Session: 8

Abstract Classes and Interfaces

Objectives

- Define and describe abstract classes
- Explain interfaces
- Compare abstract classes and interfaces

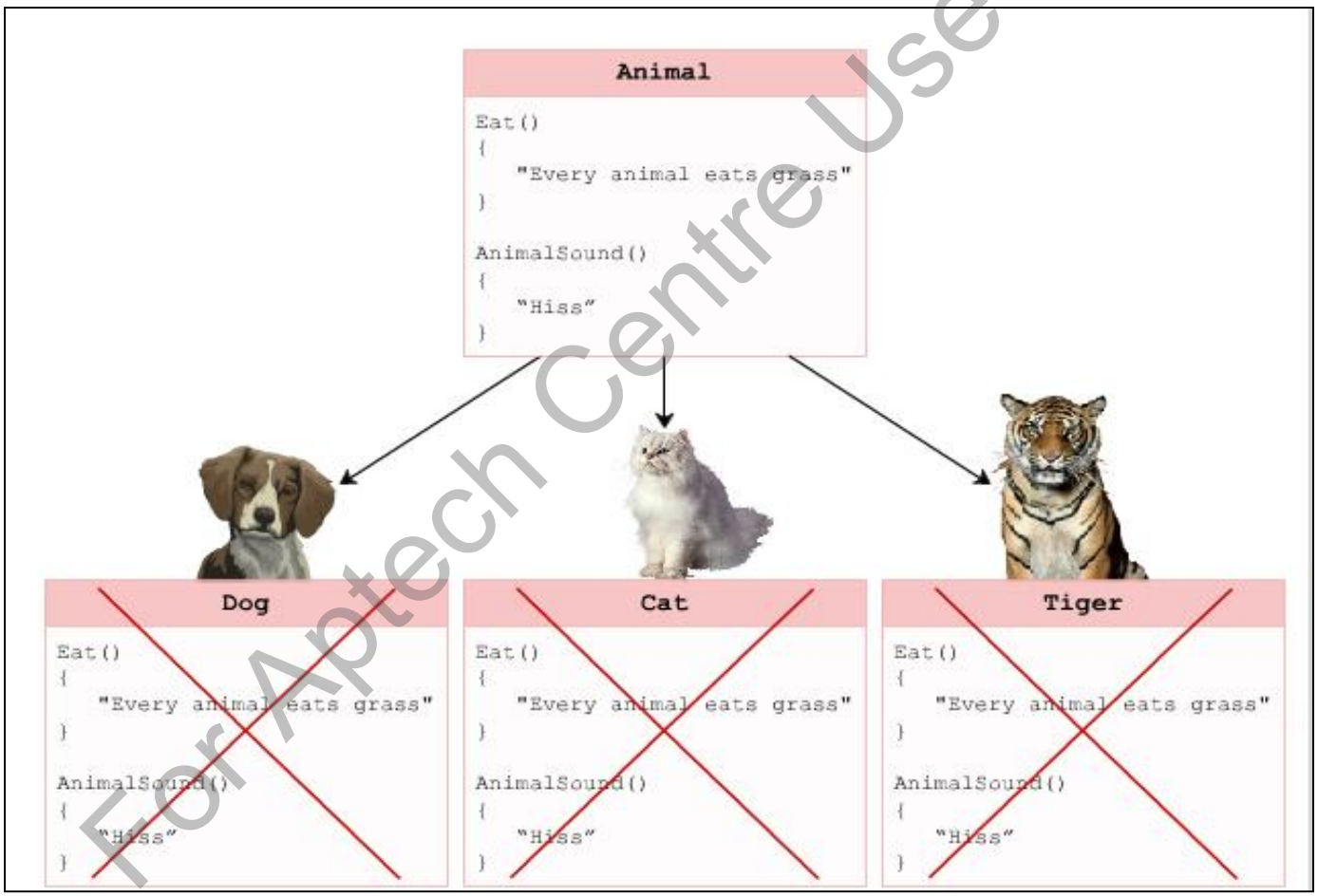
Abstract Classes

- C# allows designing a class specifically to be used as a base class by declaring it an abstract class.
- Such class can be referred to as an incomplete base class, as it cannot be instantiated, but it can only be implemented or derived.
- An abstract class is declared using the `abstract` keyword which may or may not contain one or more of the following:
  - normal data member(s)
  - normal method(s)
  - abstract method(s)

Purpose 1-2

- Consider the base class, **`Animal`**, that defines methods such as **`Eat()`**, **`Habitat()`**, and **`AnimalSound()`**.
- The **`Animal`** class is inherited by different subclasses such as **`Dog`**, **`Cat`**, **`Lion`**, and **`Tiger`**.
- The dogs, cats, lions, and tigers neither share the same food, habitat nor do they make similar sounds.
- Hence, the **`Eat()`**, **`Habitat()`**, and **`AnimalSound()`** methods need to be different for different animals even though they inherit the same base class.
- These differences can be incorporated using abstract classes.

- The following figure displays an example of abstract class and subclasses:



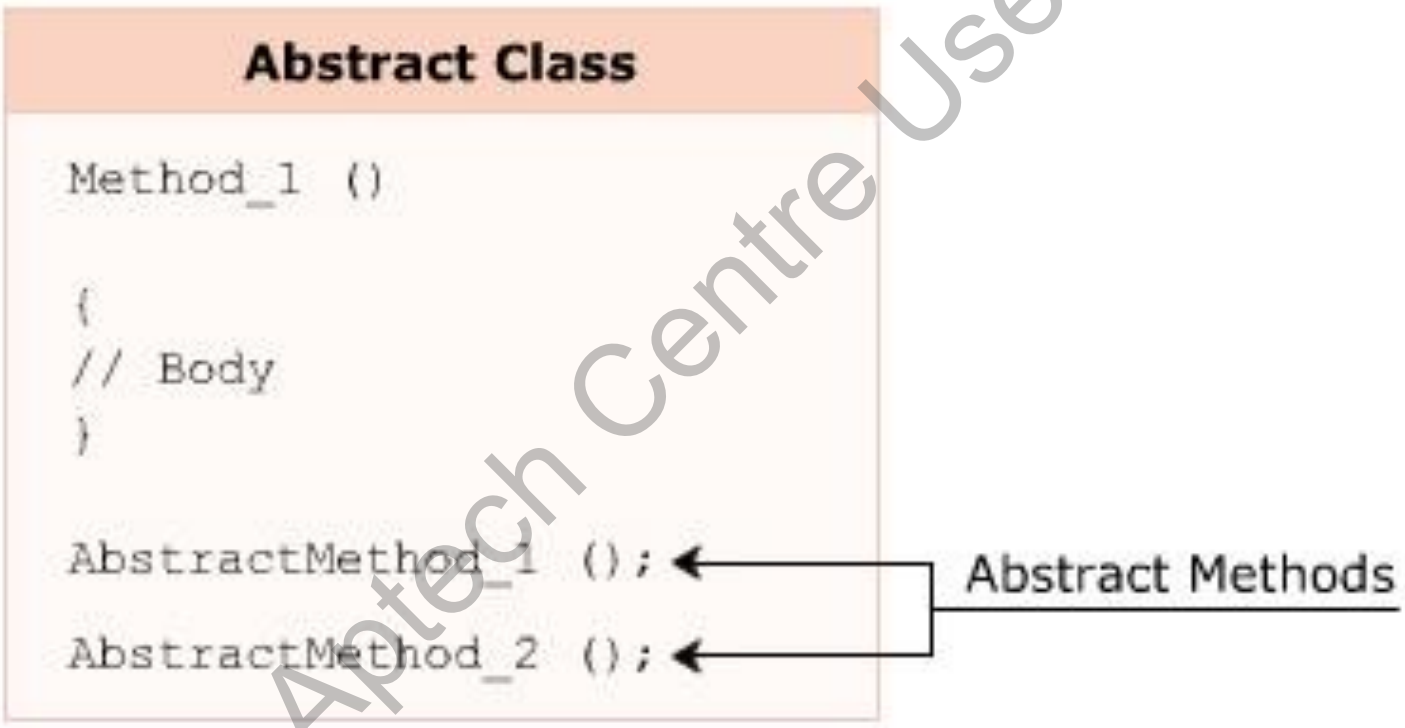
- An abstract class can implement methods that are similar for all the subclasses.

