Professional Software Engineering

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Hritik Singh and Mohab Hassaan – Tutors

Chair of Computational Modeling and Simulation

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Schedule Week 2

- Functions & References
- Object Oriented Programming
  - Inheritance
  - Abstract Classes & Interfaces

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RECAP LAST LECTURE

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Datatypes

- Value types
  - bool (true or false)
  - char (16-bit Unicode)
  - Numeric Types
  - enum
  - struct
- Reference types
  - object
  - strings
  - array
  - and everything derived (classes)
- Strings are immutable !

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if & switch statements

```
» if( condition )
» {
»     statement block...
» }
» else
» {
»     statement block...
» }
```

```
switch(var) {
        case one:
            // do something
            break;
        case two:
        case three:
            // do something if one is true
            break;
        default:
            // is executed if there is no match
            // no break needed
}
```


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while & for loops

```
» while (condition)
» {
»     statement block...
» }
```

```
» for (initializer; condition; iterator)
» {
»     statement block...
» }
```

Both *while* and *for* loop as long as condition is fulfilled.

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Loops: break & continue keywords

```
» while (condition)
» {
»     statement block...
» }
```

- break: used to jump out of a loop
- continue: continue with the next iteration in a loop

```
int counter = 0;
int limit = 5;
while (true) {
    if (counter > limit){
        // step out of loop
        break;
    }
    counter++;
}
```

Live coding

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Casting - Example

```
public void CastingExample() {
        double floatingPoint_1 = 1.4;
        double floatingPoint_2 = 1.8;
        int result = 0;

        result = (int) floatingPoint_1;
        //result will now be 1
        result = (int) floatingPoint_2;
        //result will still be 1
        floatingPoint_2 = (double) result;
        // floatingPoint_2 is 1
  }
```


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REFERENCES & FUNCTIONS

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Basics: Functions | Procedures

» What are functions? Basically, a code package… ➔ functions are ideal for repetitive work!

Example:

```
datatype Name(ParameterA, ParameterB, ...) {
    //Code
    return returnValue
}
```

» Function have multiple inputs, **but one** output

» *datatype* specifies the return type

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Basics: Functions | Procedures

» What are functions? Basically, a code package… ➔ functions are ideal for repetitive work!

Example:

```
datatype Name(ParameterA, ParameterB, ...) {
    //Code
    return returnValue
}
```

» Function have multiple inputs, **but one output**

» *datatype* specifies the return type

Input and output variables have a datatype (like *int*, *string*, *float*);

If no value is returned from the function the keyword `void` is used!

» A function is identified by its signature

- **There can be multiple functions of the same Name**
- **This is called <u>overloading</u> a function**

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Basics: Functions | Why to use functions?

- Reusability
  - **old projects**
  - **invoke multiple times**
  - **building blocks**
- Abstraction
  - **you don't need to know the internals!**
    - → can you build a car yourself?

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Basics: Functions | Scope of Variables

- The scope of a variable practically means its visibility
- Variables defined inside a function or a loop are not visible outside this function (in C#...)

  Scope depends on language…

- Information can only leave the **scope** of the function if:
  - an outside variable is set
  - a value is returned from a function
  - a reference is passed as a parameter

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Basics: Reference Types

» What is a reference type?

A reference type variable contains a reference to data stored in special part of the memory (aka heap)

» Difference to value types:

Value Types
Contain their data

int
float
enum
bool
struct

Each variable makes a copy of the data

Reference Types
Store references to their data

string
object
array
class

Multiple references to same object possible

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Basics: Passing by Reference Types

- What is a reference type?

