Object-Oriented Programming with C#

Classes, Constructors, Properties, Static Members, Interfaces, Inheritance, Polymorphism

Table of Contents

1. Defining Classes
2. Access Modifiers
3. Constructors
4. Fields, Constants and Properties
5. Static Members
6. Structures
7. Delegates and Events
8. Interfaces
9. Inheritance
10. Polymorphism (same as VB.net)

OOP and .NET

- In .NET Framework the object-oriented approach has roots in the deepest architectural level
- All .NET applications are object-oriented
- All .NET languages are object-oriented
- The class concept from OOP has two realizations:
  - Classes and structures
- There is no multiple inheritance in .NET
- Classes can implement several interfaces at the same time

Defining Classes

Classes in OOP

- Classes model real-world objects and define
  - Attributes (state, properties, fields)
  - Behavior (methods, operations)
- Classes describe structure of objects
  - Objects describe particular instance of a class
- Properties hold information about the modeled object relevant to the problem
- Operations implement object behavior

Classes in C#

- Classes in C# could have following members:
  - Fields, constants, methods, properties, indexers, events, operators, constructors, destructors
  - Inner types (delegates, …)
- Members can have access modifiers (scope)
  - public, private, protected, internal, protected internal
- Members can be
  - `static` (common) or specific for a given object

Simple Class Definition

Begin of class definition

```
public class Cat : Animal
{
    private string name;
    private string owner;

    public Cat(string name, string owner)
    {
        this.name = name;
        this.owner = owner;
    }

    public string Name
    {
        get { return name; }
        set { name = value; }
    }
```

Inherited (base) class

Fields

Constructor

Property

Simple Class Definition (2)

```
    public string Owner
    {
        get { return owner;}
        set { owner = value; }
    }

    public void SayMiau()
    {
        Console.WriteLine("Miauuuuuuu!");
    }
}
```

Method

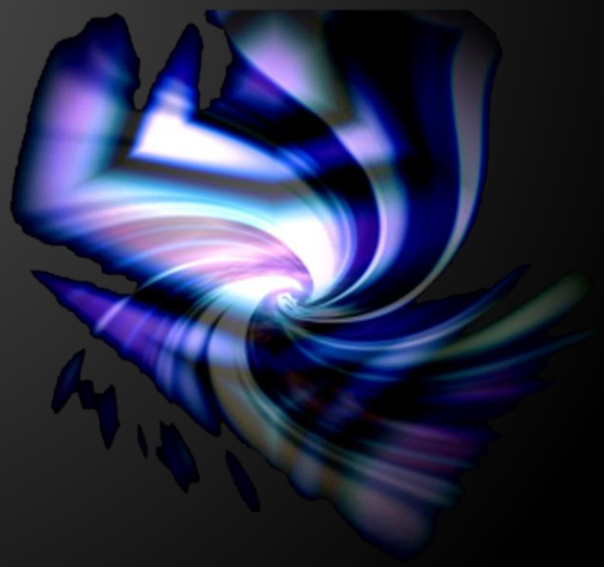
End of class definition

Classes and Their Members

- Classes have members
  - Fields, constants, methods, properties, indexers, events, operators, constructors, destructors
  - Inner types (delegates, …)
- Members have modifiers (scope)
  - public, private, protected, internal, protected internal
- Members can be
  - static (common) or for a given type

