7SENG011W Object Oriented Programming

More on Methods, Value types and Reference types, UML class Diagrams

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Readings

The topics we will discuss today can be found in the books

- Hands-On Object-Oriented Programming with C#
  - Chapter: Hello OOP—Classes and Objects
- Programming C# 10
  - Chapter 3: Types

Online

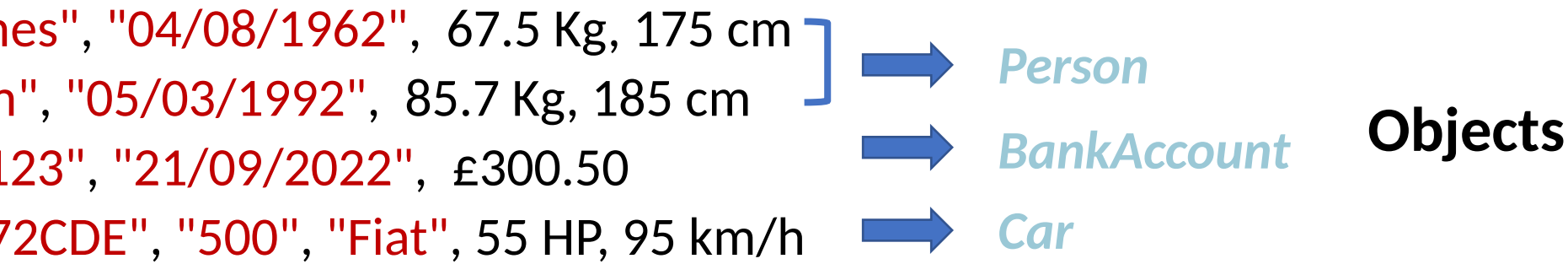
- Value Types
- Reference Types
- Classes
- Methods
- Passing Parameters
- Passing Value Types by Value

Outline

- Summary of last week and more on methods
- Value types and Reference types, Stack and Heap
- UML class diagrams

What are Objects?

- *Different types of data* can be grouped to model **entities** of a **problem** we would like to solve



What are Classes?

- Defines a set of **attributes** (data) and **methods** (behaviours) that are common for some Objects

class Person

attributes: *string name, string dateOb, double weight, int height*

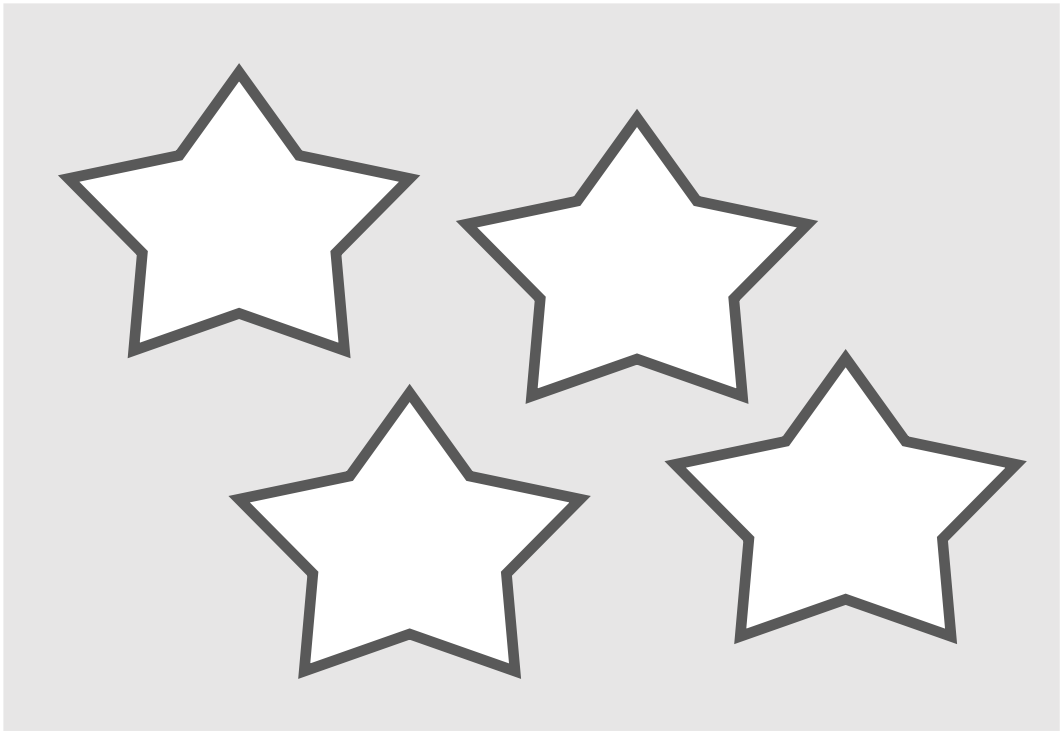
methods: *SayName, Eat, GetAge, …*

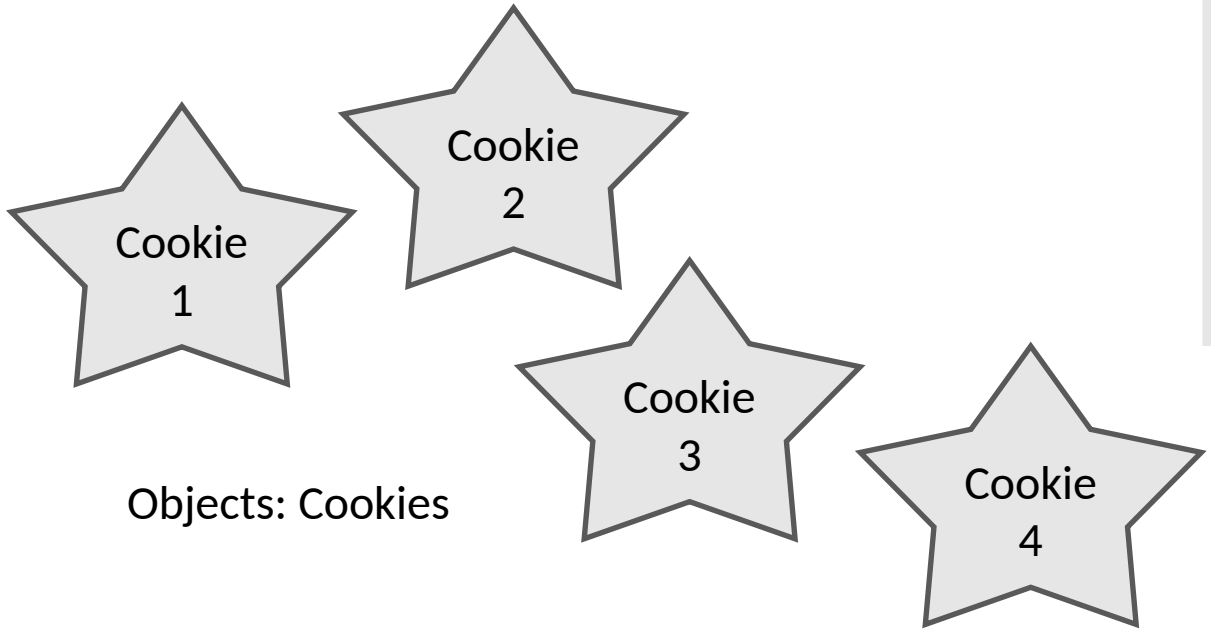
- The **blueprint** is defined **once—multiple Objects** with similar features can be created

Classes and Objects

Class Template

Cookie Dough





Objects: Cookies

Primitive variables vs Objects

```
class Program
{
    static void Main(string[] args)
    {
        int p1X = 6;
        int p1Y = 4;

        int p2X = 8;
        int p2Y = 2;

        Console.WriteLine($"p1 = ({p1X} , {p1Y})");
        Console.WriteLine($"p2 = ({p2X} , {p2Y})");
    }
}
```

versus

```
class Program
{
    static void Main(string[] args)
    {
        Point p1 = new Point(6, 4);
        Point p2 = new Point(8, 2);

        p1.Display();
        p2.Display();
    }
}
```

Custom Type: *Point* class definition

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display()
        {
            Console.WriteLine($"({x}, {y})");
        }
}
```

```
class Program
{
        static void Main(string[] args)
        {
                Point p1 = new Point(6, 4);
                Point p2 = new Point(8, 2);

                p1.Display();
                p2.Display();
        }
}
```

Custom Type: *Point* class definition

```
class Point
{
    private int x;
    private int y;

    public Point(int xarg, int yarg )
    {
        x = xarg;
        y = yarg;
    }

    public void Display()
    {
        Console.WriteLine($"({x}, {y})");
    }
}
```

Name of the class—custom type

Custom Type: *Point* class definition

```
class Point
{
    private int x;
    private int y;

    public Point(int xarg, int yarg )
    {
        x = xarg;
        y = yarg;
    }

    public void Display()
    {
        Console.WriteLine($"({x}, {y})");
    }
}
```

Attributes: variables that define the data of each object instance—different Objects have different copies of the attributes

Custom Type: *Point* class definition

```
class Point
{
    private int x;
    private int y;

    public Point(int xarg, int yarg )
    {
        x = xarg;
        y = yarg;
    }

    public void Display()
    {
        Console.WriteLine($"({x}, {y})");
    }
}
```

Methods: define the operations that an object instance can perform (on the attributes)

Custom Type: *Point* class definition

```
class Point
{
    private int x;
    private int y;

    public Point(int xarg, int yarg )
    {
        x = xarg;
        y = yarg;
    }

    public void Display()
    {
        Console.WriteLine($"({x}, {y})");
    }
}
```

Constructor: a method that initialises the attributes with some values when a new object instance is created—has the same name of the class

Method

- Allows the execution of **operations**—actions objects of a class can perform (on the attributes)
- *0*, *1*, or *n* **parameters** can be used *inside the body* of the method

Method (type1 par1, type2, par2, …)

Examples:

Display() { … } // 0 parameters

Point(int xarg, int yarg) { … } // 2 parameters

Blocks: from Lecture 1

- A block is a region of code delimited by a pair of curly braces *{}*
- Program *Main* entry-point
- Instructions within an *if*, *else* or *switch* statement
- Instructions within a *for*, *while*, or *do while* loop
- Blocks can be *nested*

- **Methods** are also blocks

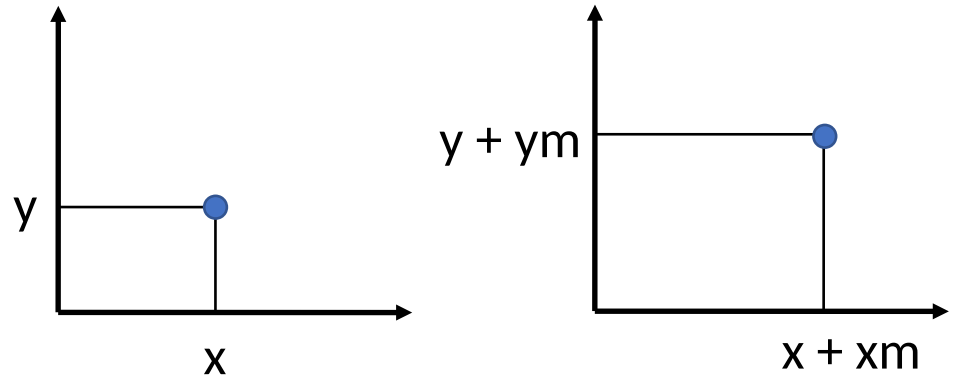
Methods: variables scope

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display()
        {
            Console.WriteLine($"({x}, {y})");
        }
}
```