  A reference type variable contains a reference to data stored in special part of the memory (aka heap)

- Difference to value types:

  Value types: contain their data

  Reference types: Store references to their data

- Strings are immutable, and behave mostly like value types

- Passing arguments as reference types via the ref or out keywords (ref requires parameter to be already initialized, out does not) will surpass the local scope of variables

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An Introduction

OBJECT-ORIENTED PROGRAMMING (OOP)

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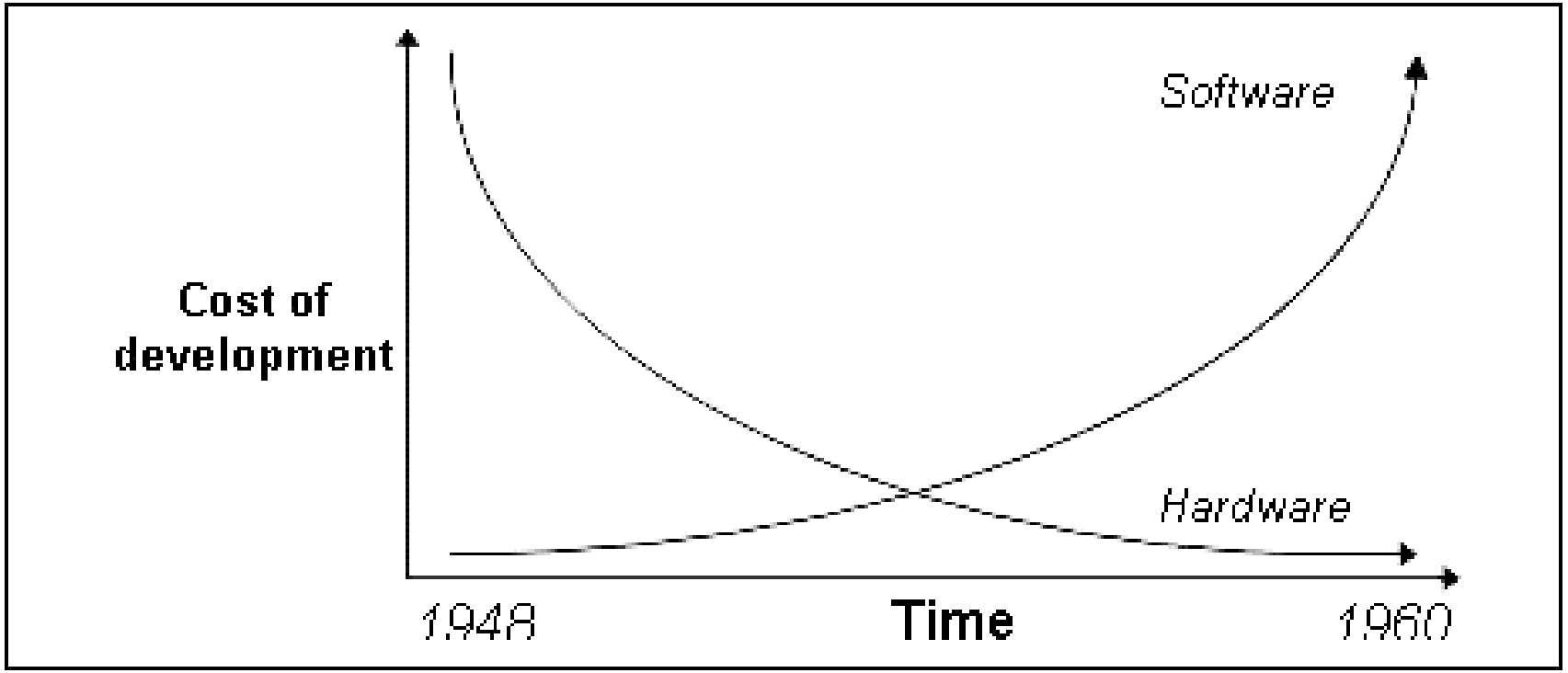
Motivation: Software Crisis