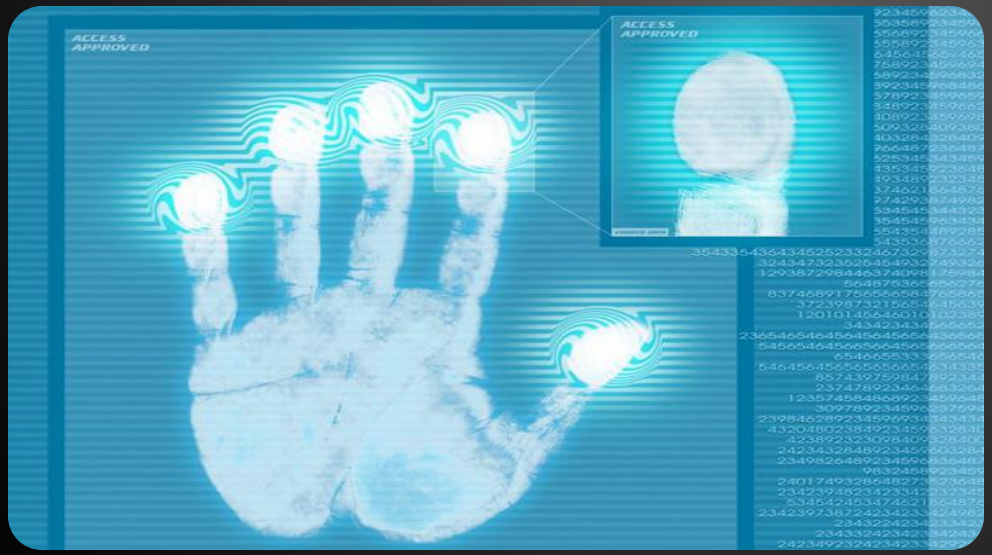
Class Definition and Members

- Class definition consists of:
  - Class declaration
  - Inherited class or implemented interfaces
  - Fields (static or not)
  - Constructors (static or not)
  - Properties (static or not)
  - Methods (static or not)
  - Events, inner types, etc.



Access Modifiers

Public, Private, Protected, Internal, Protected Internl



Access Modifiers

- Class members can have access modifiers
  - Used to restrict the classes able to access them
  - Supports the OOP principle "encapsulation"
- Class members can be:
  - `public` – accessible from any class
  - `protected` – accessible from the class itself and all its descendent classes
  - `private` – accessible from the class itself only
  - `internal` – accessible from current assembly
  - protected internal

Defining Classes

Example

Task: Define Class Dog

- Our task is to define a simple class that represents information about a dog
  - The dog should have name and breed
  - If there is no name or breed assigned to the dog, it should be named "Balkan" and its breed should be "Street excellent"
  - It should be able to view and change the name and the breed of the dog
  - The dog should be able to bark

Defining Class Dog – Example

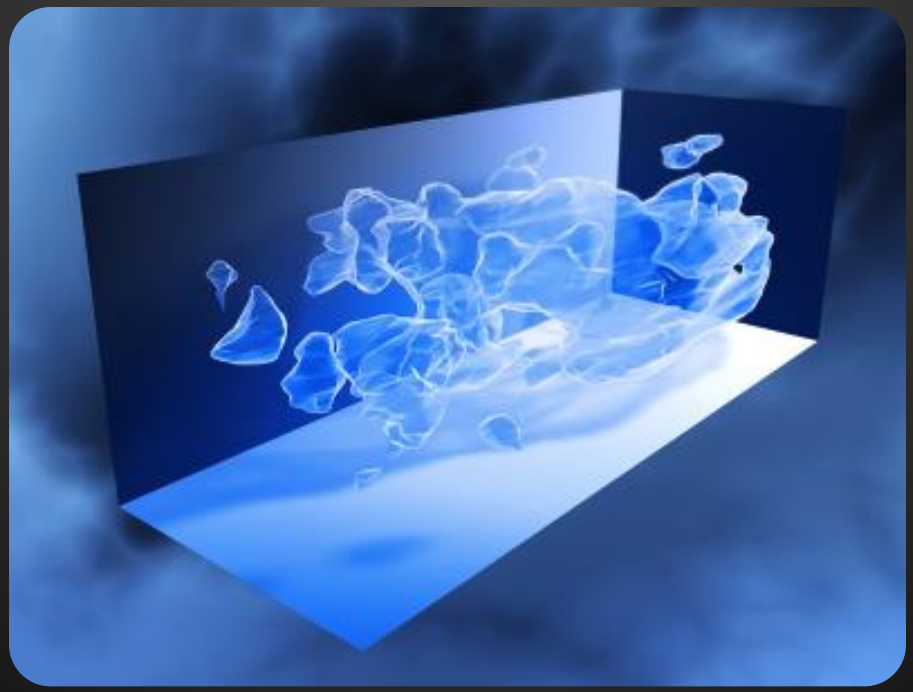
```
public class Dog
{
    private string name;
    private string breed;

    public Dog()
    {
        this.name = "Balkan";
        this.breed = "Street excellent";
    }

    public Dog(string name, string breed)
    {
        this.name = name;
        this.breed = breed;
    }
```