The code inside the methods **can access** the class attributes *x* and *y*

Methods: variables scope

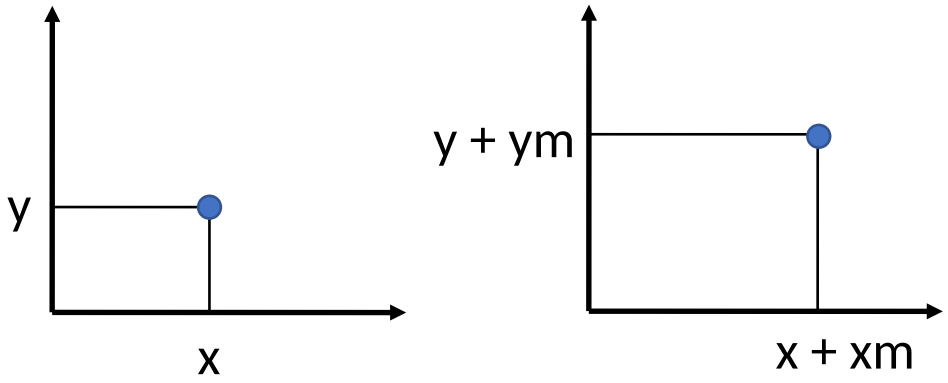
```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
         }
}
```



New method—*Move*—shifts the point of *xm* and *ym* on the x and y axis

Methods: variables scope

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
         }
}
```



New method—*Move*—shifts the point of *xm* and *ym* on the x and y axis

Methods: variables scope

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
         }
}
```

The code inside each method **can access** the class attributes *x* and *y*

Methods: variables scope

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
         }
}
```

Each method can access its parameters—they are local variables not available anywhere else in the class

Methods: variables scope

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

The same applies to other *variables* declared inside a method

Methods: Parameters and Arguments

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

When a method is called, the instructions defined inside that method are executed

Methods: Parameters and Arguments

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

accepted input **parameters**

(6, 4)

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

actual values passed, **arguments**

The values of the **arguments** (a, b) are copied into the **parameters** (xarg, yarg)

Methods: Parameters and Arguments

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

What happens to the *x* and *y* attributes of *p1* when the method *Move* is called?

Methods: invocation within the same class

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { ... }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
            Display();
         }
}
```

A method can call any other methods defined in the same class using the method name

Methods: invocation within the same class

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
            Display();
         }
}
```

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

p1.Move will call *Display()* on the same object (*p1*)

Methods: void or return

When called, a **method** can:

- Perform some operations and ***terminate*—void**
- Perform some operations and **return** a ***value*** to the caller

Methods: void

When called, a **method** can:

- Perform some operations and ***terminate*—void**
- Perform some operations and **return** a ***value*** to the caller

```
public void methodName(type arg1, type arg2, ...)
{
        // statements
}
```

Methods: void

When called, a **method** can:

- Perform some operations and ***terminate*—void**
- Perform some operations and **return** a ***value*** to the caller

```
class Point
{
      // x and y attributes declaration

      public void Display()
      {
         // prints x and y of the Point
      }
}
```

Methods: void

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display()
        {
            Console.WriteLine($"({x}, {y})");
        }
}
```

```
class Program
{
        static void Main(string[] args)
        {
                Point p1 = new Point(6, 4);
                Point p2 = new Point(8, 2);

                p1.Display();
                p2.Display();
        }
}
```

When *Display*() is invoked, the *Main* does not receive anything back from the execution—no **values** are produced

Methods: return

When called, a **method** can:

- Perform some operations and *terminate*—**void**
- Perform some operations and **return** a ***value*** to the caller

```
public TYPE methodName(type arg1, type arg2, ...)
{
        // statements
        return EXPRESSION
}
```

Methods: return

When called, a **method** can:

- Perform some operations and *terminate*—**void**
- Perform some operations and **return** a ***value*** to the caller

```
//In the Circle class

public double Area()
{
        double area = Math.PI * radius * radius;
        return area;
}
```

Methods: return – Random class example

```
Random r = new Random();

int randomInt = r.Next(1, 7);
```

- The method *Next* of the *Random* class returns a random int value in the range specified via the provided arguments

```
double randomDouble = r.NextDouble();
```

- The method *NextDouble* of the *Random* class returns a random *double* value in the range 0-1 (no arguments can be provided)

Methods: *Point* class example

Let's add two new methods to our *Point* class

- *GetX*(): when called, returns the content of the object's *x* attribute
- *GetY*(): when called, returns the content of the object's *y* attribute

Methods: *Point* class example

Let's add two new methods to our *Point* class

- *GetX*(): when called, returns the content of the object's *x* attribute
- *GetY*(): when called, returns the content of the object's y attribute

In OOP, these methods are referred to as *Getter Methods*

Similarly, *Setter Methods* are used to set the value of an attribute

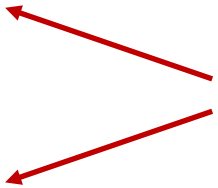
Methods: Point class example

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }

        public int GetX()
        {
            return x;
        }

        public int GetY()
        {
            return y;
        }
}
```


The methods *Display*() and *Move*() perform some operations and terminate—**void**

Methods: Point class example

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }

        public int GetX()
        {
            return x;
        }

        public int GetY()
        {
            return y;
        }
}
```



The methods *GetX*() and *GetY*() *return* the content of the attributes *x* and *y* as **int** values

Methods: Point class example

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }

        public int GetX()
        {
            return x;
        }

        public int GetY()
        {
            return y;
        }
}
```

```
class Program
{
        public static void Main(string[] args)
        {
            Point p1 = new Point(2, 3);
                int xt =2, yt = 1;
            p1.Move(xt, yt);
            int x1 = p1.GetX();

            Point p2 = new Point(6, 2);
            int x2 = p2.GetX();

            if (x2 > x1)
            {
                Console.WriteLine("x of p2 greater than x of p1");
            }
        }
}
```

Methods: Constructors

- The *constructor*'s name must be **identical** to the class *Name*
- *Constructors* have **no return type**—implicitly void