A class that is defined using the `abstract` keyword and that contains at least one method which is not implemented in the class itself is referred to as an abstract class.

In the absence of the `abstract` keyword, the class will not be compiled.

Since the abstract class contains at least one method without a body, the class cannot be instantiated using the `new` keyword.

- The following figure displays the contents of an abstract class:



- The following syntax is used for declaring an abstract class:

Syntax

```
public abstract class <ClassName>
{
    <access_modifier> abstract <return_type>
      <MethodName>(argument_list);
}
```

where,

- `abstract`: Specifies that the declared class is abstract.
- `ClassName`: Specifies the name of the class.

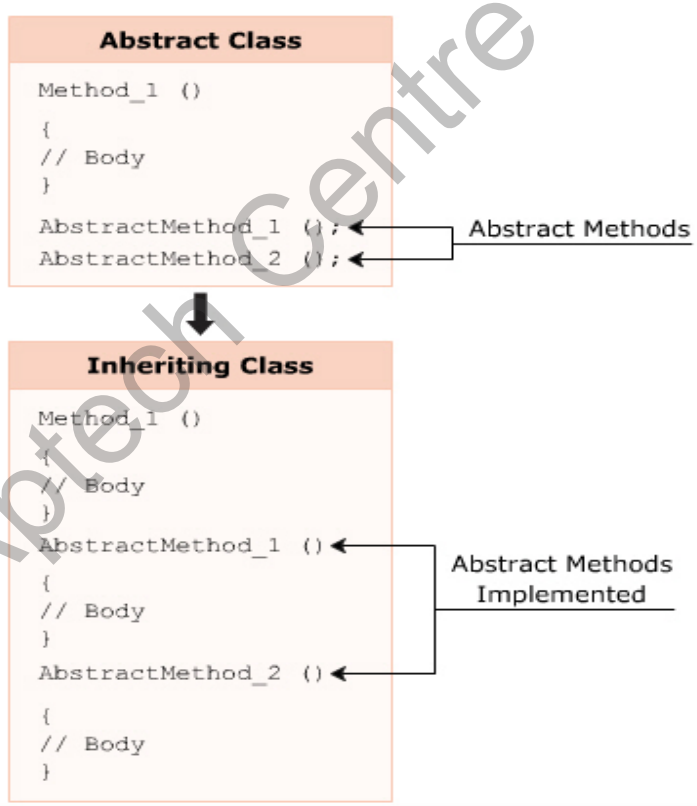
- The following code declares an abstract class **Animal**:

Snippet

```
public abstract class Animal
{
  //Non-abstract method implementation public void Eat()
  {
     Console.WriteLine("Every animal eats food in order to
                        survive");
  }
  //Abstract method declaration
    public abstract void AnimalSound();
    public abstract void Habitat();
 }
```

- In the code:
  - The abstract class **Animal** is created using the `abstract` keyword.
  - The **Animal** class implements the non-abstract method, **Eat()**, as well as declares two abstract methods, **AnimalSound()** and **Habitat()**.

- The subclass inheriting the abstract class has to override and implement the abstract methods with the same name and arguments.
- On failing to implement, the subclass cannot be instantiated as the C# compiler considers it as abstract.
- The following figure displays an example of inheriting an abstract class:



- The following syntax is used to implement an abstract class:

Syntax

```
class <ClassName> : <AbstractClassName>
{
// class members;
}
```

where,

`AbstractClassName`: Specifies the name of the inherited abstract class.

- The following code declares and implements an abstract class:

Snippet

```
abstract class Animal
{
     public void Eat()
     {
       Console.WriteLine("Every animal eats food in order to survive");
     }

    public abstract void AnimalSound();
}
class Lion : Animal
{
   public override void AnimalSound()
    {
       Console.WriteLine("Lion roars");
     }
 static void Main(string[] args)
 {
      Lion objLion = new Lion();
      objLion.AnimalSound();
      objLion.Eat();
  }
}
```

Output

```
Lion roars
Every animal eats food in order to survive
```

- In the code:
  - The abstract class **`Animal`** is declared, and the class **`Lion`** inherits the abstract class **`Animal`**.
  - Since the **`Animal`** class declares an abstract method called **`AnimalSound()`**, the **`Lion`** class overrides the method **`AnimalSound()`** using the `override` keyword and implements it.
  - The `Main()` method of the **`Lion`** class then invokes the methods **`AnimalSound()`** and **`Eat()`** using the dot(`.`) operator.

Implement Abstract Base Class Using IntelliSense 1-2

- IntelliSense provides access to member variables, functions, and methods of an object or a class. Thus, it helps the programmer to easily develop the software by reducing the amount of input typed in, since IntelliSense performs the required typing. IntelliSense can be used to implement system-defined abstract classes.
- The steps performed to implement an abstract class using IntelliSense are as follows:

1. Place Cursor	• Place the cursor after the **class IntelliSenseDemo** statement.
2. Type the following : TimeZone	• The class declaration becomes class IntelliSenseDemo : TimeZone.
3. Click Smart Tag	• Click the smart tag that appears below the **`TimeZone`** class.
4. Click Implement abstract class `System.TimeZone`	• IntelliSense provides four override methods from the system-defined TimeZone class to the user-defined **IntelliSenseDemo** class.

Implement Abstract Base Class Using IntelliSense 2-2

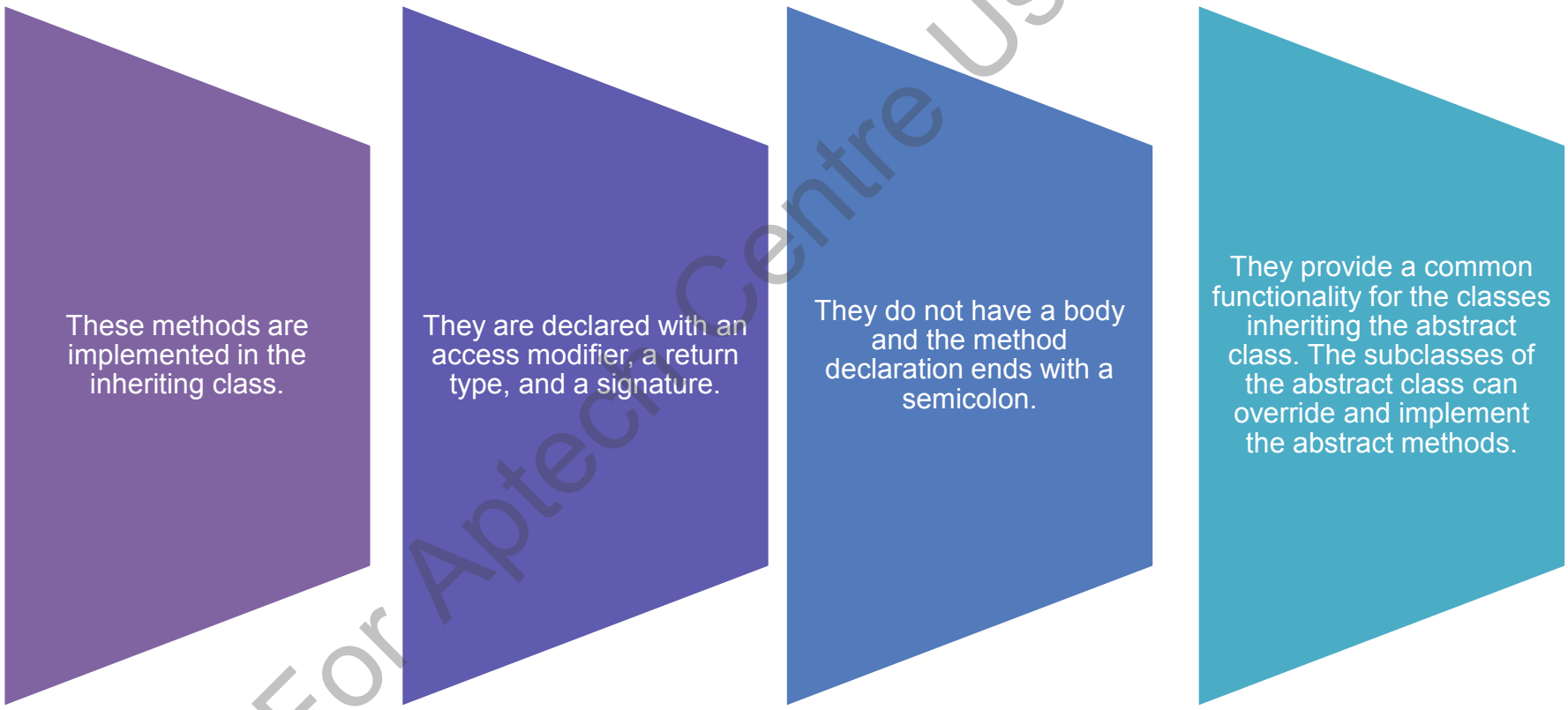
- The following code demonstrates the way the methods of the abstract class **TimeZone** are invoked automatically by IntelliSense:

Snippet

```
using System;
class IntelliSenseDemo : TimeZone
{
     public override string DaylightName
     {
        get { throw new Exception("The method or operation is not implemented."); }
     }
     public override System.Globalization.DaylightTime GetDaylightChanges (int year)
     {
        throw new Exception("The method or operation is not implemented.");
     }
     public override TimeSpan GetUtcOffset(DateTime time)
     {
       throw new Exception("The method or operation is not implemented.");
     }
     public override string StandardName
     {
         get { throw new Exception("The method or operation is not implemented."); }
     }
}
```

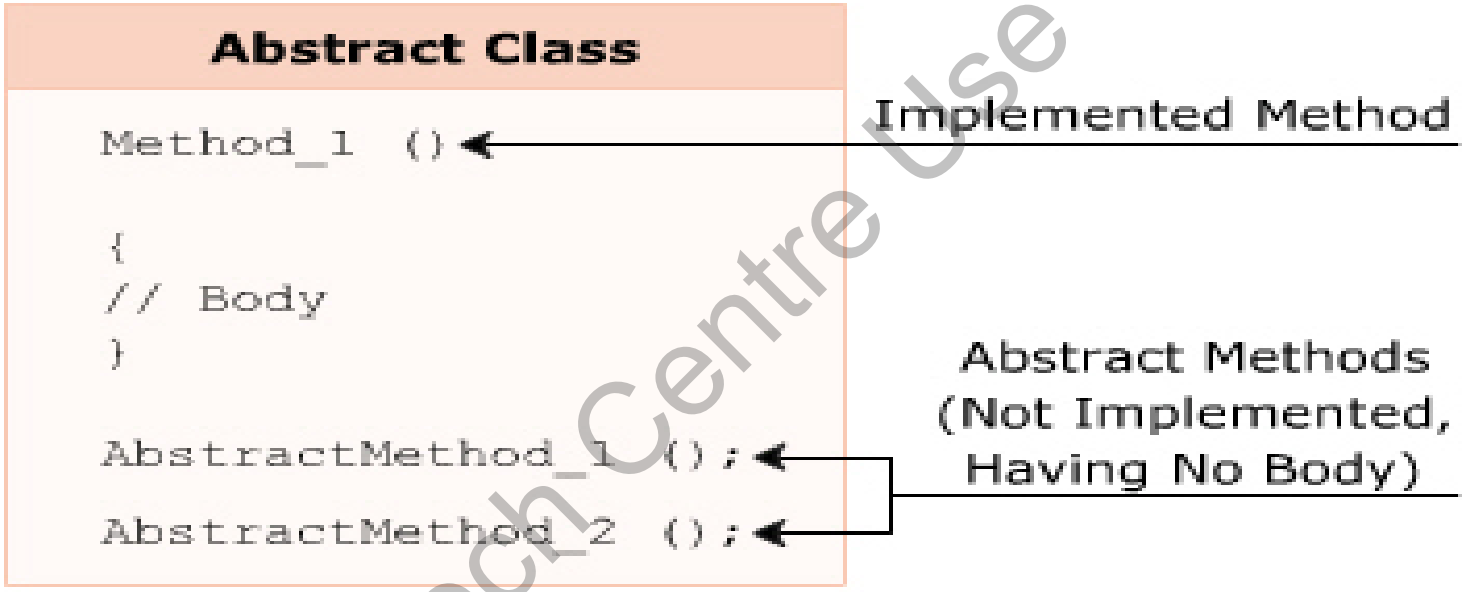
Abstract Methods 1-2

- The methods in the abstract class that are declared without a body are termed as abstract methods.
- Following are the features of the abstract methods:



Abstract Methods 2-2

- The following figure displays an example of abstract methods:

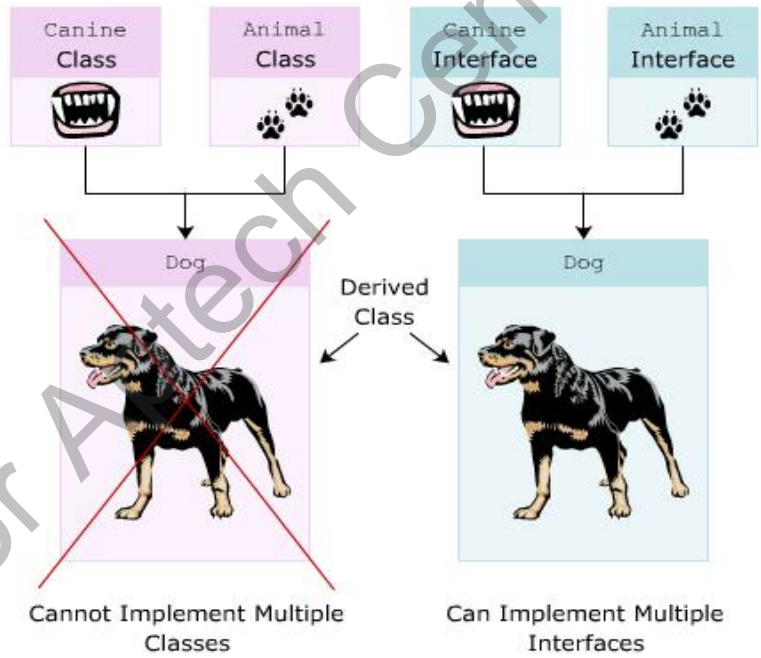


Multiple Inheritance through Interfaces

- A subclass in C# cannot inherit two or more base classes because C# does not support multiple inheritance.
- To overcome this drawback, interfaces were introduced.
- A class in C# can implement multiple interfaces.