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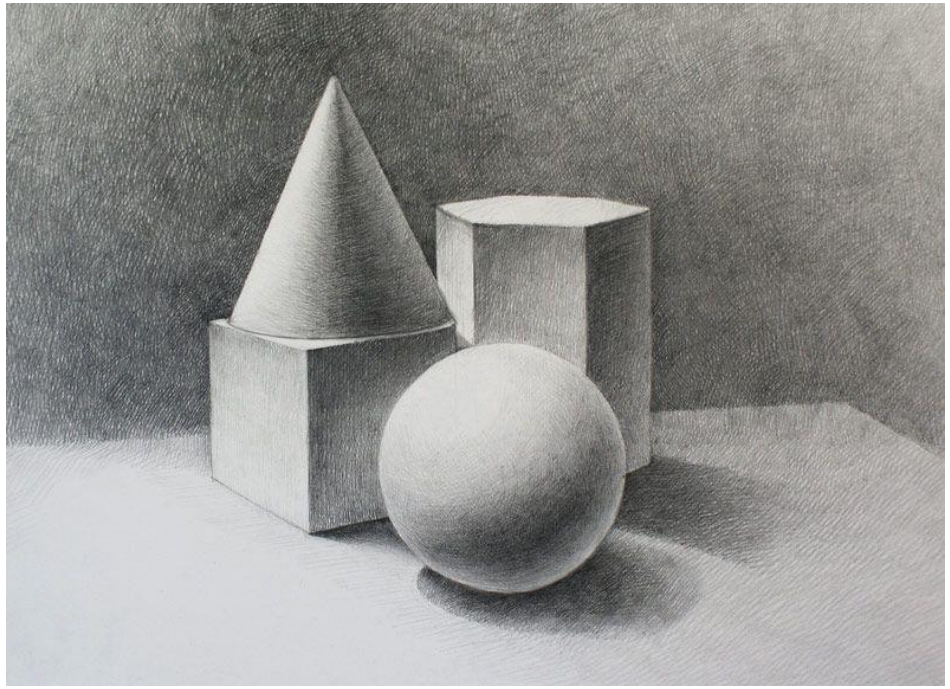
“[The major cause of the software crisis is] that the machines have become several orders of magnitude more powerful! To put it quite bluntly: as long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem, and now we have gigantic computers, programming has become an equally gigantic problem.”

Edsger W. Dijkstra: The humble programmer

Solution - OOP

- To handle complex projects, code is broken down to comprehensible and isolated fragments (= objects)
- The objects are instances of categories (=classes), e.g. ‘User’, ‘Car’, ‘Circle’ or ‘UserDataController’
- OOP improves Maintainability, Reusability and Comprehensiveness of Code



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Key Concept And Naming

- two basic constructs:
  - class
  - object
- the class is a **blueprint**, or **template**
  - defines the behavior
  - complex **datatype**
- an object is a “concrete” entity
  - based on defined class
  - independent from other objects
- function bound to objects are often called **methods**
- in C# attributes only visible to the object itself are called **fields**
- Fields and methods are oftentimes referred to as class **member**