```
class Point
{
        public (void) Point(int xarg, int yarg) { … }
        …
}
```

- All classes need **at least one** constructor
- If you do not write one, then ***Name*** **() { }** is created by default

Outline

- Summary of last week and more on methods
- Value types and Reference types, Stack and Heap
- UML class diagrams

Question

On C# memory management

Answer on PollEveryWhere

https://pollev.com/francescotusa

Value and Reference Types

- **Primitive** types are basic C# types:
  - int, double, bool, char, etc.

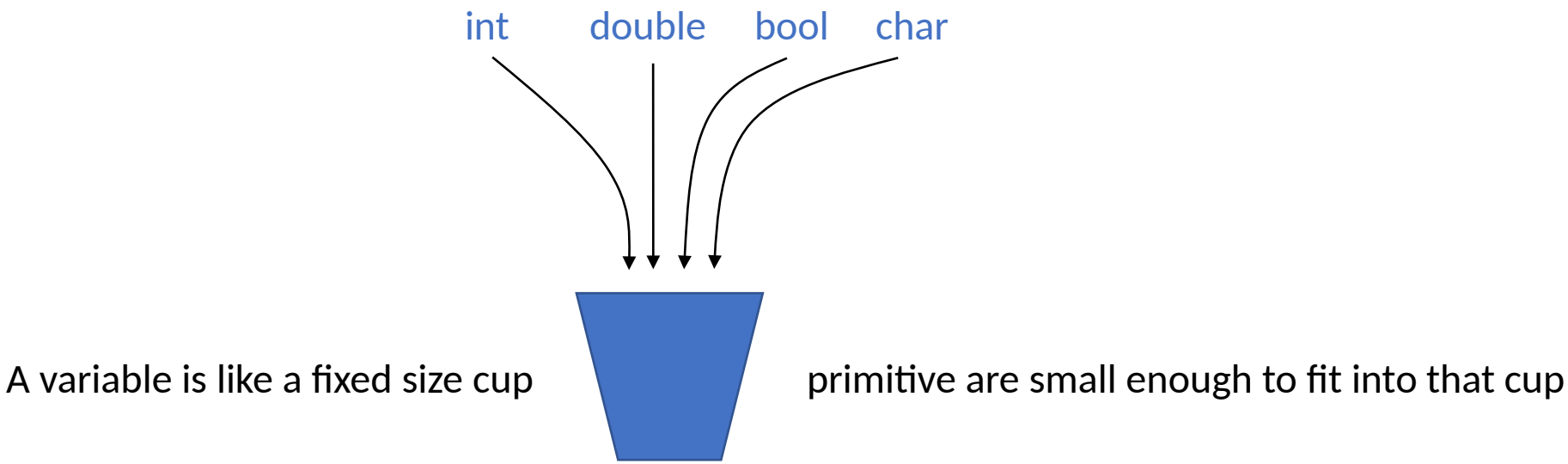
- **Reference** types are *arrays* and *objects*:
  - string, int[], double[], *Point*, *Circle*, *BankAccount*, etc.

Value and Reference Types

- **Primitive** types are basic C# types:
  - int, double, bool, char, etc.
  - the actual data **values are stored inside** the variable: **value type**
- **Reference** types are *arrays* and *objects*:
  - string, int[], double[], *Point*, *Circle*, *BankAccount*, etc.
  - the actual data values **are not stored inside** the variable
  - the variable contains a **reference** to the data (object's address)

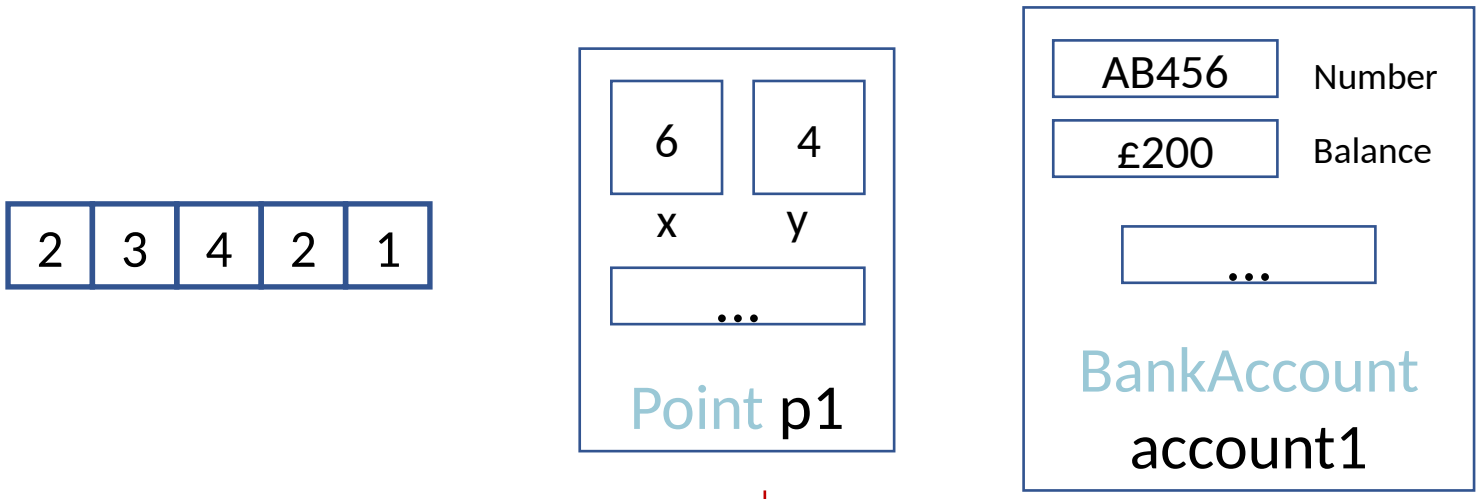
How primitive types are stored

- **Primitive** types are basic C# types:
  - int, double, bool, char, etc. – the variable **contains its data**
- Have a well-defined standard size (between 8-64 bits)



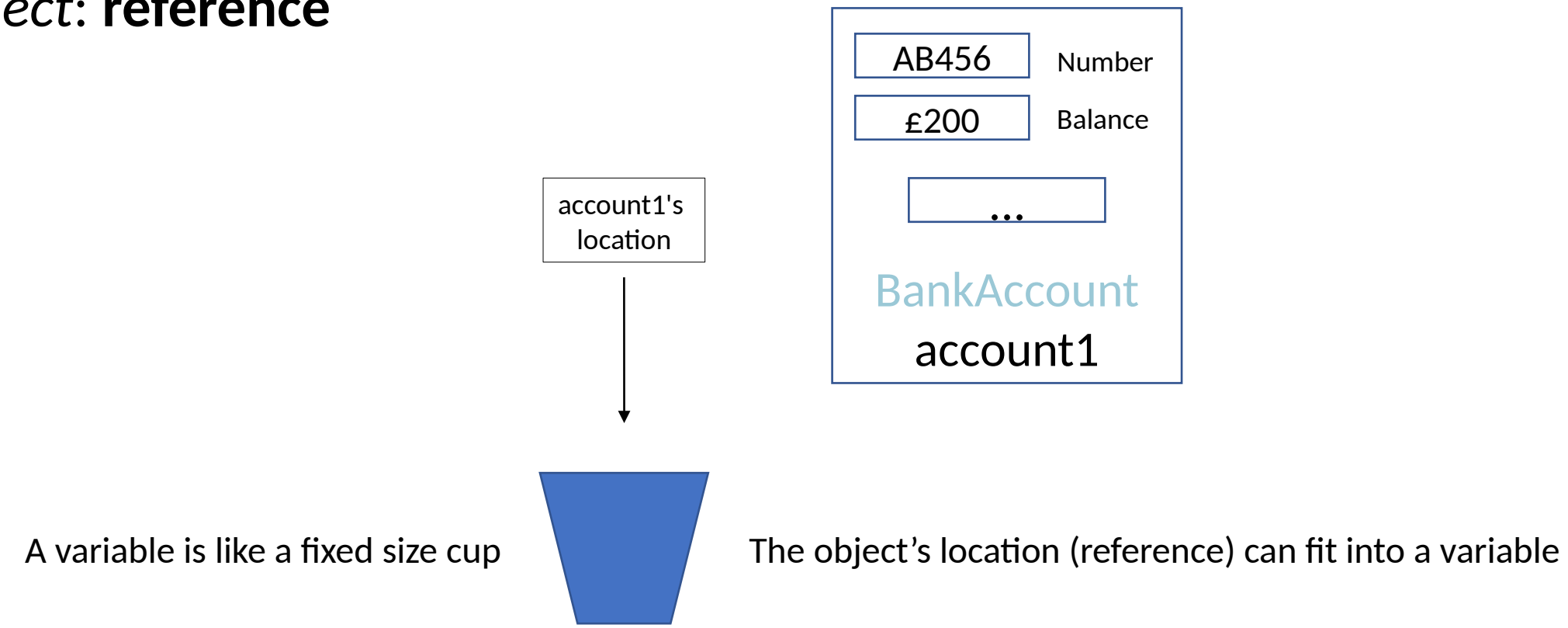
How reference types are stored

- **Reference** types are *arrays* and *objects*:
  - string, int[], double[], *Point*, *Circle*, *BankAccount*, etc.



How reference types are stored

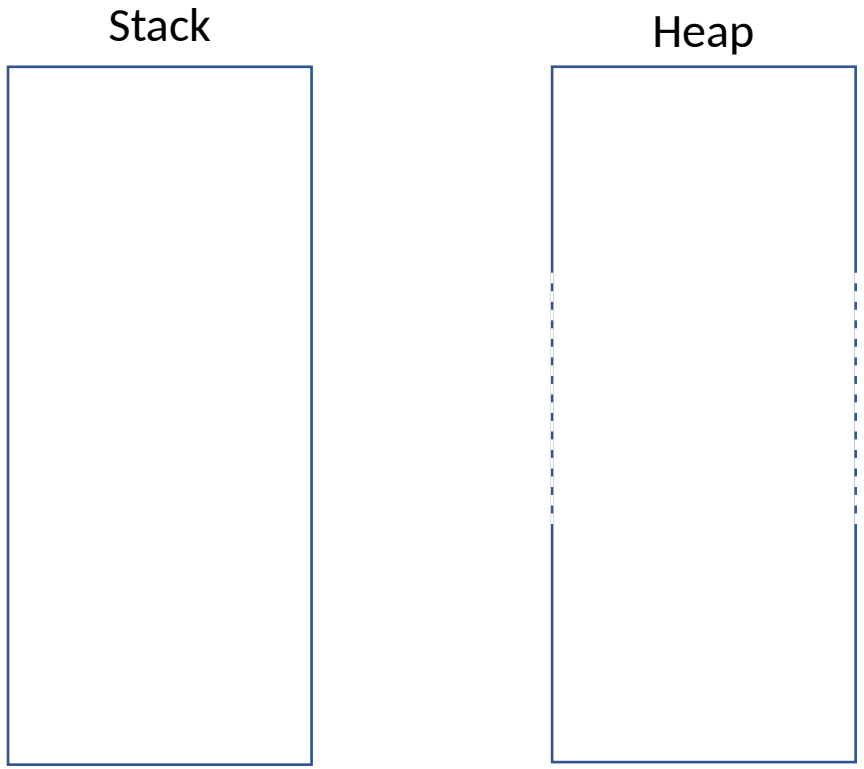
- The data (object) **is not** stored inside the **variable**
- The **variable** stores a number (address) that locates that *object*: **reference**



Memory stack and heap