//(example continues)

Defining Class Dog – Example (2)

```
    public string Name
    {
        get { return name; }
        set { name = value; }
    }

    public string Breed
    {
        get { return breed; }
        set { breed = value; }
    }

    public void SayBau()
    {
        Console.WriteLine("{0} said: Bauuuuuu!", name);
    }
}
```

Using Classes and Objects

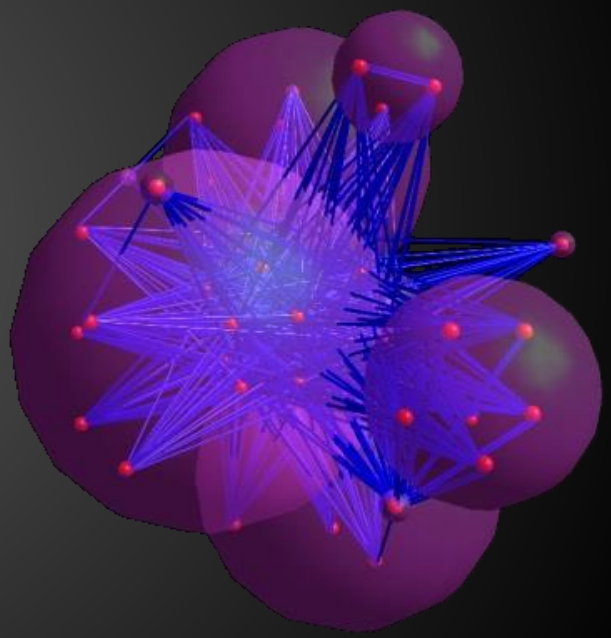


Using Classes

- How to use classes?
  - Create a new instance
  - Access the properties of the class
  - Invoke methods
  - Handle events
- How to define classes?
  - Create new class and define its members
  - Create new class using some other as base class

How to Use Classes (Non-static)?

1. Create an instance
   - Initialize fields
2. Manipulate instance
   - Read / change properties
   - Invoke methods
   - Handle events
3. Release occupied resources
   - Done automatically in most cases



Task: Dog Meeting

- Our task is as follows:
  - Create 3 dogs
    - First should be named "Sharo", second – "Rex" and the last – left without name
  - Add all dogs in an array
  - Iterate through the array elements and ask each dog to bark
  - Note:
    - Use the Dog class from the previous example!

Dog Meeting – Example

```
static void Main()
{
    Console.WriteLine("Enter first dog's name: ");
    dogName = Console.ReadLine();
    Console.WriteLine("Enter first dog's breed: ");
    dogBreed = Console.ReadLine();

    // Using the Dog constructor to set name and breed
    Dog firstDog = new Dog(dogName, dogBreed);
    Dog secondDog = new Dog();
    Console.WriteLine("Enter second dog's name: ");
    dogName = Console.ReadLine();
    Console.WriteLine("Enter second dog's breed: ");
    dogBreed = Console.ReadLine();

    // Using properties to set name and breed
    secondDog.Name = dogName;
    secondDog.Breed = dogBreed;
}
```

Constructors

Defining and Using Class Constructors

What is Constructor?

- Constructors are special methods
  - Invoked when creating a new instance of an object
  - Used to initialize the fields of the instance
- Constructors has the same name as the class
  - Have no return type
  - Can have parameters
  - Can be `private`, `protected`, `internal`, `public`

Defining Constructors

- Class `Point` with parameterless constructor:

```
public class Point
{
    private int xCoord;
    private int yCoord;

    // Simple default constructor
    public Point()
    {
        xCoord = 0;
        yCoord = 0;
    }

    // More code ...
}
```

Defining Constructors (2)

```
public class Person
{
    private string name;
    private int age;
    // Default constructor
    public Person()
    {
        name = "[no name]";
        age = 0;
    }
    // Constructor with parameters
    public Person(string name, int age)
    {
        this.name = name;
        this.age = age;
    }
    // More code ...
}
```

As rule constructors should initialize all own class fields.