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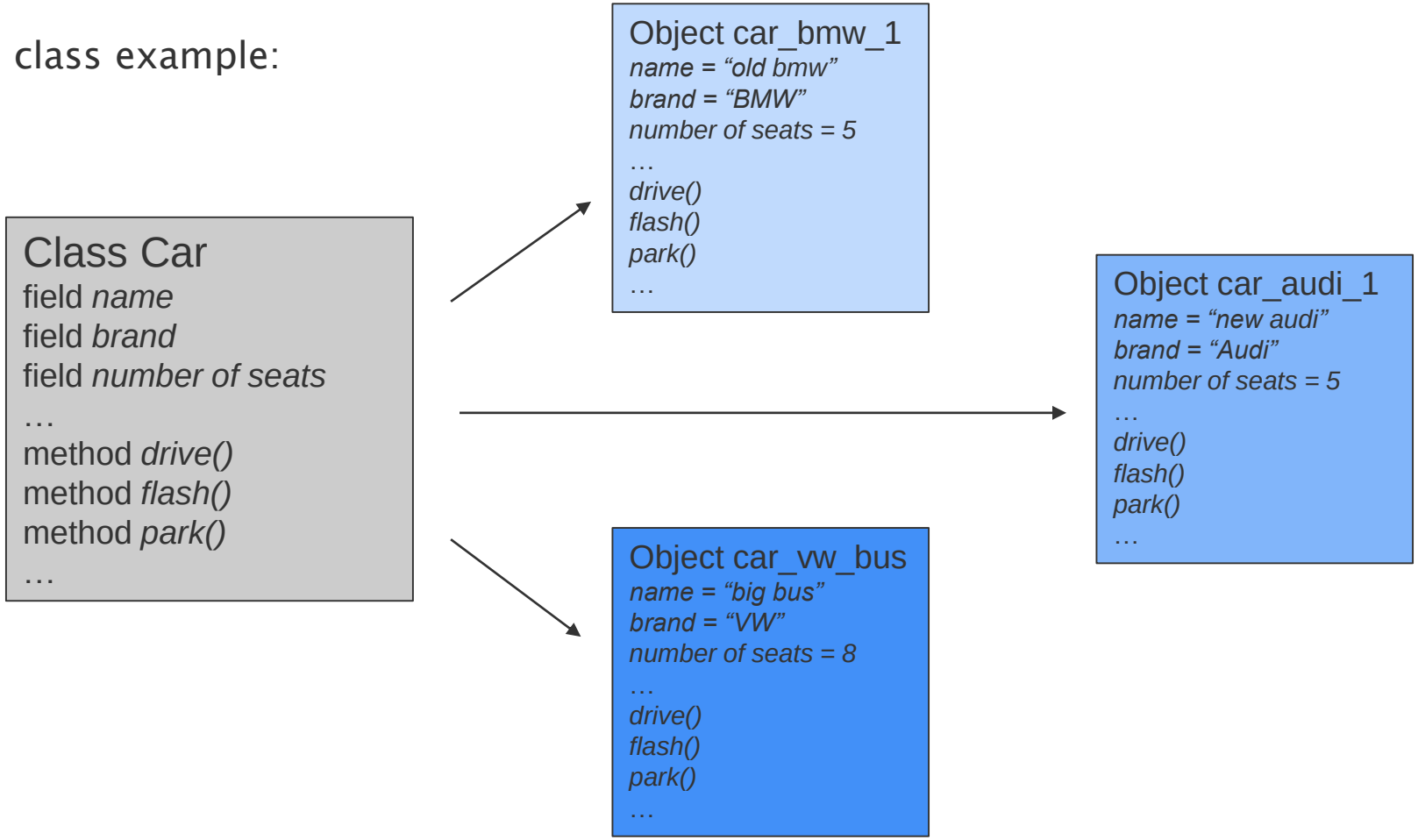
Key Concept And Naming

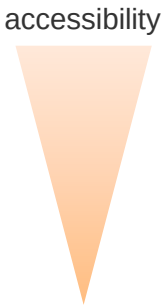
» A simple class example:



Encapsulation

- Data hiding is important
- The programmer does not need to know about internals
- Communication via available interface (public)

- Access modifiers
  - `public` ➔ **members can be seen on the outside**
  - `protected` ➔ **members can be seen to the object and its derived classes**
  - `private` ➔ **members elements can only be seen to the object itself**



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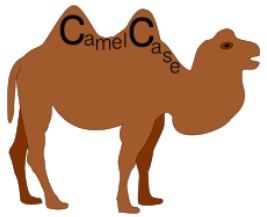
Class Declaration in C#

```
class Vector2D {
    // fields = member variables
    public double x;
    public double y;

    // methods = member functions
    public double Norm() {
        double nrm = Math.Sqrt(x * x + y * y);
        return nrm;
    }
}
```

1. Use UpperCamelCase for class names
2. use lowerCamelCase for fields
3. Use UpperCamelCase for methods



Please pay attention to this in your Assignment!

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Object Instantiation and Use

```
Vector2D vec1 = new Vector2D();
vec1.x = 5;
vec2.y = 10;
Console.Write(vec1.Norm());
```

Create Object

Assign public field

Access public method

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Constructor

- Special method(s) that is always called automatically when the object is created
- Method name = class name
- If no constructer is defined, the compiler automatically creates the standard constructor

```
class Circle {
   private double r;
   private double x;
   private double y;

   //hide the standard constructor
   private Circle() {
   }

   public Circle(double radius) {
       this.r = radius;
   }
}
```