- When a program is executed, it is given an initial amount of **memory** by the *operating system*
- A part of this memory is the ***program stack***
- Another part of this memory is the ***program heap***

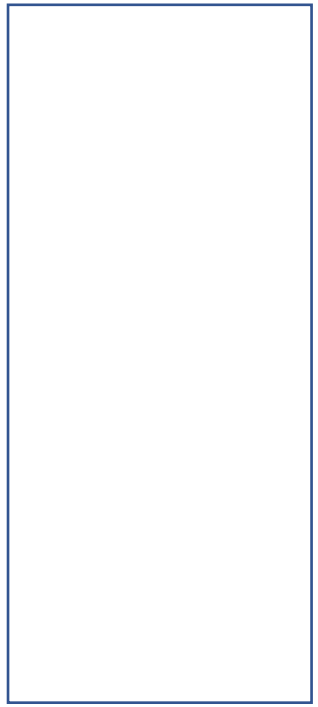
Memory stack and heap



Size	Small (1-4 MB)	Large (hundreds of MB)
Memory Allocation	*Last In First Out (LIFO)*	*Pattern Free*
Speed	Fast	Slower than Stack

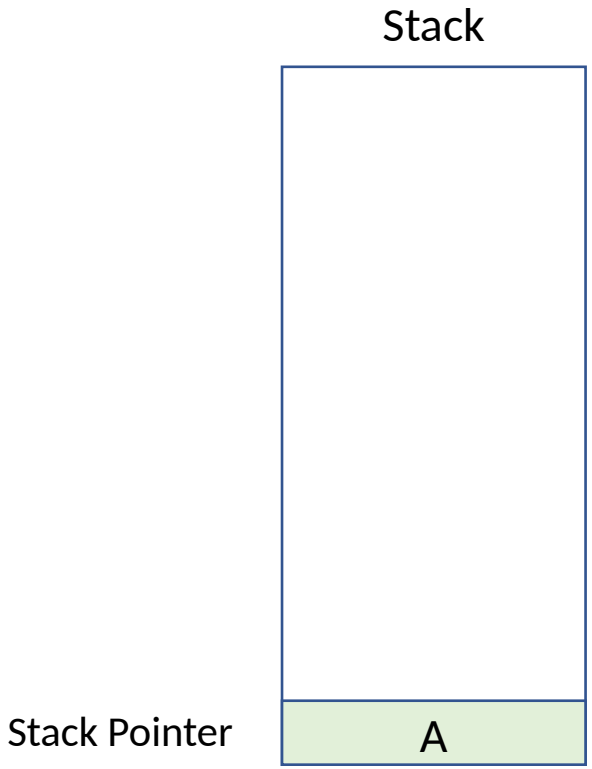
Memory **stack** and heap

Stack



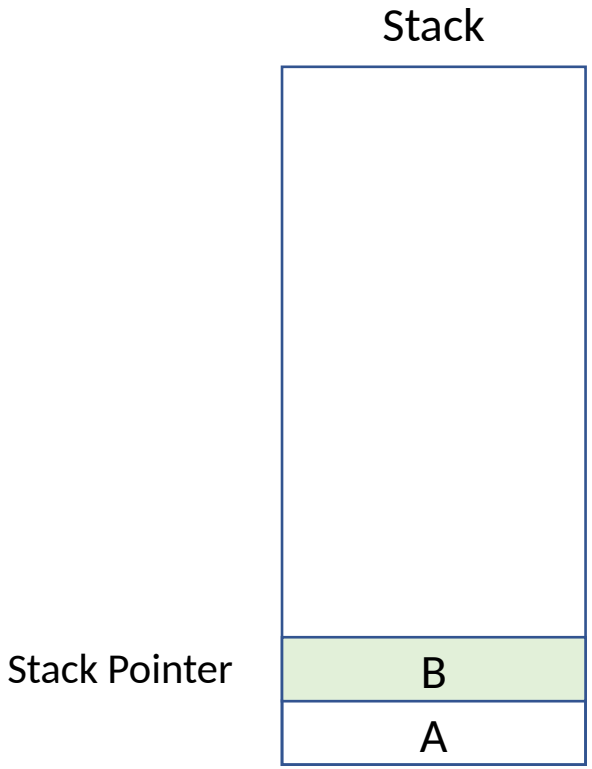
Adding element: **Push** A

Memory **stack** and heap



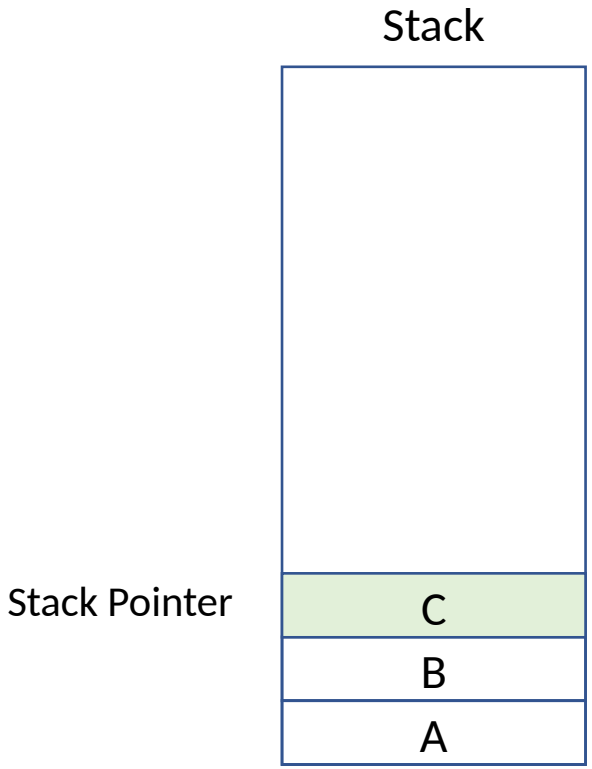
Added element: A

Memory **stack** and heap



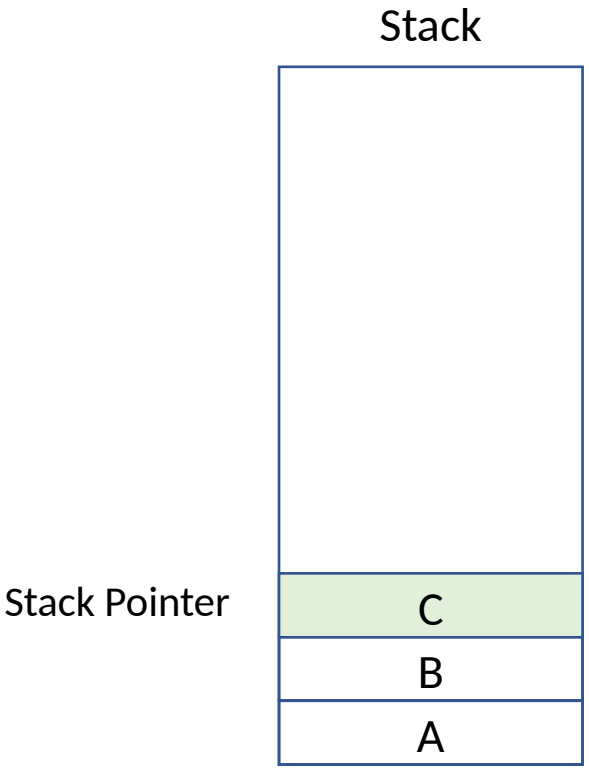
Added element: B

Memory **stack** and heap



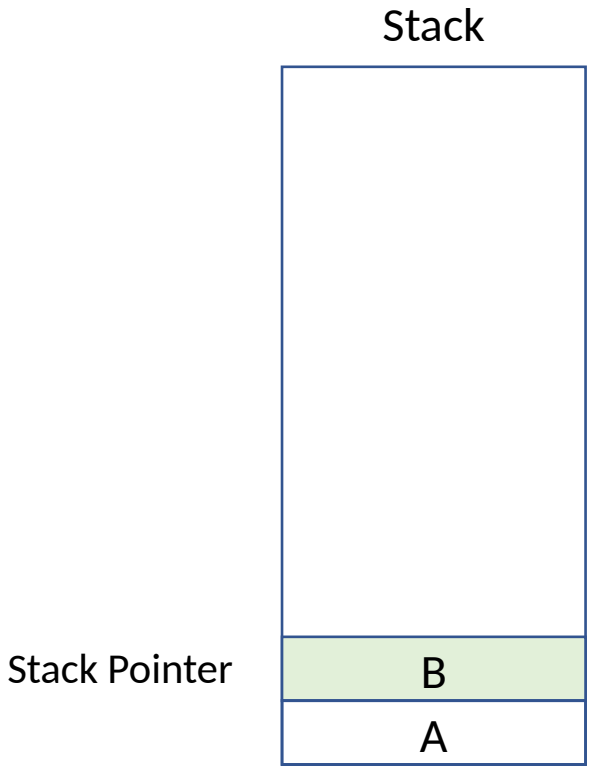
Added element: C

Memory **stack** and heap



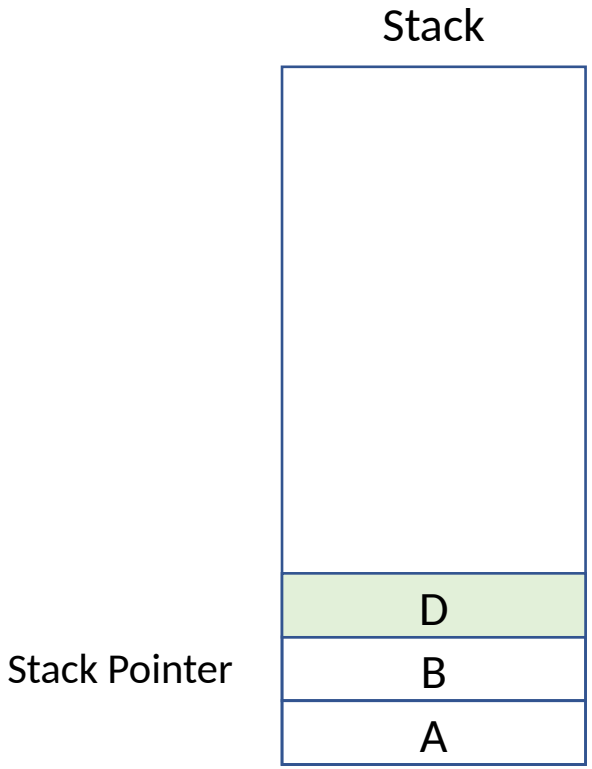
Removing element: **Pop** C

Memory **stack** and heap



Removed element: C

Memory **stack** and heap

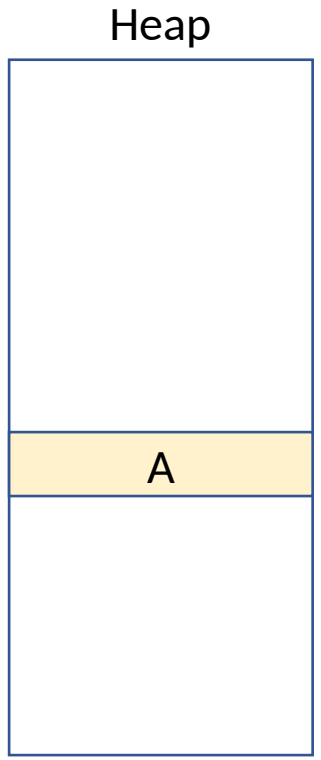


Added element: D

Stack memory allocation pattern: LIFO

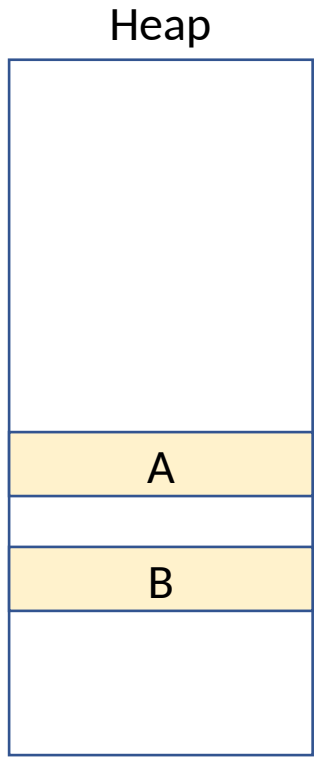
Memory stack and **heap**

Added element: A



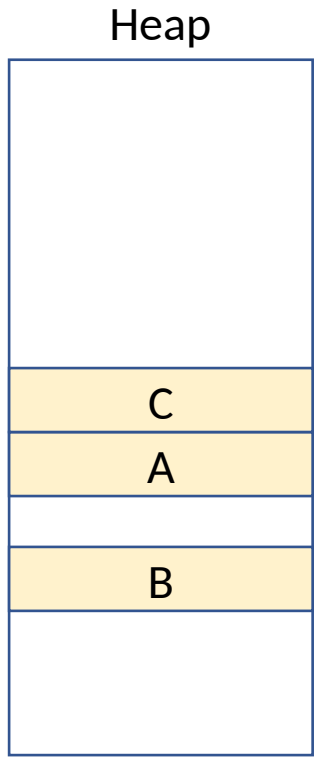
Memory stack and **heap**

Added element: B



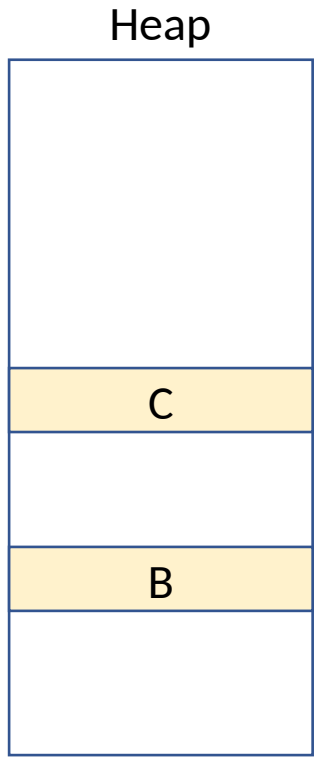
Memory stack and **heap**

Added element: C



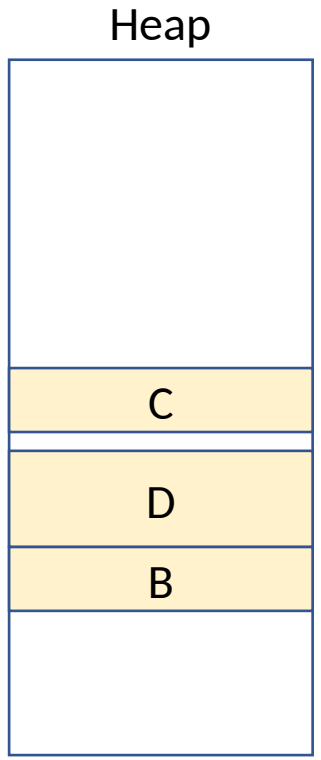
Memory stack and **heap**

Removed element: A



Memory stack and **heap**

Added element: D



Heap memory allocation: pattern-free, complex and may lead to fragmentation

Method Invocation

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

What happens inside the memory when *Move* is called from the *Main*?

Method Invocation

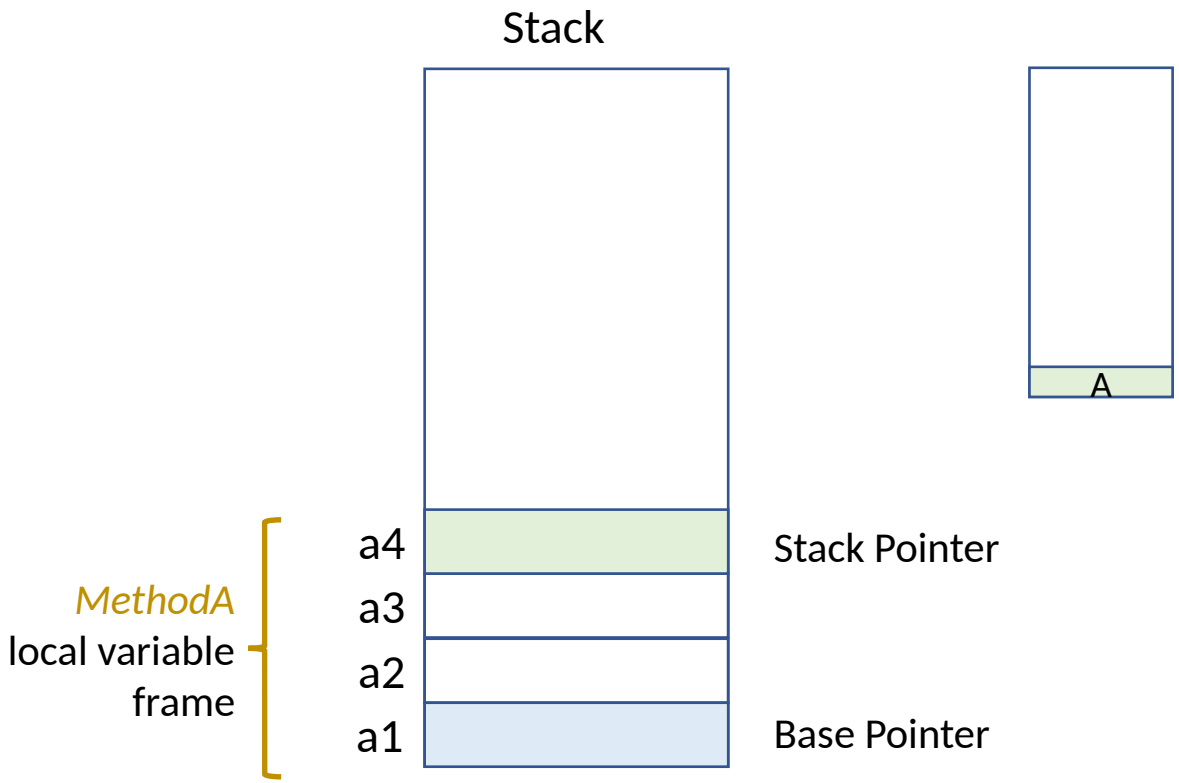
```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg )
        {
            x = xarg;
            y = yarg;
        }