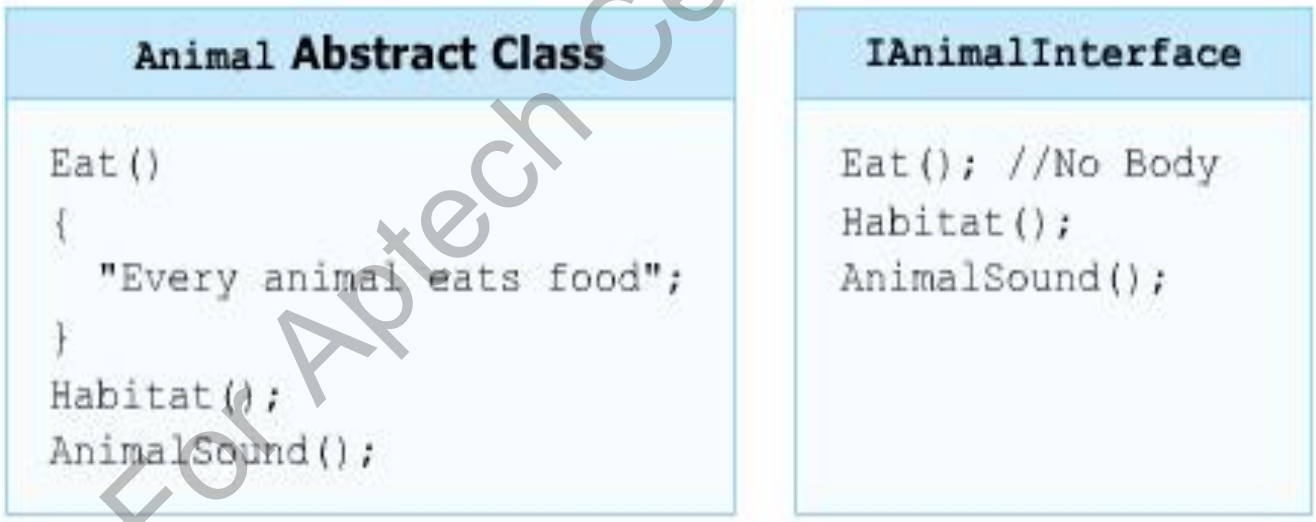
Purpose of Interfaces

- Consider a class **Dog** that needs to inherit features of **Canine** and **Animal** classes.
- The **Dog** class cannot inherit methods of both these classes as C# does not support multiple inheritance.
- However, if **Canine** and **Animal** are declared as interfaces, the class **Dog** can implement methods from both the interfaces.
- The following figure displays an example of subclasses with interfaces in C#:



Interfaces 1-2

- An interface contains only abstract members that cannot implement any method.
- An interface cannot be instantiated but can only be inherited by classes or other interfaces.
- An interface is declared using the keyword `interface`.
- In C#, by default, all members declared in an interface have `public` as the access modifier.
- The following figure displays an example of an interface:



- The following syntax is used to declare an interface:

Syntax

```
interface <InterfaceName>
{
     //interface members
}
```

where,

- `interface`: Declares an interface.
- `InterfaceName`: Is the name of the interface.

- The following code declares an interface **`IAnimal`**:

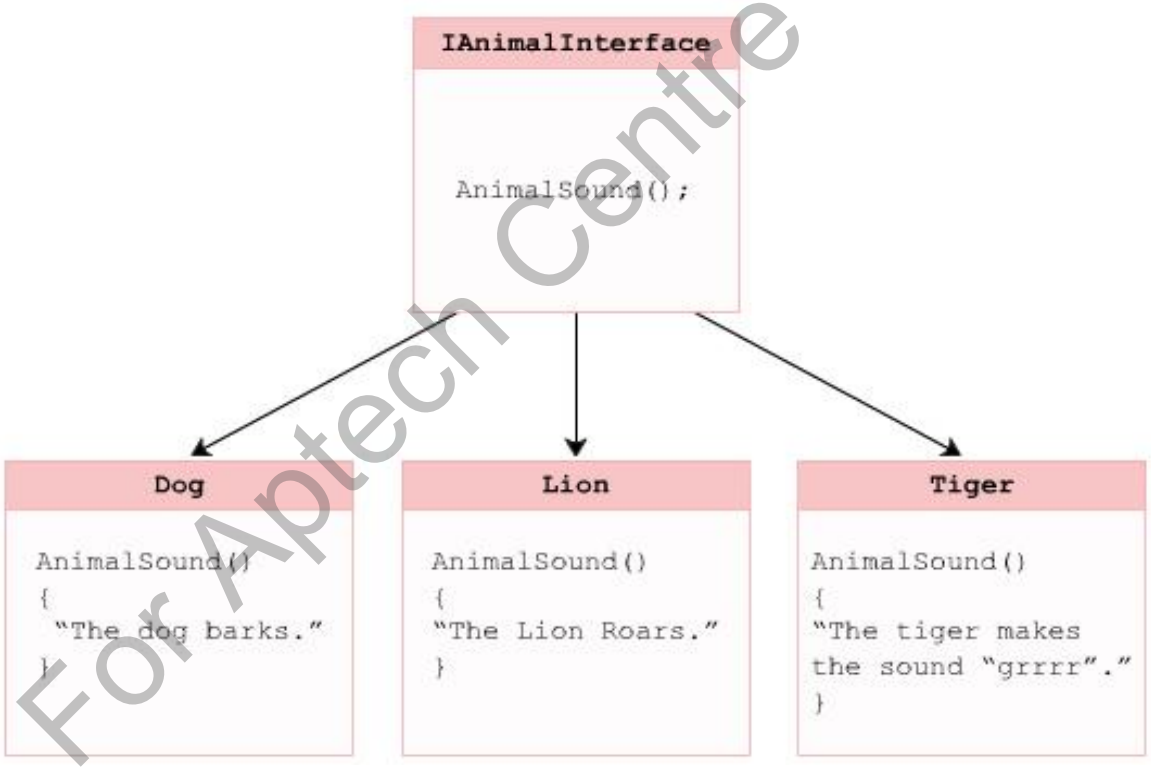
Snippet

```
interface IAnimal
{
     void AnimalType();
}
```

- In the code:
  - The interface **`IAnimal`** is declared which contains an abstract method **`AnimalType()`**.

Implementing an Interface 1-4

- An interface is implemented by a class in a way similar to inheriting a class.
- When implementing an interface in a class, implement all the abstract methods declared in the interface. If all the methods are not implemented, the class cannot be compiled.
- The methods implemented in the class should be declared with the same name and signature as defined in the interface.
- The following figure displays the implementation of an interface:



- The following syntax is used to implement an interface:

Syntax

```
class <ClassName> : <InterfaceName>
{
     //Implement the interface methods.
     //Define class members.
}
```

where,

- `InterfaceName`: Specifies the name of the interface.

- The following code declares an interface **IAnimal** and implements it in the class **Dog**:

Snippet

```
interface IAnimal
{
  void Habitat();
}

class Dog : IAnimal
{
   public void Habitat()
   {
     Console.WriteLine("Can be housed with human beings");
   }
   static void Main(string[] args)
   {

     Dog objDog = new Dog();
     Console.WriteLine(objDog.GetType().Name);
     objDog.Habitat();
   }

}
```

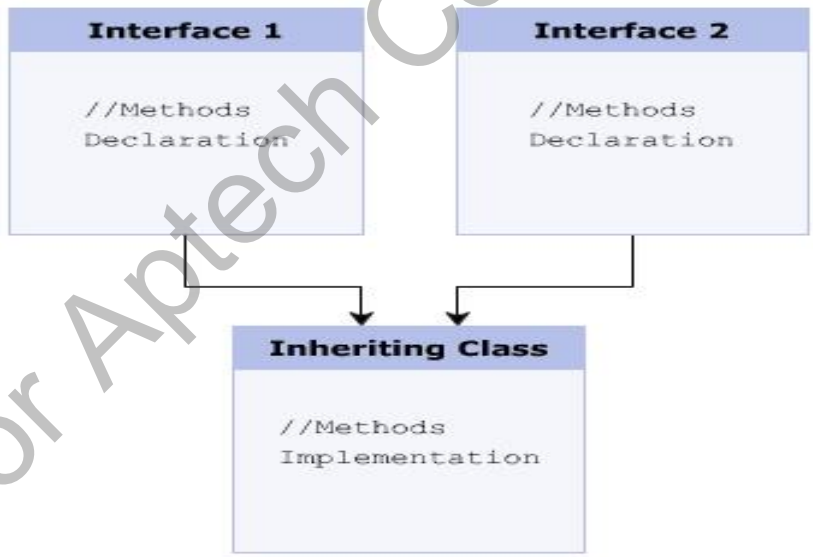
Output

```
Dog
Can be housed with human beings
```

- In the code:
  - The code creates an interface **`IAnimal`** that declares the method **`Habitat()`**.
  - The class **`Dog`** implements the interface **`IAnimal`** and its method **`Habitat()`**.
  - In the **`Main()`** method of the **`Dog`** class, the class name is displayed using the object and then, the method **`Habitat()`** is invoked using the instance of the **`Dog`** class.