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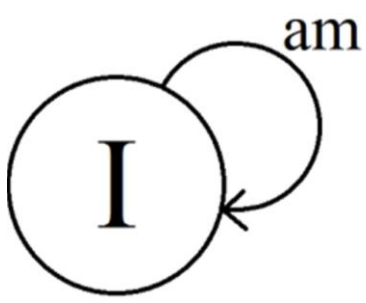
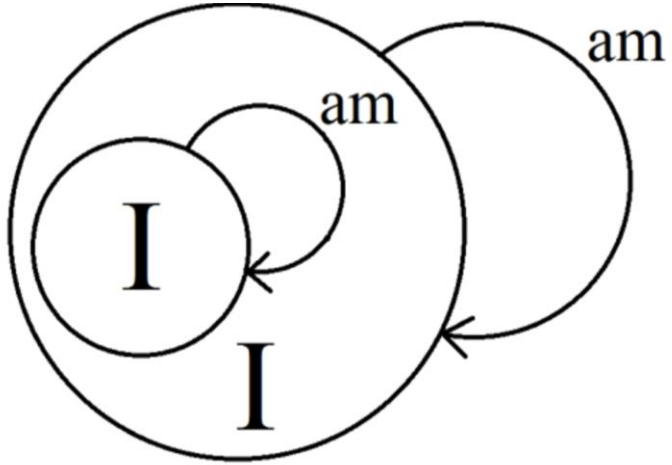
The Reference *this*

- Refers to current instance (object)
- Helps to this distinguish local variable and field
- Can be passed as parameter to a method
- **this** implicitly passed to every method
  - **Not available in <u>static</u> function**



Level 1 Self-reference
I am



Level 2 Self-reference
I am "I am"

Live coding

Getters & Setters

- Makes private fields available to the public
- You can define which fields you want to make accessible!
- Apply changes with simple function call

- Important remarks:
  - Naming!
  - Default access modifier set to `private` within classes (so make them `public` explicitly)

```
private string myProperty;

public string GetMyProperty() {
    return this.myProperty;
}

public void SetMyProperty(string value) {
    this.myProperty = value;
}
```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Properties – A C# Special

- A property is a field with a get/set block
- Accessed from outside like a normal field, implemented as a method
- Advantage: complete control!

```
public void Main() {
    Circle myCircle = new Circle();
    // set accessor is called
    myCircle.Radius = 23;
    // get accessor is called
    double x = myCircle.Radius;
}
```

```
public class Circle {
    // hidden “backing“ field
    private double radius;
    // public property
    public double Radius {
        get {
            return this.radius;
        }
        set {
           if(value >= 0){
              this.radius = value;
           }
           else{
              Console.Write("Illegal value.");
           }
        }
    }
}
```


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Automatic Properties

```
public class Circle {
    // property
    public double Radius { get; set; }
}

public void Main() {
    Circle myCircle = new Circle();

    // set accessor is called
    myCircle.Radius = 23;

    // get accessor is called
    double x = myCircle.Radius;
}
```

- automatic properties
- get and set assessors are automatically generated
- Backup field is <u>implicitly</u> created

Live coding

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Static Keyword

- Static method: not associated with an object, unlike regular methods
- Static class: class which can only contain static members

- No object of static class!
- Object related function cannot be static!
  - Constructor
  - Types

```
class SomeClass {
   private double member = 3;

   public double NormalMethod() {
      return this.member;
   }

   public static double StaticMethod() {
       // return this.x does not work
       return 3;
   }
SomeClass instance = new SomeClass();
instance.normal_fct(); //Fine
instance.static_fct(); //Won't compile

SomeClass.normal_fct(); //Won't compile
SomeClass.static_fct(); //Fine
```

Pass an object to a function

```
public void InstallNewCamera(Camera newCamera){
    this.AddElement((Element) newCamera);
}
```

What's to see here?