Constructors and Initialization

- Pay attention when using inline initialization!

```
public class ClockAlarm
{
   private int hours = 9; // Inline initialization
   private int minutes = 0; // Inline initialization
   // Default constructor
   public ClockAlarm()
   { }
   // Constructor with parameters
   public ClockAlarm(int hours, int minutes)
   {
      this.hours = hours;      // Invoked after the
  inline
      this.minutes = minutes;  // initialization!
   }
   // More code ...
}
```

Chaining Constructors Calls

- Reusing constructors

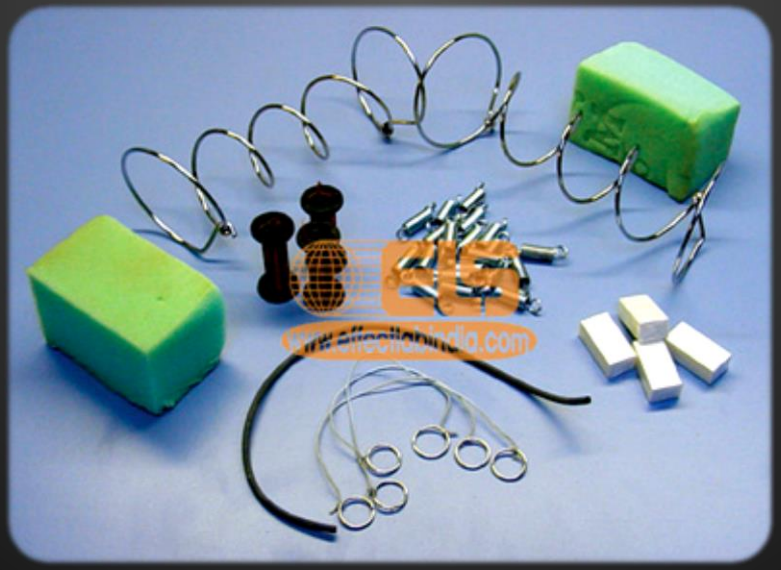
```
public class Point
{
    private int xCoord;
    private int yCoord;

    public Point() : this(0,0) // Reuse construc
    {
    }

    public Point(int xCoord, int yCoord)
    {
        this.xCoord = xCoord;
        this.yCoord = yCoord;
    }

    // More code ...
}
```

Copy Constructor

- Create copy of existing object as new object

```
public class Point
{
    private int xCoord;
    private int yCoord;

    public Point(int x, int y)  //Constructor
    {
       xCoord = x; yCoord = y;
    }

    public Point(Point p1) //Copy Constructor
    {
        this.xCoord = p1.xCoord;
        this.yCoord = p1.yCoord;
    }

    // More code ...
}
```

Fields, Constants and and Properties



Fields

- Fields contain data for the class instance
- Can be arbitrary type
- Have given scope
- Can be declared with a specific value

```
class Student
{
    private string firstName;
    private string lastName;
    private int course = 1;
    private string speciality;
    protected Course[] coursesTaken;
    private string remarks = "(no remarks)";
}
```

Constants

- Constant fields are defined like fields, but:
  - Defined with `const`
  - Must be initialized at their definition
  - Their value can not be changed at runtime

```
public class MathConstants
{
    public const string PI_SYMBOL = "π";
    public const double PI = 3.14159265358979323385;
    public const double E = 2.71828182845904523354;
    public const double LN10 = 2.30258509299405;
    public const double LN2 = 0.693147180559945;
}
```

Read-Only Fields

- Initialized at the definition or in the constructor
  - Can not be modified further
- Defined with the keyword `readonly`
- Represent runtime constants

```
public class ReadOnlyDemo
{
    private readonly int size;
    public ReadOnlyDemo(int Size)
    {
      size = Size; // can not be further modified!
    }
}
```

The Role of Properties

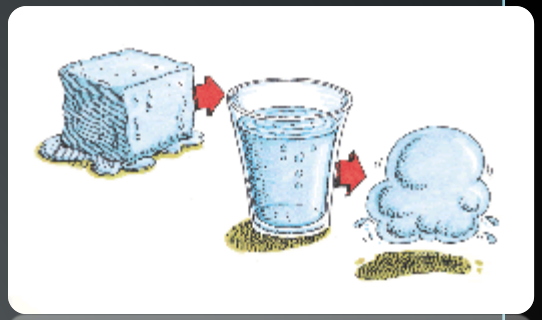
- Expose object's data to the outside world
- Control how the data is manipulated
- Properties can be:
  - Read-only
  - Write-only
  - Read and write
- Give good level of abstraction
- Make writing code easier