Interfaces and Multiple Inheritance 1-3

- Multiple interfaces can be implemented in a single class which provides the functionality of multiple inheritance.
- You can implement multiple interfaces by placing commas between the interface names while implementing them in a class.
- A class implementing multiple interfaces has to implement all abstract methods declared in the interfaces.
- The `override` keyword is not used while implementing abstract methods of an interface.
- The following figure displays the concept of multiple inheritance using interfaces:



- The following syntax is used to implement multiple interfaces:

Syntax

```
class <ClassName> : <Interface1>, <Interface2>
{
    //Implement the interface methods
}
```

- where,
  - `Interface1`: Specifies the name of the first interface.
  - `Interface2`: Specifies the name of the second interface.

- The following code declares and implements multiple interfaces:

Snippet

```
interface ITerrestrialAnimal
{
    void Eat();
}
interface IMarineAnimal
{
    void Swim();
}
class Crocodile : ITerrestrialAnimal, IMarineAnimal
{
    public void Eat()
    {
       Console.WriteLine("The Crocodile eats flesh");
    }
    public void Swim()
    {
       Console.WriteLine("The Crocodile can swim four times faster than an Olympic swimmer");
    }
    static void Main(string[] args)
    {
      Crocodile objCrocodile = new Crocodile();
      objCrocodile.Eat();
      objCrocodile.Swim();
    }
}
```

Output

```
The Crocodile eats flesh
The Crocodile can swim four times faster than an
Olympic swimmer
```

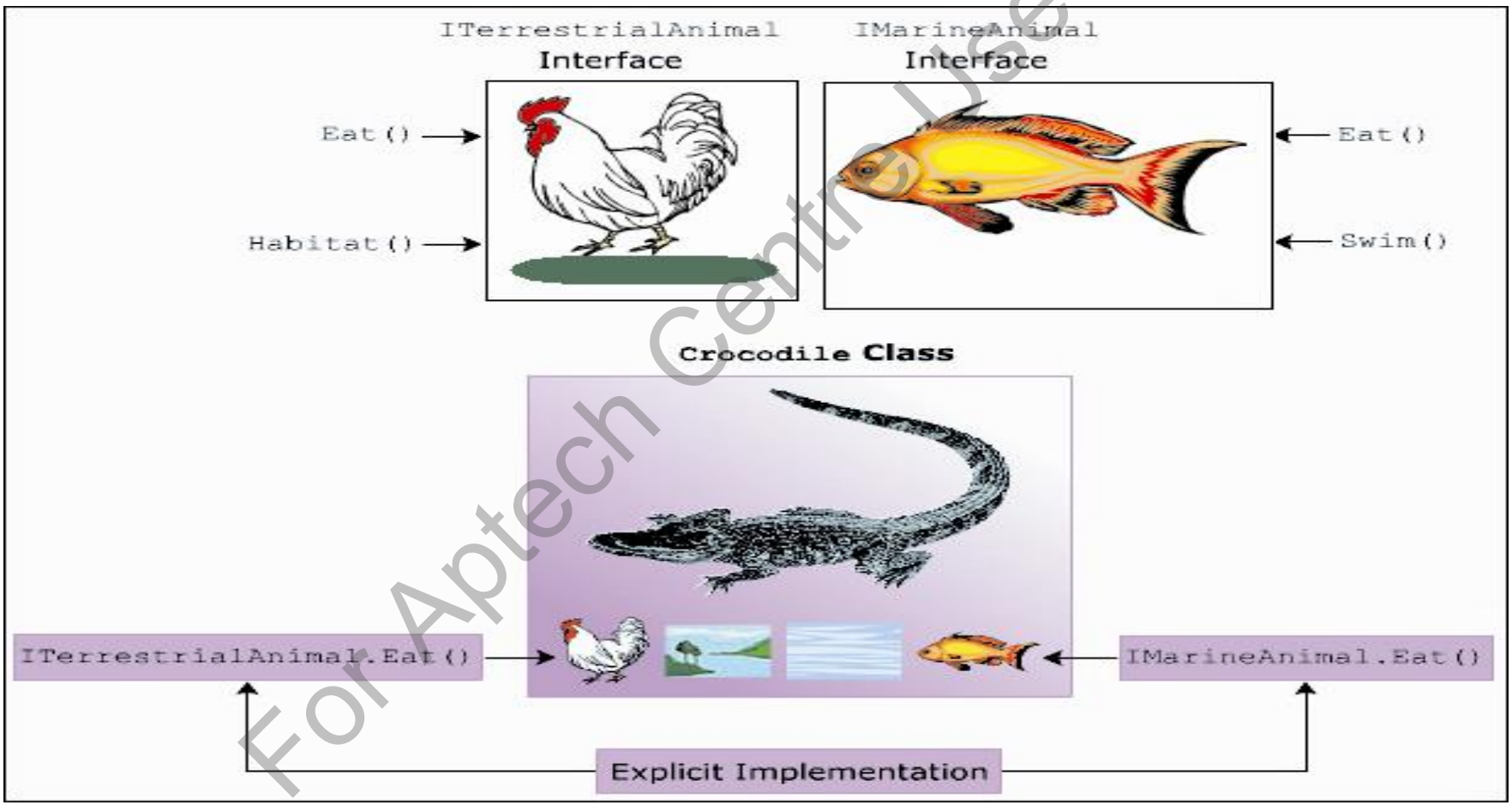
Explicit Interface Implementation 1-5

- A class has to explicitly implement multiple interfaces if these interfaces have methods with identical names.
- If an interface has a method name identical to the name of a method declared in the inheriting class, this interface has to be explicitly implemented.

Example

- Consider the interfaces **`ITerrestrialAnimal`** and **`IMarineAnimal`**. The interface **`ITerrestrialAnimal`** declares methods **`Eat()`** and **`Habitat()`**.
- The interface **`IMarineAnimal`** declares methods **`Eat()`** and **`Swim()`**.
- The class **`Crocodile`** implementing the two interfaces has to explicitly implement the method **`Eat()`** from both interfaces by specifying the interface name before the method name.
- While explicitly implementing an interface, you cannot mention modifiers such as `abstract`, `virtual`, `override`, or `new`.

- The following figure displays the explicit implementation of interfaces:



Explicit Interface Implementation 3-5

- The following syntax is used to explicitly implement interfaces:

Syntax

```
class <ClassName> : <Interface1>, <Interface2>
{
   <access modifier> Interface1.Method();
   {
   //statements;
   }
   <access modifier> Interface2.Method();
   {
   //statements;
   }
}
```

- where,
  - `Interface1`: Specifies the first interface implemented.
  - `Interface2`: Specifies the second interface implemented.
  - `Method()`: Specifies the same method name declared in the two interfaces.