- Function is available to the outside and has no return type (void)
- An object of type `Camera` is passed in
- `AddElement(Element param)` is another member (`this`-keyword) in this class which takes in a parameter of type `Element` (thus casting)

Destructor

- Same as constructor, but always called if object's memory is freed up (program exits or scope of the object ends)
- "There can be only one" *(Highlander, 1986)*
- Tilde operator (~)
- Cannot be called directly
- Cannot be inherited

```
class Circle {
    private double r;
    private double x;
    private double y;

    private ~Circle() {
        // some final code?
    }
}
```


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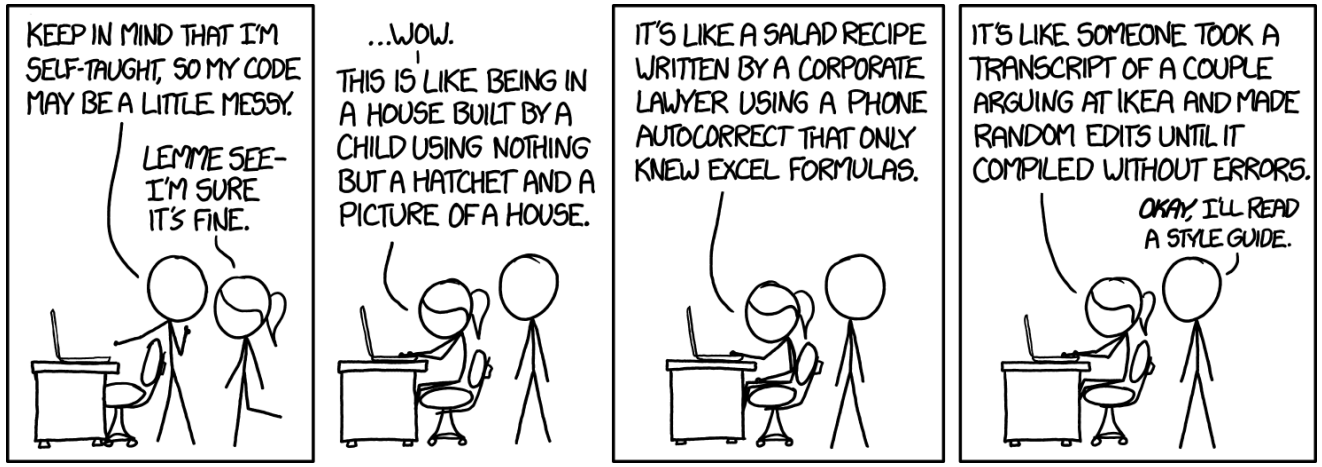
Good Programming Practice

- Maximize adherence
  - One class per file
  - Now what belongs together will grow together (Willi Brandt)
- Consistency
- Names should be self-explanatory,



Always choose readability!

Inheritance, Abstract Classes, Interfaces

HIERARCHIES IN OOP

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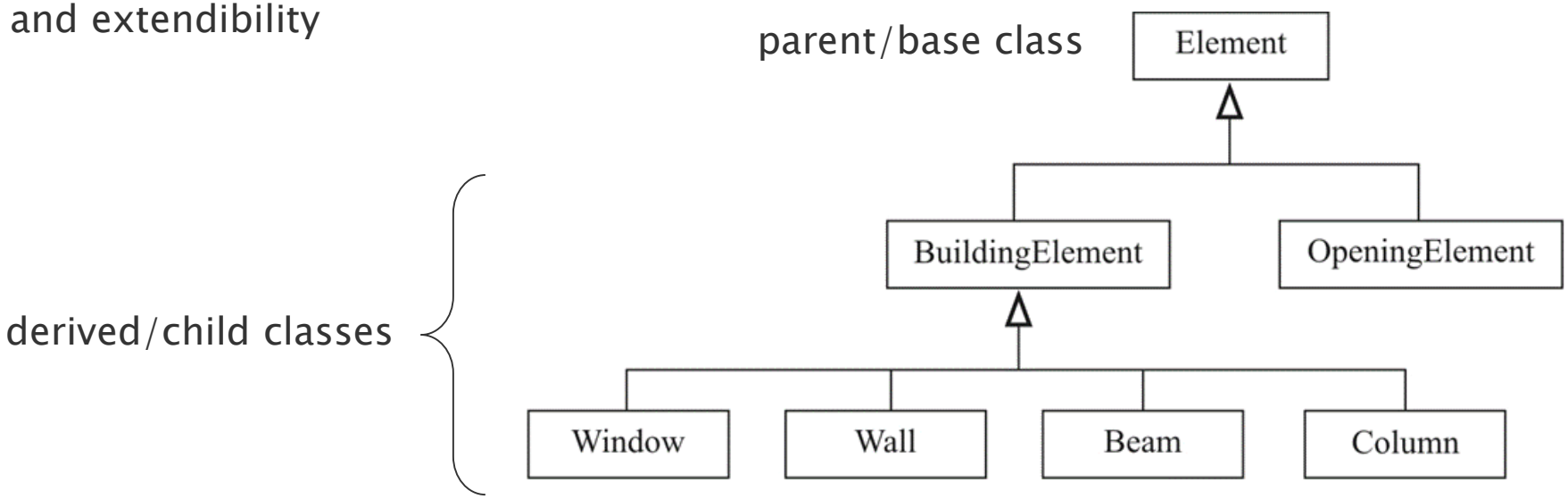
Inheritance