Defining Properties in C#

- Properties should have:
  - Access modifier (`public`, `protected`, etc.)
  - Return type
  - Unique name
  - Get and / or Set part
  - Can contain code processing data in specific way

Defining Properties – Example

```
public class Point
{
    private int xCoord;
    private int yCoord;

    public int XCoord
    {
        get { return xCoord; }
        set { xCoord = value; }
    }

    public int YCoord
    {
        get { return yCoord; }
        set { yCoord = value; }
    }

    // More code ...
}
```



Static Members

Static vs. Instance Members

Static Members

- Static members are associated with a type rather than with an instance
  - Defined with the modifier `static`
- Static can be used for
  - Fields
  - Properties
  - Methods
  - Events
  - Constructors

Static vs. Non-Static

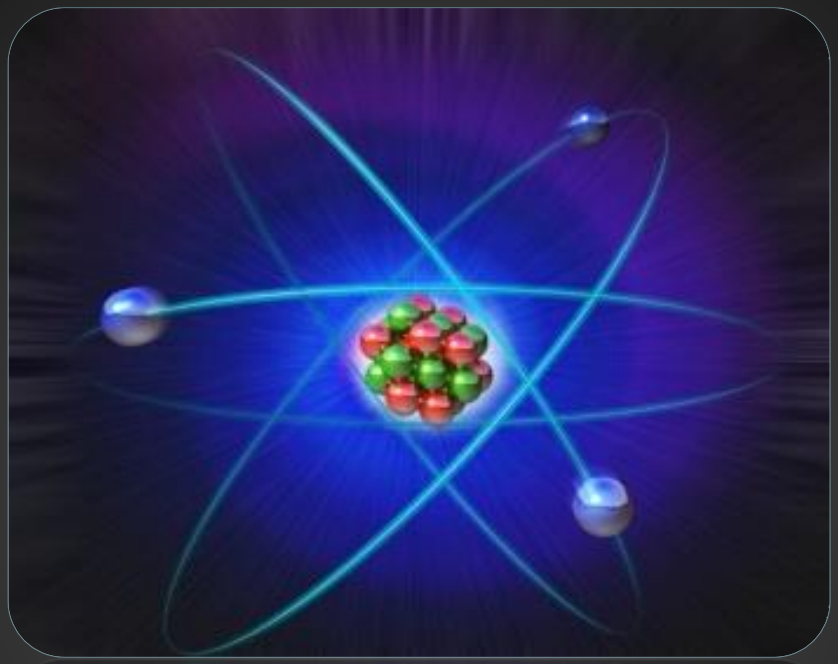
- Static:
  - Associated with a type, not with an instance
- Non-Static:
  - The opposite, associated with an instance
- Static:
  - Initialized just before the type is used for the first time
- Non-Static:
  - Initialized when the constructor is called

Static Members – Example

```
public class SqrtPrecalculated
{
    public const int MAX_VALUE = 10000;

    // Static field
    private static int[] sqrtValues;

    // Static constructor
    private static SqrtPrecalculated()
    {
        sqrtValues = new int[MAX_VALUE + 1];
        for (int i = 0; i < sqrtValues.Length; i++)
        {
            sqrtValues[i] = (int)Math.Sqrt(i);
        }
    }
                                        //(example continues)
```

Static Members – Example (2)

```
    // Static method
    public static int GetSqrt(int value)
    {
        return sqrtValues[value];
    }

    // The Main() method is always static
    static void Main()
    {
        Console.WriteLine(GetSqrt(254));
    }
}
```



Structures

Structures

- Structures represent a combination of fields with data
  - Look like the classes, but are value types
  - Their content is stored in the stack
  - Transmitted by value
  - Destroyed when go out of scope
- However classes are reference type and are placed in the dynamic memory (heap)
  - Their creation and destruction is slower