        public void Display() { … }

        public void Move(int xm, int ym)
        {
            x = x + xm;
            y = y + ym;
            int sum = xm + ym;
         }
}
```

```
class Program {
    static void Main(string[] args)
    {
        int a = 6, b = 4;
        Point p1 = new Point(a, b);

        int xt = 1, yt = 1;
        p1.Move(xt, yt);
    }
}
```

The *Move* method's *parameters* and *local variables* need to be allocated

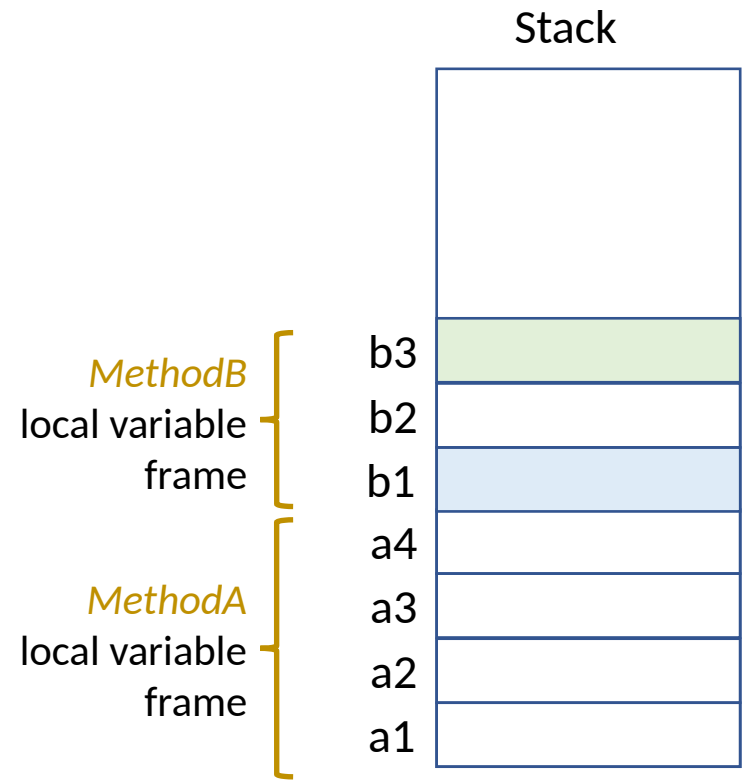
Method Invocation

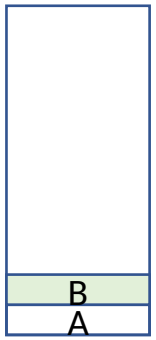
```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```



Method Invocation

```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```

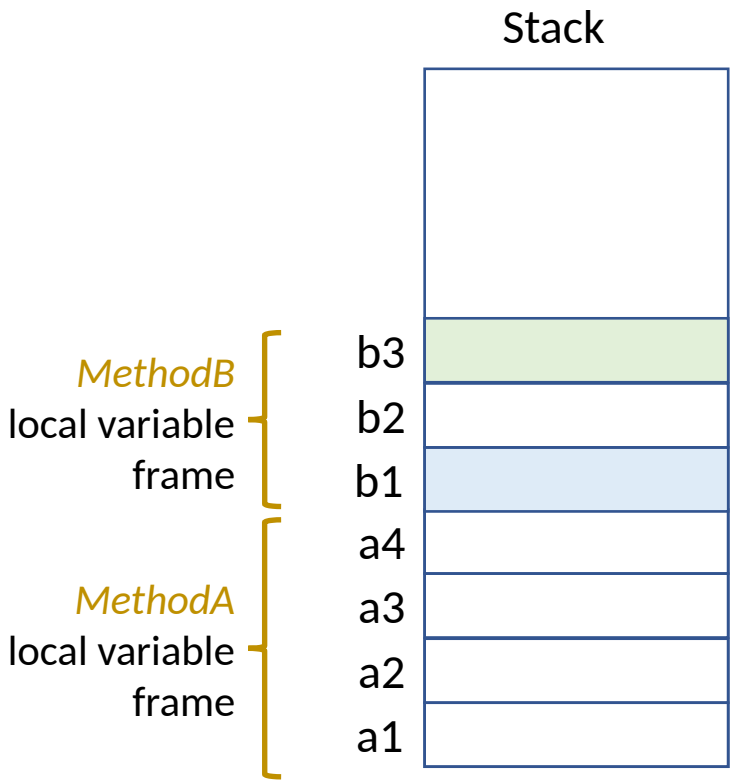




Method Invocation

If *MethodA* is called using argument values 3.0 and 4, what the content of *b2* will be in *MethodB*?

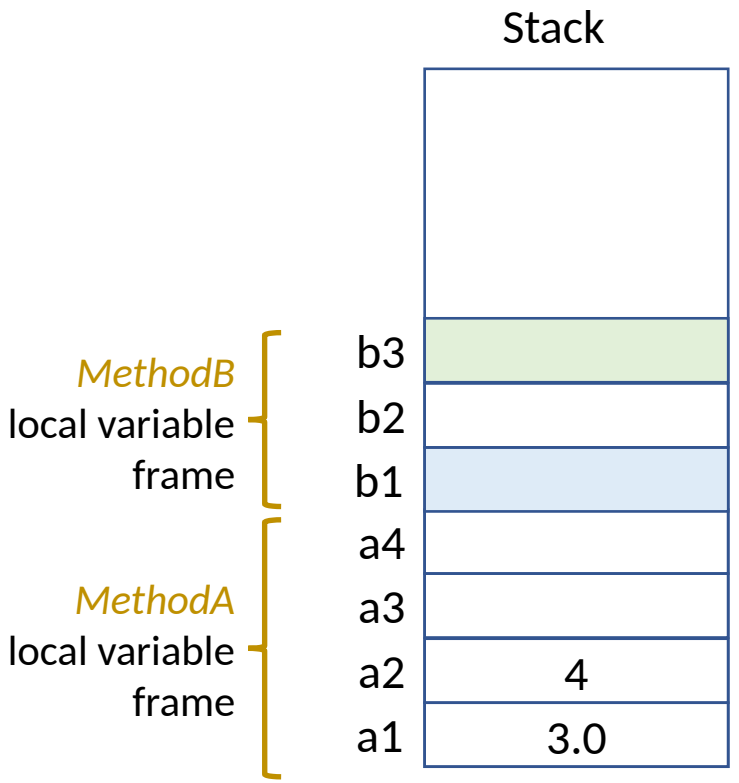
```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```



Method Invocation

If *MethodA* is called using argument values 3.0 and 4, what the content of *b2* will be in *MethodB*?

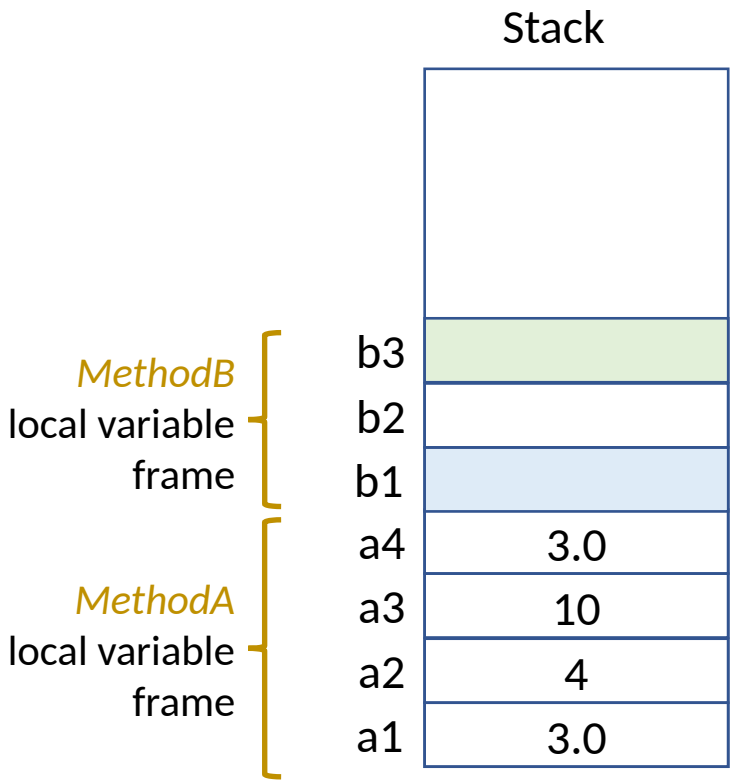
```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

                                3.0      4
void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```



Method Invocation

If *MethodA* is called using argument values 3.0 and 4, what the content of *b2* will be in *MethodB*?