- Powerful concept of object-oriented programming
- Inheritance hierarchy reflects generalization / refinement
- Derived classes inherit fields and methods from super-classes
- Facilitates re-use and extendibility



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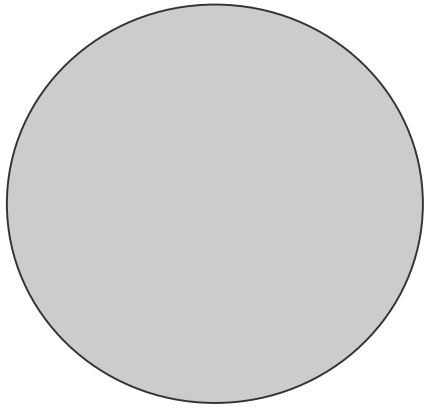
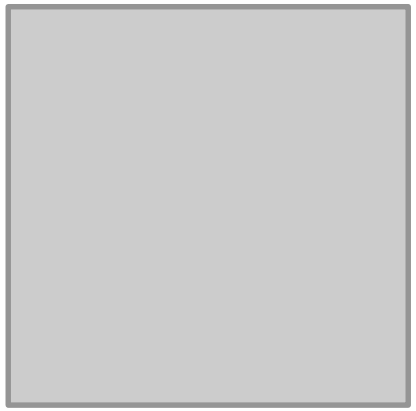
Example: Figure





- Circle
  - 1 sides
  - Perimeter($2\pi r$) and Area(πr^2)
- Square
  - 4 sides
  - Each side has same length
  - Perimeter(4x) and Area(^{2})

Declaration And Use

- **Circle** and **Rectangle** are defined as subclasses of **Figure**
- They inherit the properties *PositionX* and *PositionY*
- They inherit the method Move()
- When instantiated, base constructor is called first, then derived constructor

```
public class Figure {
    protected int PositionX { get; set; }
    protected int PositionY { get; set; }

    public void Move(int dx, int dy) {
        PositionX = PositionX + dx;
        PositionY = PositionY + dy;
    }
}
public class Circle : Figure {
    public int Radius { get; set; }
}
public class Rectangle : Figure {
    public int A { get; set; }
    public int B { get; set; }
}
```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Declaration And Use II

- sub-class can be used where superclass
  - **Implicit** upcast
  - Downcasts must be performed explicitly