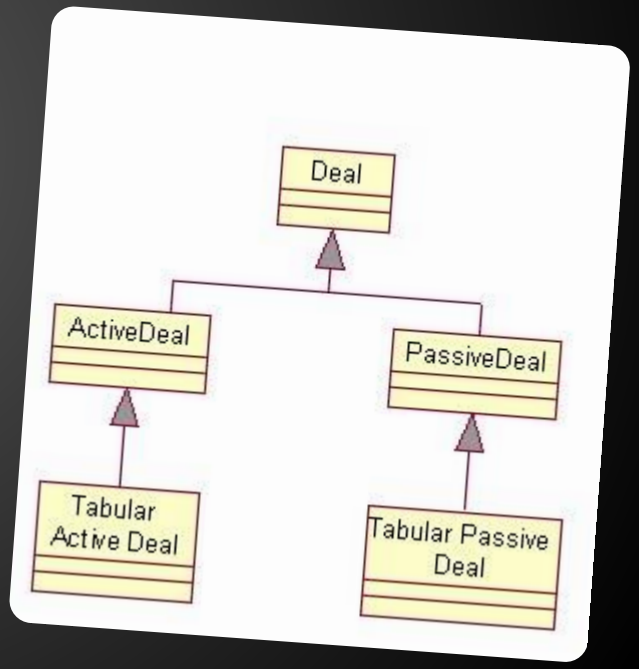
Structures – Example

```
struct Point
{
    public int X, Y;
}

struct Color
{
    public byte redValue;
    public byte greenValue;
    public byte blueValue;
}

struct Square
{
    public Point location;
    public int size;
    public Color borderColor;
    public Color surfaceColor;
}
```

When to Use Structures?

- Use structures
  - To make your type behave as a primitive type
  - If you create many instances and after that you free them – e.g. in a cycle
- Do not use structures
  - When you often transmit your instances as method parameters

Inheritance



Inheritance

- Inheritance is the ability of a class to implicitly gain all members from another class
  - Inheritance is fundamental concept in OOP
- The class whose methods are inherited is called base (parent) class
- The class that gains new functionality is called derived (child) class
- Inheritance establishes an is-a relationship between classes: A is B

Inheritance (2)

- All class members are inherited
  - Fields, methods, properties, …
- In C# classes could be inherited
  - The structures in C# could not be inherited
- Inheritance allows creating deep inheritance hierarchies
- In .NET there is no multiple inheritance, except when implementing interfaces

How to Define Inheritance?

- We must specify the name of the base class after the name of the derived

```
public class Shape
{...}
public class Circle : Shape
{...}
```

- In the constructor of the derived class we use the keyword base to invoke the constructor of the base class

```
public Circle (int x, int y) : base(x)
{...}
```

Inheritance – Example

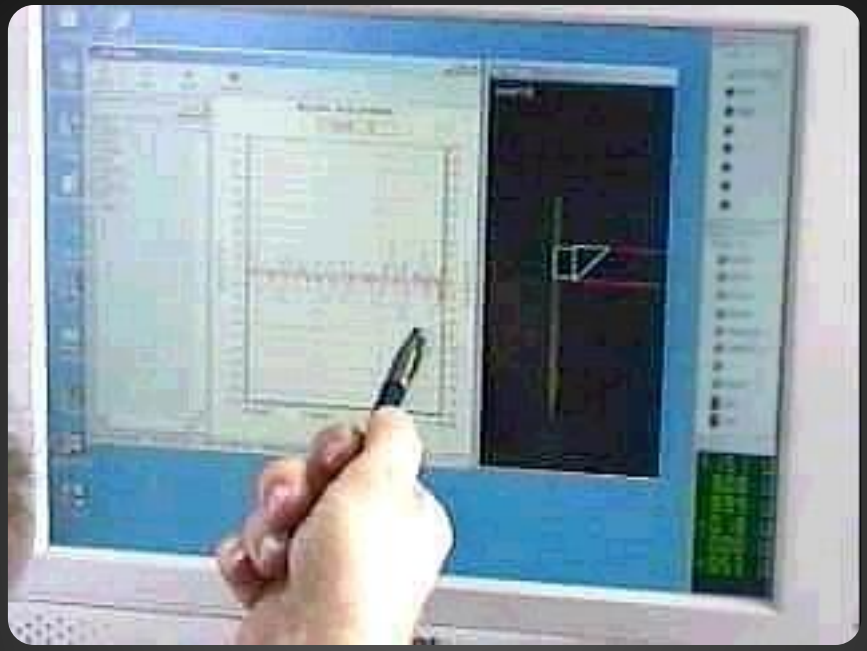
```
public class Mammal
{
    private int age;

    public Mammal(int age)
    {
        this.age = age;
    }

    public int Age
    {
        get { return age; }
        set { age = value; }
    }

    public void Sleep()
    {
        Console.WriteLine("Shhh! I'm sleeping!");
    }
}
```