```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```

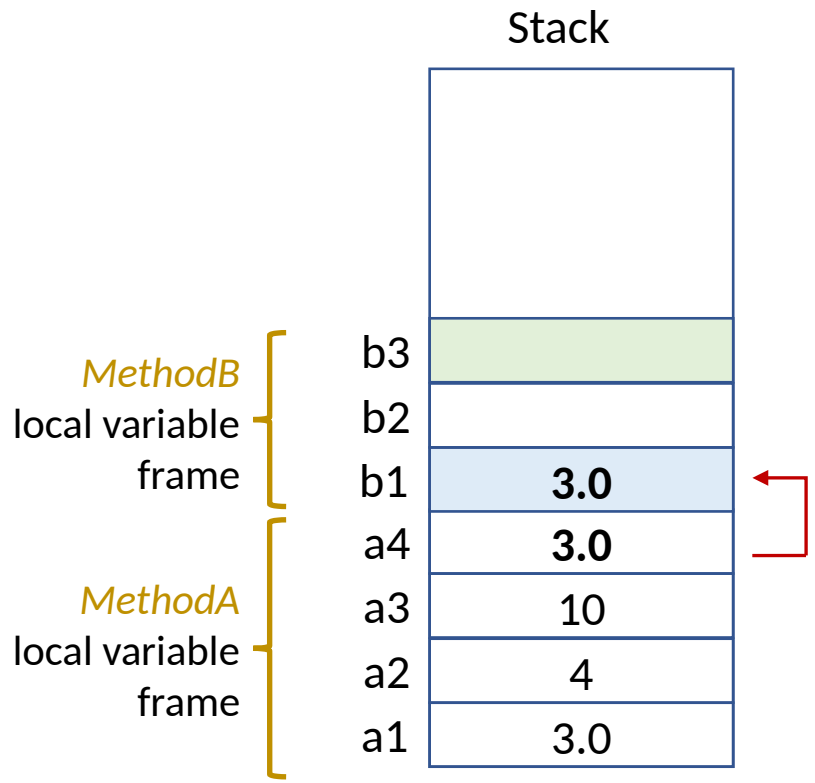


Method Invocation

C#'s default way of **passing** parameters is **by value**—a copy of the arguments' content is stored in the parameters of the method being called—they are **different** areas of the memory

The content of *a4* is **copied** to *b1*

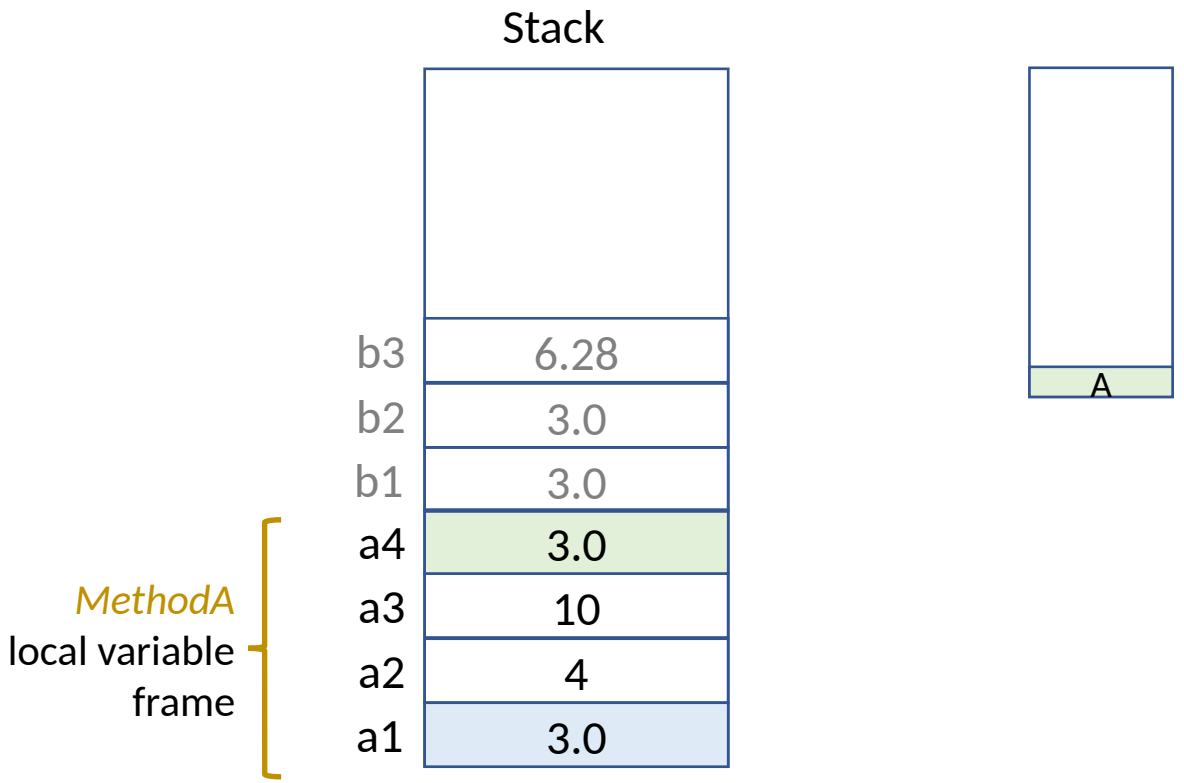
```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
  int a3 = 10;
  double a4 = a1;
  MethodB(a4);
}
```



Method Invocation

When *MethodB* terminates its local variables are no longer needed

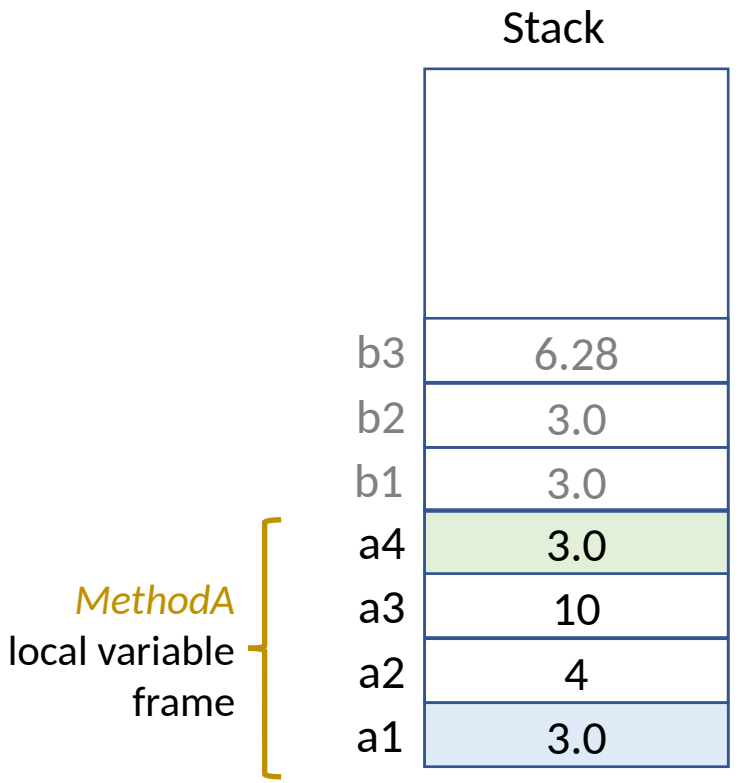
```
void MethodB(double b1)
{
  double b2 = b1;
  double b3 = 6.28;
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
}
```



Method Invocation

What happens if another method, e.g., *MethodC* is called inside *MethodA*?

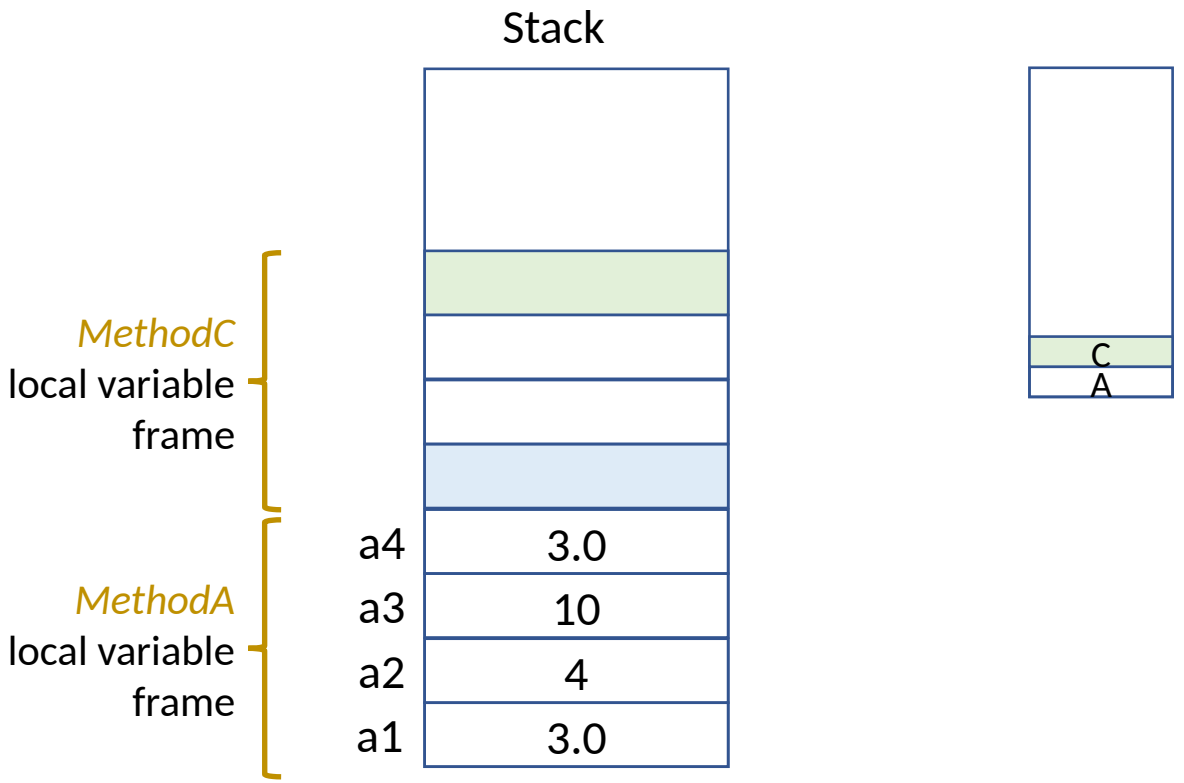
```
void MethodC( ... )
{
   ...

}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
   MethodC(a3);
}
```



Method Invocation

MethodC's local variable frame is created at the top of the stack and will overwrite *MethodB* one

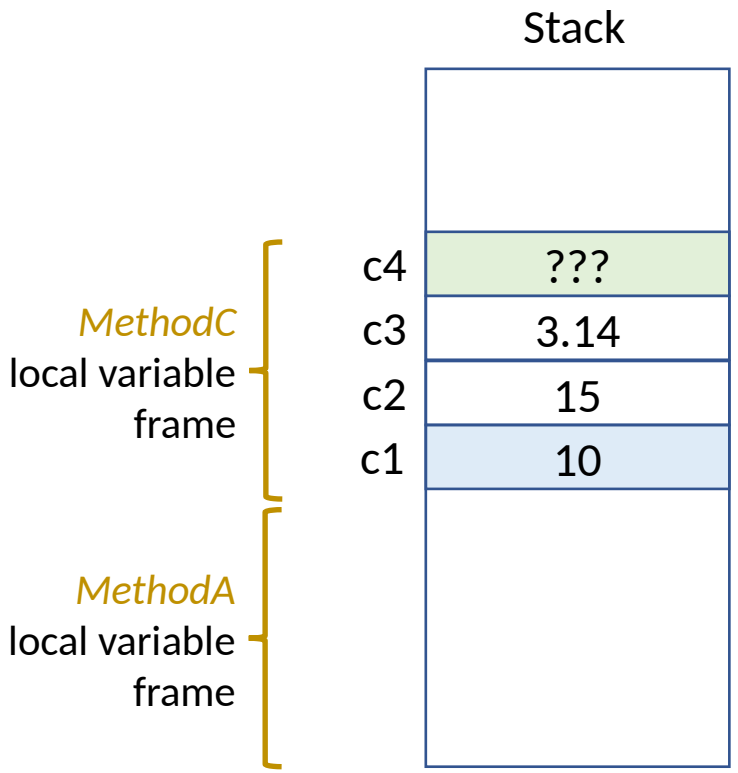
```
void MethodC( … )
{
   …

}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
   MethodC(a3);
}
```



