one part of a program to another. C++ exception handling is built upon three keywords: **try, catch,** and **throw**.

- **throw** – A program throws an exception when a problem shows up. This is done using a **throw** keyword.
- **catch** – A program catches an exception with an exception handler at the place in a program where you want to handle the problem. The **catch** keyword indicates the catching of an exception.
- **try** – A **try** block identifies a block of code for which particular exceptions will be activated. It's followed by one or more catch blocks.

Assuming a block will raise an exception, a method catches an exception using a combination of the **try** and **catch** keywords. A try/catch block is placed around the code that might generate an exception. Code within a try/catch block is referred to as protected code, and the syntax for using try/catch as follows –

```
try {
   // protected code
} catch( ExceptionName e1 ) {
   // catch block
} catch( ExceptionName e2 ) {
   // catch block
} catch( ExceptionName eN ) {
   // catch block
}
```

Throwing Exceptions

Exceptions can be thrown anywhere within a code block using **throw** statement. The operand of the throw statement determines a type for the exception and can be any expression and the type of the result of the expression determines the type of exception thrown.

Following is an example of throwing an exception when dividing by zero condition occurs –

```
double division(int a, int b) {
   if( b == 0 ) {
      throw "Division by zero condition!";
   }
   return (a/b);
}
```

Catching Exceptions

The **catch** block following the **try** block catches any exception. You can specify what type of exception you want to catch and this is determined by the exception declaration that appears in parentheses following the keyword catch.

```
try {
   // protected code
} catch( ExceptionName e ) {
  // code to handle ExceptionName exception
}
```

Above code will catch an exception of **ExceptionName** type.

Template:

Templates are the foundation of generic programming, which involves writing code in a way that is independent of any particular type.

A template is a blueprint or formula for creating a generic class or a function. The library containers like iterators and algorithms are examples of generic programming and have been developed using template concept.

There is a single definition of each container, such as **vector**, but we can define many different kinds of vectors for example, **vector <int>** or **vector <string>**.

You can use templates to define functions as well as classes, let us see how they work –

Function Template

The general form of a template function definition is shown here −

```
template <class type> ret-type func-name(parameter list) {
   // body of function
}
```

Here, type is a placeholder name for a data type used by the function. This name can be used within the function definition.