- The following code demonstrates the use of implementing interfaces explicitly:

Snippet

```
interface ITerrestrialAnimal
{
     string Eat();
}
interface IMarineAnimal
{
     string Eat();
}
class Crocodile : ITerrestrialAnimal, IMarineAnimal
{
     string ITerrestrialAnimal.Eat()
     {
        string terCroc = "Crocodile eats other animals";
        return terCroc;
     }
     string IMarineAnimal.Eat()
     {
         string marCroc = "Crocodile eats fish and marine animals";
         return marCroc;
     }
     public string EatTerrestrial()
     {
          ITerrestrialAnimal objTerAnimal;
          objTerAnimal = this;
          return objTerAnimal.Eat();
      }
      public string EatMarine()
      {
          IMarineAnimal objMarAnimal;
          objMarAnimal = this;
          return objMarAnimal.Eat();
      }
      public static void Main(string[] args)
      {
          Crocodile objCrocodile = new Crocodile();
          string terCroc = objCrocodile.EatTerrestrial();
          Console.WriteLine(terCroc);
          string marCroc = objCrocodile.EatMarine();
          Console.WriteLine(marCroc);
      }
}
```

Output

```
Crocodile eats other animals
Crocodile eats fish and marine animals
```

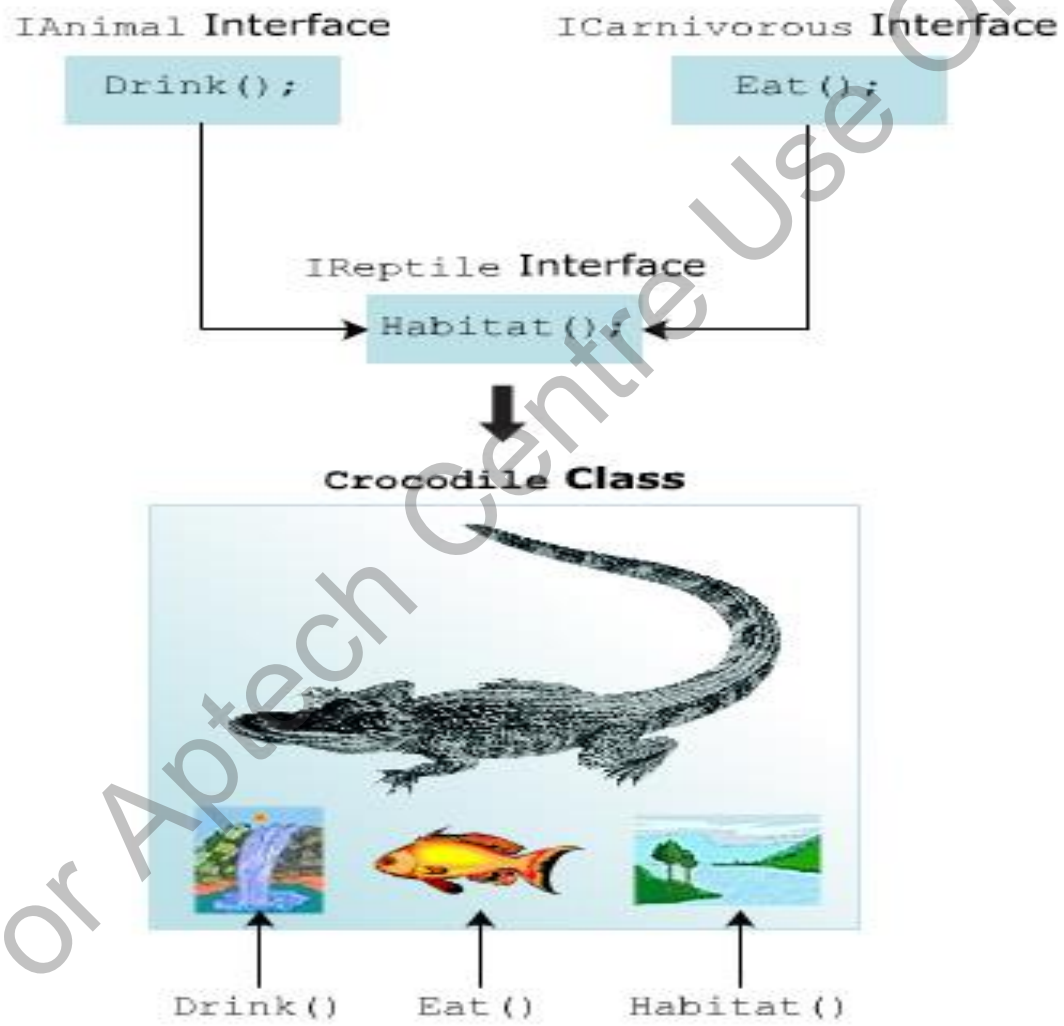
- In the code:
  - The class **`Crocodile`** explicitly implements the method **`Eat()`** of the two interfaces, **`ITerrestrialAnimal`** and **`IMarineAnimal`**.
  - The method **`Eat()`** is called by creating a reference of the two interfaces and then calling the method.

- An interface can inherit multiple interfaces but cannot implement them. The implementation has to be done by a class.

Example

- Consider three interfaces, **`IAnimal`**, **`Icarnivorous`**, and **`IReptile`**.
- The interface **`IAnimal`** declares methods defining general behavior of all animals.
- The interface **`ICarnivorous`** declares methods defining the general eating habits of carnivorous animals.
- The interface **`IReptile`** inherits interfaces **`IAnimal`** and **`ICarnivorous`**.
- However, these interfaces cannot be implemented by the interface **`IReptile`** as interfaces cannot implement methods.
- The class implementing the **`IReptile`** interface must implement the methods declared in the **`IReptile`** interface as well as the methods declared in the **`IAnimal`** and **`ICarnivorous`** interfaces.

- The following figure displays an example of interface inheritance:



- The following syntax is used to inherit an interface:

Syntax

```
interface <InterfaceName> : <Inherited_InterfaceName>
{
// method declaration;
}
```

- where,
  - `InterfaceName`: Specifies the name of the interface that inherits another interface.
  - `Inherited_InterfaceName`: Specifies the name of the inherited interface.

- The following code declares interfaces that are inherited by other interfaces:

Snippet

```
interface IAnimal
{
    void Drink();
}
interface ICarnivorous
{
   void Eat();
}
interface IReptile : IAnimal, ICarnivorous
{
   void Habitat();
}
class Crocodile : IReptile
{
     public void Drink()
     {
       Console.WriteLine("Drinks fresh water");
     }
     public void Habitat()
     {
        Console.WriteLine("Can stay in Water and Land");
     }
     public void Eat()
     {
         Console.WriteLine("Eats Flesh");
     }
     static void Main(string[] args)
     {
         Crocodile objCrocodile = new Crocodile();
         Console.WriteLine(objCrocodile.GetType().Name);
         objCrocodile.Habitat();
         objCrocodile.Eat();
         objCrocodile.Drink();
     }
}
```

Output

```
Crocodile
Can stay in Water and Land
Eats Flesh
Drinks fresh water
```

- In the code:
  - Three interfaces, **`IAnimal`**, **`ICarnivorous`**, and **`IReptile`**, are declared.
  - The three interfaces declare methods **`Drink()`**, **`Eat()`**, and **`Habitat()`** respectively.
  - The **`IReptile`** interface inherits the **`IAnimal`** and **`ICarnivorous`** interfaces.
  - The class **`Crocodile`** implements the interface **`IReptile`**, its declared method **`Habitat()`** and the inherited methods **`Eat()`** and **`Drink()`** of the **`ICarnivorous`** and **`IAnimal`** interfaces.

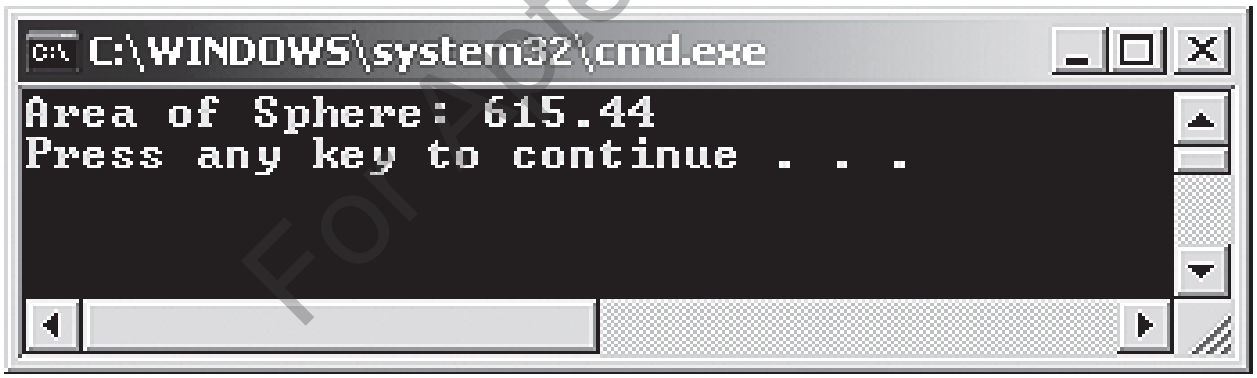
Interface Re-implementation 1-2

- A class can re-implement an interface.
- Re-implementation occurs when the method declared in the interface is implemented in a class using the `virtual` keyword and this virtual method is then overridden in the derived class.
- The following code demonstrates the purpose of re-implementation of an interface:

Snippet

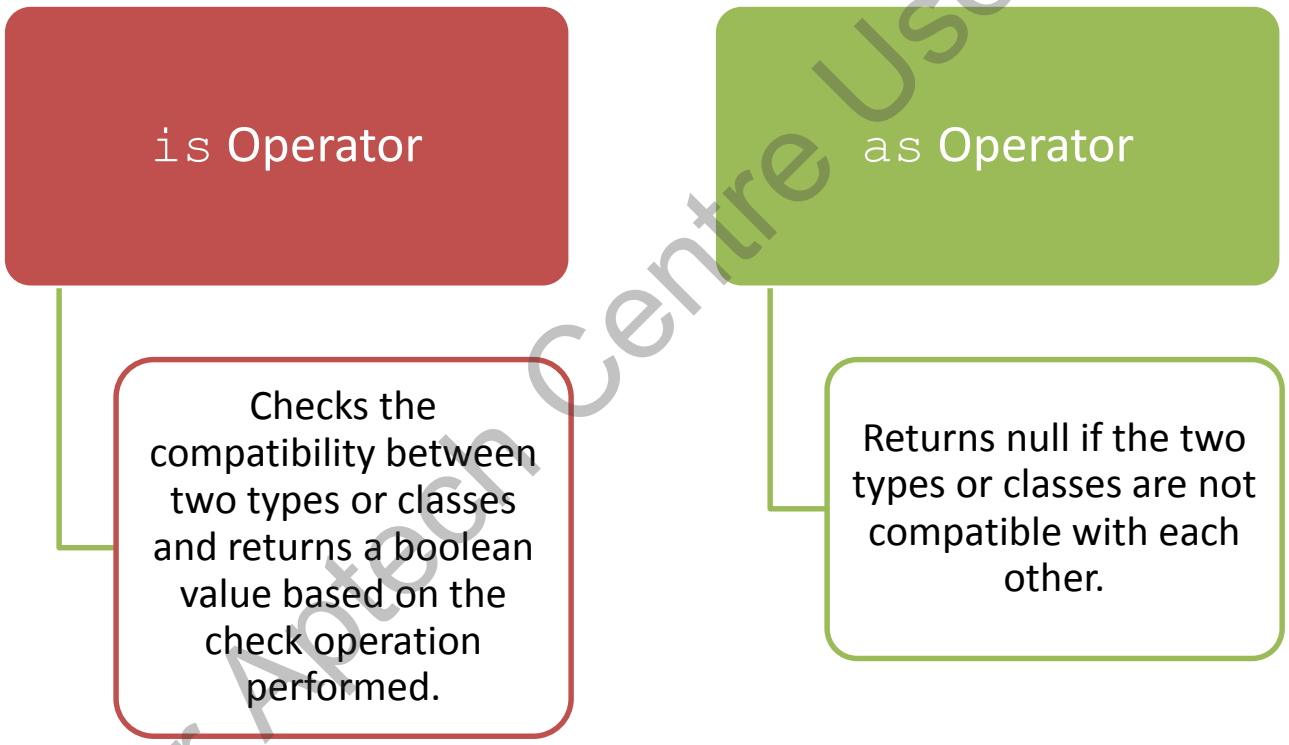
```
using System;
interface IMath {
  void Area();
}
class Circle : IMath
{
     public const float PI = 3.14F;
     protected float Radius;
     protected double AreaOfCircle;
     public virtual void Area()
     {
     AreaOfCircle = (PI * Radius * Radius);
     }
     }
     class Sphere : Circle
     {
     double _areaOfSphere;
     public override void Area()
     {
      base.Area();
       _areaOfSphere = (AreaOfCircle * 4 );
     }
      static void Main(string[] args)
      {
          Sphere objSphere = new Sphere();
          objSphere.Radius = 7;
          objSphere.Area();
          Console.WriteLine("Area of Sphere: {0:F2}" ,
          objSphere._areaOfSphere);
      }

}
```

- In the code:
  - The interface **`IMath`** declares the method **`Area()`**.
  - The class **`Circle`** implements the interface **`IMath`**.
  - The class **`Circle`** declares a virtual method **`Area()`** that calculates the area of a circle.
  - The class **`Sphere`** inherits the class **`Circle`** and overrides the base class method **`Area()`** to calculate the area of the sphere.
  - The `base` keyword calls the base class method **`Area()`**, thereby allowing the use of base class method in the derived class.
- The following figure displays the output of re-implementation of an interface:



The `is` and `as` Operators in Interfaces 1-5

- The `is` and `as` operators in C# when used with interfaces, verify whether the specified interface is implemented or not.



The is and as Operators in Interfaces 2-5

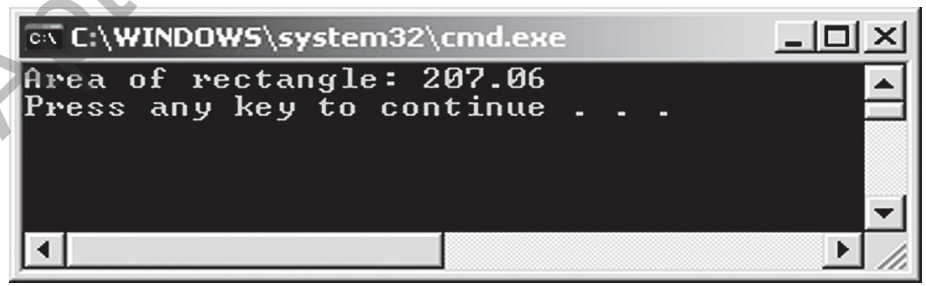
- The following code demonstrates an interface with the `is` operator:

Snippet

```
using System;
interface ICalculate {
    double Area();
}
class Rectangle : ICalculate{
   float _length;
   float _breadth;
   public Rectangle(float valOne, float valTwo) {
   _length = valOne;
   _breadth = valTwo;
   }
   public double Area() {
   return _length * _breadth;
  }
   static void Main(string[] args) {
       Rectangle objRectangle = new Rectangle(10.2F, 20.3F);
       if (objRectangle is ICalculate) {
       Console.WriteLine("Area of rectangle: {0:F2}" , objRectangle.Area());
       }
       else {
       Console.WriteLine("Interface method not implemented");
       }
   }
}
```

- In the code:
  - An interface **ICalculate** declares a method **Area()**.
  - The class **Rectangle** implements the interface **ICalculate** and it consists of a parameterized constructor that assigns the dimension values of the rectangle.
  - The **Area()** method calculates the area of the rectangle. The `Main()` method creates an instance of the class **Rectangle.**
  - The `is` operator is used within the `if-else` construct to check whether the class **Rectangle** implements the methods declared in the interface **ICalculate**.