Objects allocation

What happens when a reference-type variable, e.g., an object of *ClassX*, is created inside a method?

```
void MethodC(int c1)
{
   int c2 = 15;
   double c3 = 3.14;
   ClassX c4 = new ClassX();
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
   MethodC(a3);
}
```



Memory stack and heap

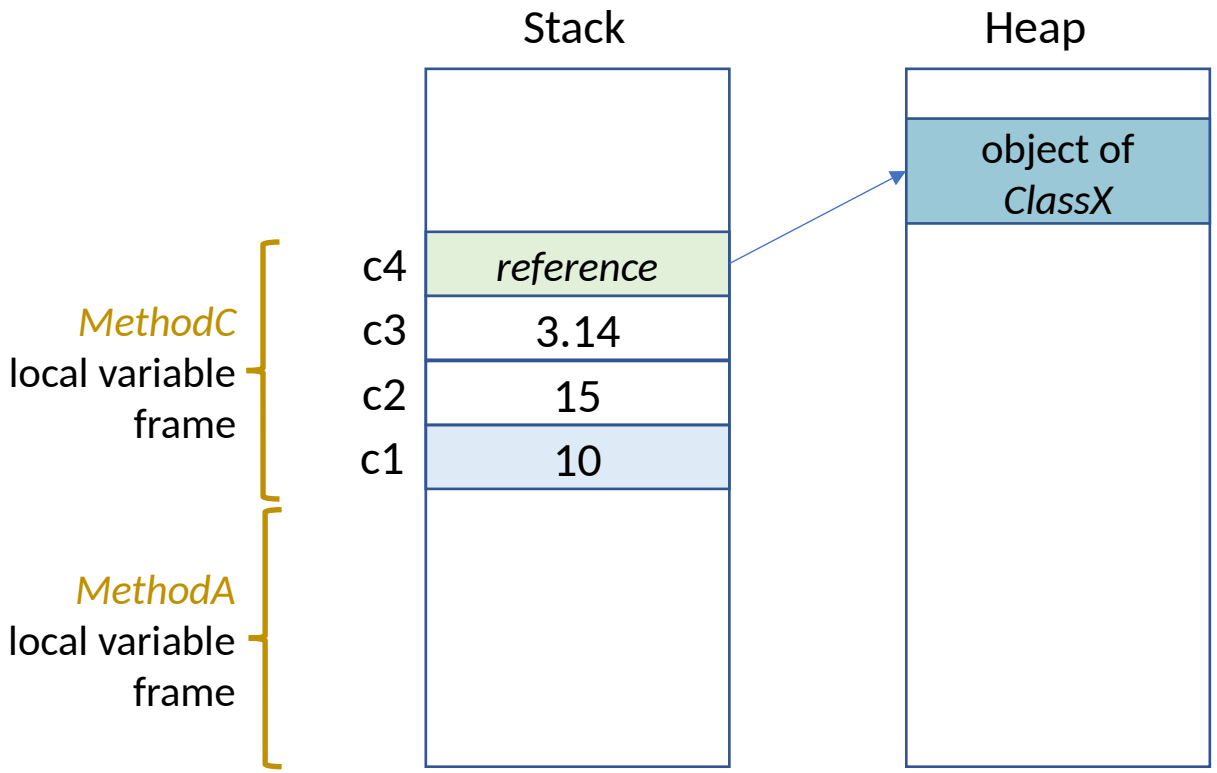
- *Primitive types* (**value types**) methods' *parameters* and local variables declared inside methods are allocated on the ***stack***

- An *object* or *array* (**reference types**) created via the new operator
  - Is allocated on the ***heap*** – also its attributes of *primitive types*
  - The **reference** variable for that object is allocated on the ***stack***

Objects allocation

The object is created on the heap—*c4* (on the stack) contains a reference to it

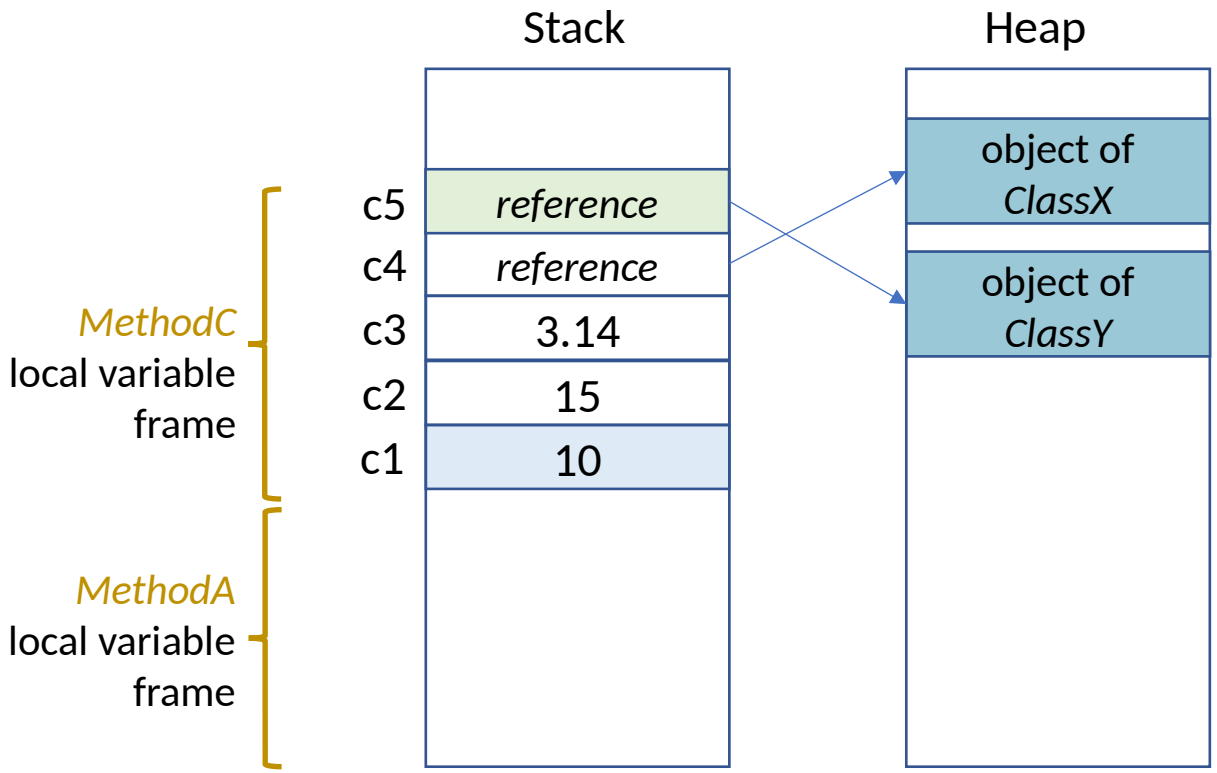
```
void MethodC(int c1)
{
   int c2 = 15;
   double c3 = 3.14;
   ClassX c4 = new ClassX();
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
   MethodC(a3);
}
```



Objects allocation

Adding another object of the *ClassY* class— it is created on the heap, and it is referenced by *c5*

```
void MethodC(int c1)
{
   int c2 = 15;
   double c3 = 3.14;
   ClassX c4 = new ClassX();
   ClassX c5 = new ClassY();
}

void MethodA(double a1, int a2)
{
   int a3 = 10;
   double a4 = a1;
   MethodB(a4);
   MethodC(a3);
}
```