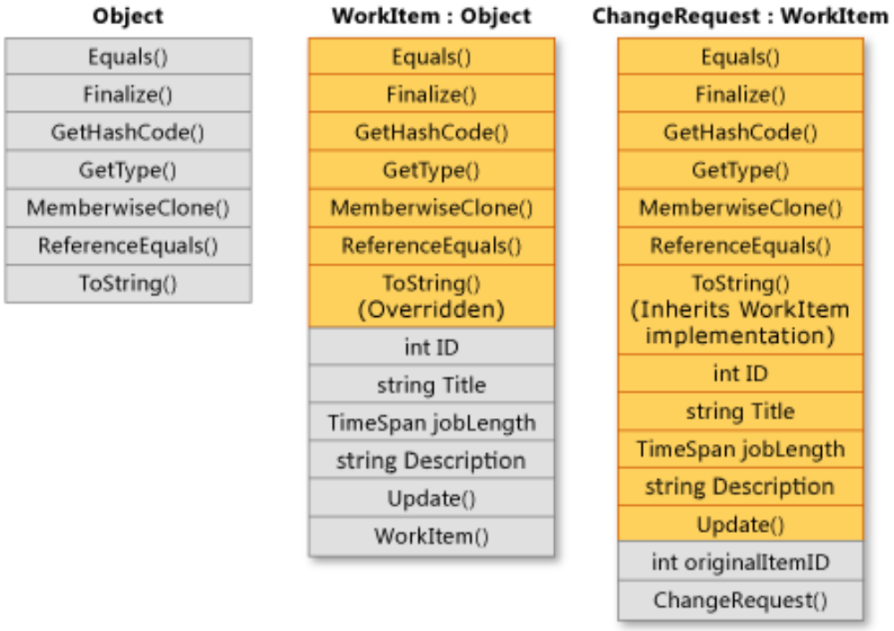
- Downcasting or type refinement is the act of casting a base class object to one of its derived classes

```
public class Painter {
    public static void Paint(Figure fig)
    {
        // ...
    }
}

Rectangle myRect = new Rectangle();
Painter.paint(myRect);

Circle myCircle = new Circle();
Painter.paint(myCircle);

Figure myFigure = new Circle();
Circle aCircle = (Circle) myFigure;
```

Live coding

System.Object

- All classes inherit from System.Object class
- Provides specific methods



- Provides methods:
  - **Equals()**
  - **GetType()**
  - **ToString()**
  - **GetHashCode()**

Virtual Methods – override

- A base method marked as virtual can be overridden by derived classes
- Keyword: override
- Used to provide a specialized implementation
- If casted to base again, will invoke the override the base method
- Not using override will issue a warning (not an error though)…

```
public class Figure {
    public virtual void Output() {
        Console.Write("Figure object");
    }
}

public class Circle : Figure {
    public override void Output() {
        Console.Write("Circle object");
    }
}

public class Rectangle : Figure {
    public override void Output() {
        Console.Write("Rectangle object");
    }
}
```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Virtual Methods – new

- hide base class members
- new to suppress compiler warning

- Not often used in real code
- If casted to base, will invoke the base method

- **Typically, override is preferred!**

```
public class Figure {
    // ...
    public void Output() {
        Console.WriteLine("Base class");
    }
}

public class Circle : Figure {
    // ...
    public new void Output() {
        Console.WriteLine("Circle class");
    }
}
```

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The Keyword Base

- Similar to keyword this
- Used to access an overridden method from the base class
- Used to call a base class constructor

```
public class Figure {
   public virtual void Output() {
       Console.WriteLine("Figure object");
   }
}

public class Circle : Figure {
   public override void Output() {
       base.Output();
       Console.WriteLine("Circle object");
   }
}

// outputs:
Circle circle = new Circle();
circle.Output(); // prints "Figure object\nCircle object"
```


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Abstract classes

```
public abstract class Figure {
     public abstract double Area();
}

public class Circle : Figure {
    public override double Area() {
        return Math.Pi * Radius * Radius;
}
```

- Basically “concept” classes
- Can be used to indicate missing components or implementations

- Abstract classes can’t be instantiated (no objects!!!)
- Abstract methods can <u>only</u> be contained in abstract classes
- All abstract methods <u>must</u> be implemented by the child class

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Summary

- virtual: indicates that a method may be overridden by an inheritor
- override: overrides the functionality of a virtual method in a base class, providing different functionality.
- new: hides the original method (which doesn't have to be virtual), providing different functionality. This should only be used where it is absolutely necessary.
- abstract: abstract methods must be implemented by the child and don’t contain a body. Abstract classes can only be inherited, never instantiated!

THANK YOU!

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