Inheritance – Example (2)

```
public class Dog : Mammal
{
    private string breed;
    public Dog(int age, string breed): base(age)
    {
        this.breed = breed;
    }
    public string Breed
    {
        get { return breed; }
        set { breed = value; }
    }
    public void WagTail()
    {
        Console.WriteLine("Tail wagging...");
    }
}
```

Inheritance – Example (3)

```
static void Main()
{
    // Create 5 years old mammal
    Mamal mamal = new Mamal(5);
    Console.WriteLine(mamal.Age);
    mamal.Sleep();

    // Create a bulldog, 3 years old
    Dog dog = new Dog("Bulldog", 3);
    dog.Sleep();
    dog.Age = 4;
    Console.WriteLine("Age: {0}", dog.Age);
    Console.WriteLine("Breed: {0}", dog.Breed);
    dog.WagTail();
}
```



Interfaces and Abstract Classes

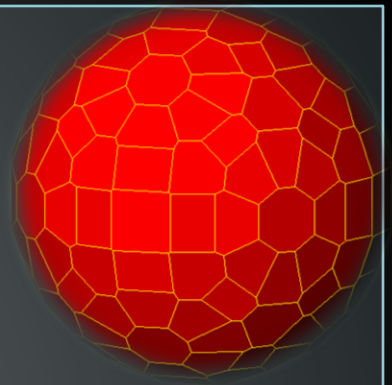
Interfaces

- Describe a group of methods (operations), properties and events
  - Can be implemented by given `class` or `structure`
- Define only the methods' prototypes
- No concrete implementation
- Can be used to define `abstract` data types
- Can not be instantiated
- Members do not have scope modifier and by default the scope is `public`

Interfaces – Example

```
public interface IPerson
{
    string Name  // property Name
    { get; set; }
    DateTime DateOfBirth  // property Date
    { get; set; }
    int Age  // property Age (read-only)
    { get; }
}
```

Interfaces – Example (2)



```
interface IShape
{
    void SetPosition(int x, int y);
    int CalculateSurface();
}

interface IMovable
{
    void Move(int deltaX, int deltaY);
}

interface IResizable
{
    void Resize(int weight);
    void Resize(int weightX, int weightY);
    void ResizeByX(int weightX);
    void ResizeByY(int weightY);
}
```

Interface Implementation

- Classes and structures can implement (support) one or many interfaces
- Interface realization must implement all its methods
- If some methods do not have implementation the `class` or `structure` have to be declared as an abstract

Interface Implementation – Example

```
class Rectangle : IShape, IMovable
{
    private int x, y, width, height;
    public void SetPosition(int x, int y) // IShape
    {
        this.x = x;
        this.y = y;
    }
    public int CalculateSurface() // IShape
    {
        return this.width * this.height;
    }
    public void Move(int deltaX, int deltaY) // IMovable
    {
        this.x += deltaX;
        this.y += deltaY;
    }
}
```

Abstract Classes

- Abstract method is a method without implementation
  - Left empty to be implemented by descendant classes
- When a class contains at least one abstract method, it is called abstract class
  - Mix between class and interface
  - Inheritors are obligated to implement their abstract methods
  - Can not be directly instantiated

Abstract Class – Example

```
abstract class MovableShape : IShape, IMovable
{
    private int x, y;
    public void Move(int deltaX, int deltaY)
    {
        this.x += deltaX;
        this.y += deltaY;
    }
    public void SetPosition(int x, int y)
    {
        this.x = x;
        this.y = y;
    }
    public abstract int CalculateSurface();
}
```

Object-Oriented Programming with C#

Questions?