- The following figure displays the output of the example using `is` operator:



The is and as Operators in Interfaces 4-5

- The code demonstrates an interface with the as operator:

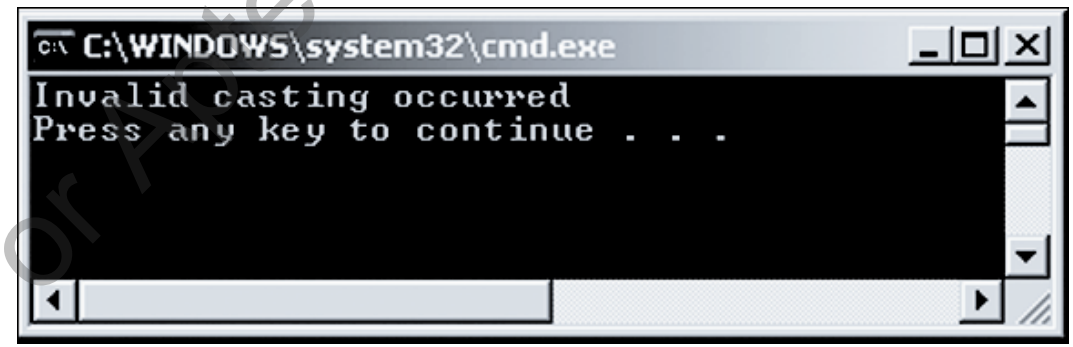
Snippet

```
using System;
interface ISet
{
    void AcceptDetails(int valOne, string valTwo);
}
interface IGet
{
  void Display();
}
class Employee : ISet
{
    int _empID;
    string _empName;
    public void AcceptDetails(int valOne, string valTwo)
    {
       _empID = valOne;
       _empName = valTwo;
    }
    static void Main(string[] args)
    {
        Employee objEmployee = new Employee();
        objEmployee.AcceptDetails(10, "Jack");
        IGet objGet = objEmployee as IGet;
        if (objGet != null)
        {
            objGet.Display();
        }
        else
        {
            Console.WriteLine("Invalid casting occurred");
        }
    }
}
```

The is and as Operators in Interfaces 5-5

- In the code:
  - The interface **ISet** declares a method **AcceptDetails** with two parameters and the interface **IGet** declares a method **Display()**.
  - The class **Employee** implements the interface **ISet** and implements the method declared within **ISet**.
  - The `Main()` method creates an instance of the class **Employee**.
  - An attempt is made to retrieve an instance of **IGet** interface checks whether the class **Employee** implements the methods defined in the interface.
  - Since the `as` operator returns null, the code displays the specified error message.

- The following figure displays the output of the example that uses the `as` operator:



Abstract Classes and Interfaces 1-2

- Abstract classes and interfaces both declare methods without implementing them.
- Although both abstract classes and interfaces share similar characteristics, they serve different purposes in a C# application.
- The similarities between abstract classes and interfaces are as follows:

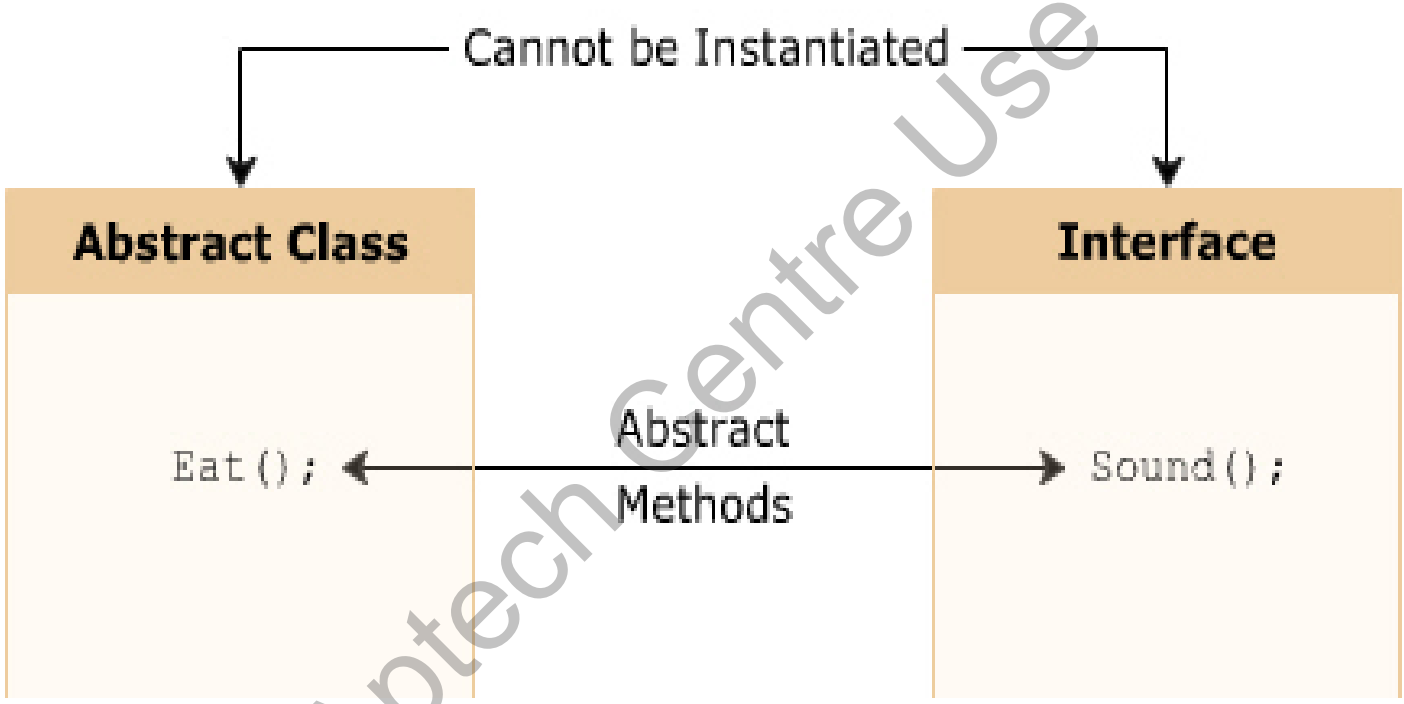
Neither an abstract class nor an interface can be instantiated.

Both, abstract classes as well as interfaces, contain abstract methods.

Abstract methods of both, the abstract class as well as the interface, are implemented by the inheriting subclass.

Both, abstract classes as well as interfaces, can inherit multiple interfaces.

- The following figure displays the similarities between abstract class and interface:



Differences Between an Abstract Class and an Interface

- Abstract classes and interfaces are similar because both contain abstract methods that are implemented by the inheriting class.
- However, there are certain differences between an abstract class and an interface as shown in the following table:

Abstract Classes	Interfaces
An abstract class can inherit a class and multiple interfaces.	An interface can inherit multiple interfaces but cannot inherit a class.
An abstract class can have methods with a body.	An interface cannot have methods with a body.
An abstract class method is implemented using the `override` keyword.	An interface method is implemented without using the `override` keyword.
An abstract class is a better option when you need to implement common methods and declare common abstract methods.	An interface is a better option when you need to declare only abstract methods.
An abstract class can declare constructors and destructors.	An interface cannot declare constructors or destructors.

Recommendations for Using Abstract Classes and Interfaces

- An abstract class can inherit another class whereas an interface cannot inherit a class.
- Therefore, abstract classes and interfaces have certain similarities as well as certain differences.
- Following are the guidelines to decide when to use an interface and when to use an abstract class:

Interface	•If a programmer wants to create reusable programs and maintain multiple versions of these programs, it is recommended to create an abstract class. •Abstract classes helps to maintain the version of the programs in a simple manner. •Unlike abstract classes, interfaces cannot be changed once they are created. •A new interface needs to be created to create a new version of the existing interface.
Abstract class	•If a programmer wants to create different methods that are useful for different types of objects, it is recommended to create an interface. •There must exist a relationship between the abstract class and the classes that inherit the abstract class. •On the other hand, interfaces are suitable for implementing similar functionalities in dissimilar classes.

Summary

- An abstract class can be referred to as an incomplete base class and can implement methods that are similar for all the subclasses.
- IntelliSense provides access to member variables, functions, and methods of an object or a class.
- When implementing an interface in a class, you need to implement all the abstract methods declared in the interface.
- A class implementing multiple interfaces has to implement all abstract methods declared in the interfaces.
- A class has to explicitly implement multiple interfaces if these interfaces have methods with identical names.
- Re-implementation occurs when the method declared in the interface is implemented in a class using the virtual keyword and this virtual method is then overridden in the derived class.
- The is operator is used to check the compatibility between two types or classes and as operator returns null if the two types or classes are not compatible with each other.