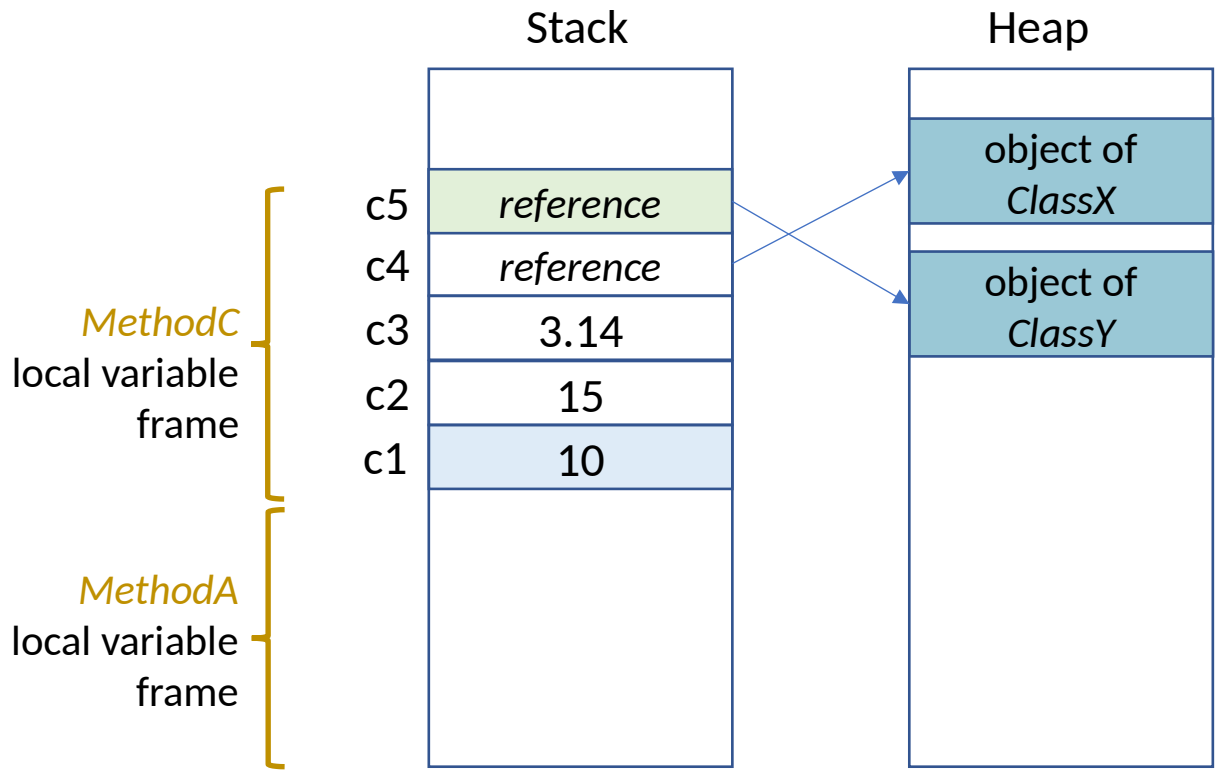


Objects allocation

Where will the *value type* attributes of *c4* be stored? Example coming soon…

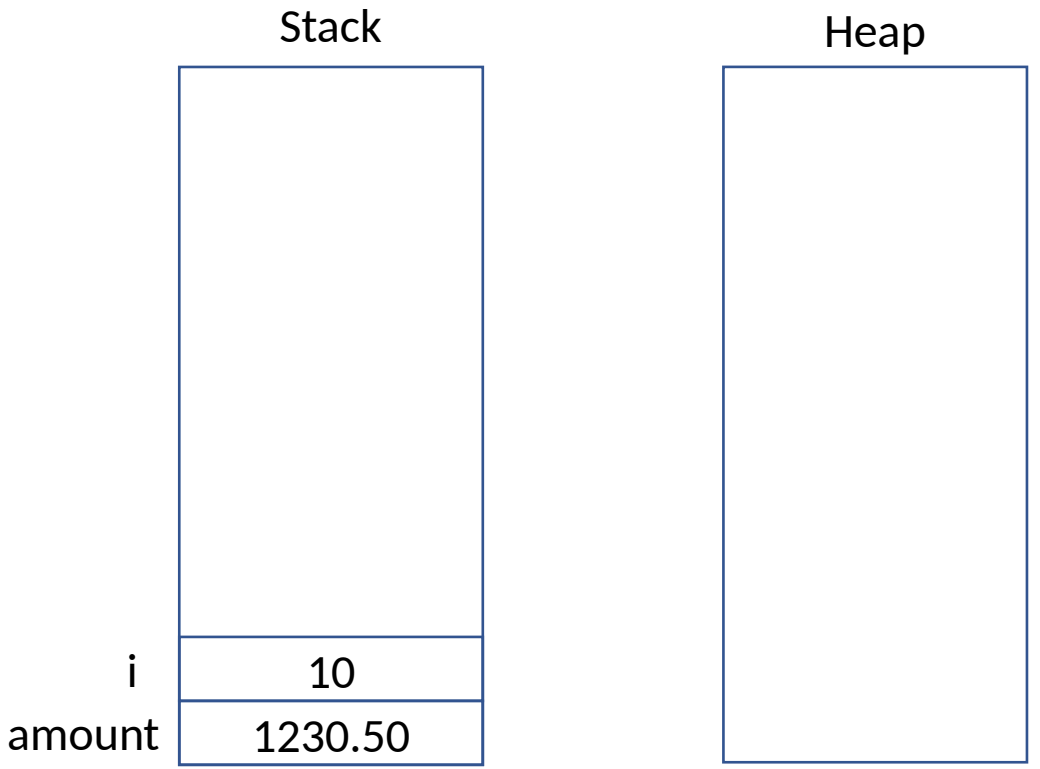
```
void MethodC(int c1)
{
  int c2 = 15;
  double c3 = 3.14;
  ClassX c4 = new ClassX();
  ClassX c5 = new ClassY();
}
```

```
class ClassX
{
  int attr1;
  int attr2;
  public ClassX() { … }
}
```



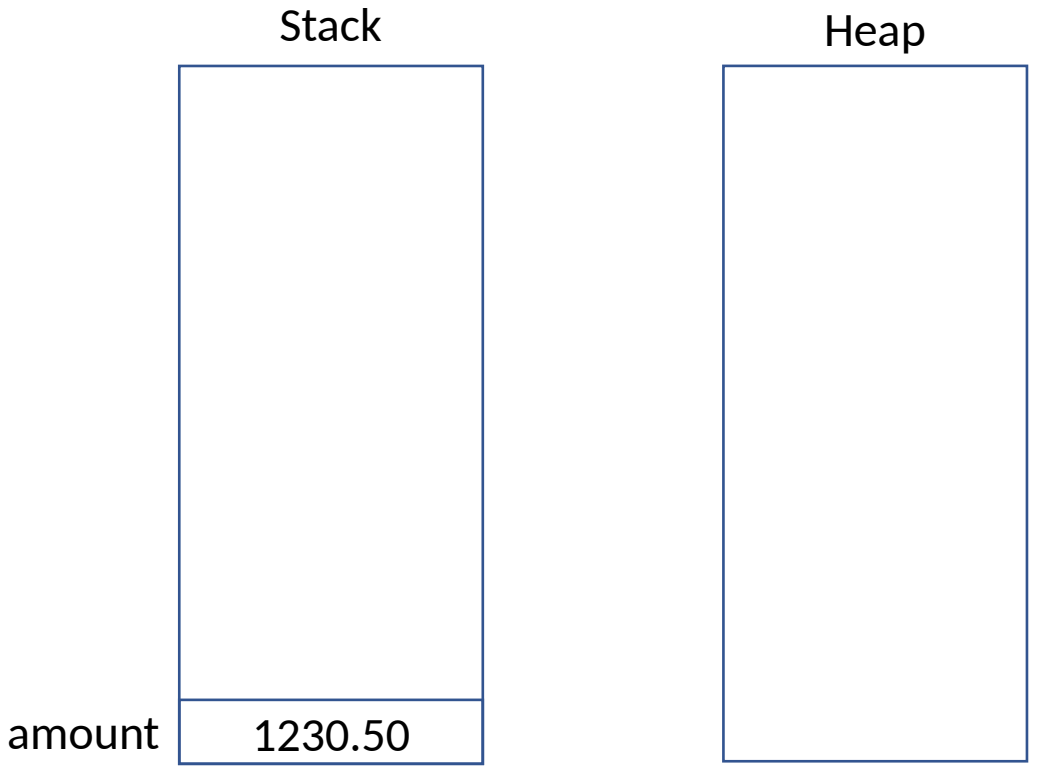
Example 1: double and int

```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        int i = 10;
    }
}
```



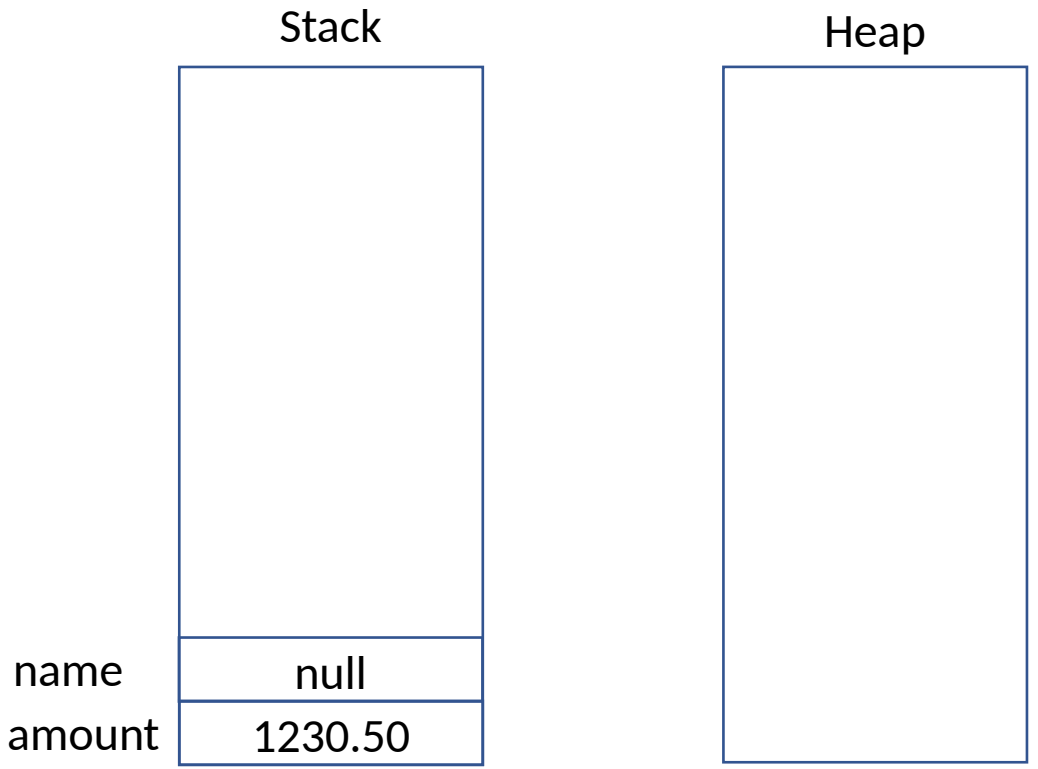
Example 2: double and string

```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;

    }
}
```



Example 2: double and string

```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        string name;
    }
}
```



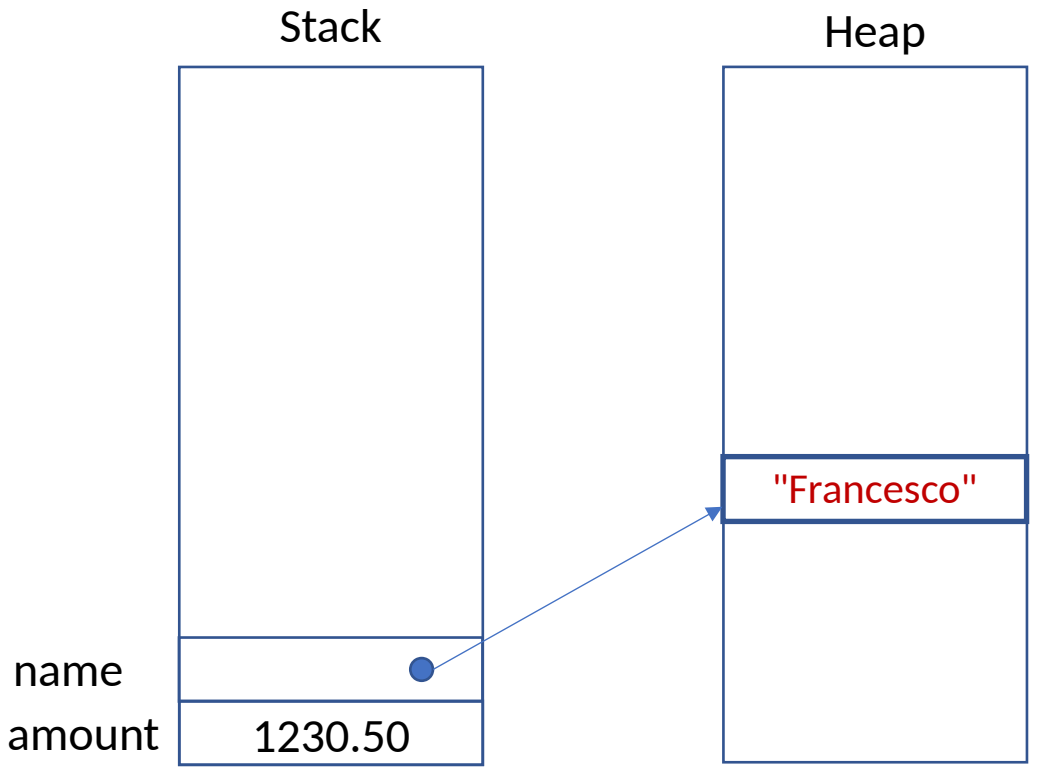
A string is an object—*name* holds a reference

null means that no object is referenced

it is the default value for a *non-initialised* reference variable

Example 2: double and string

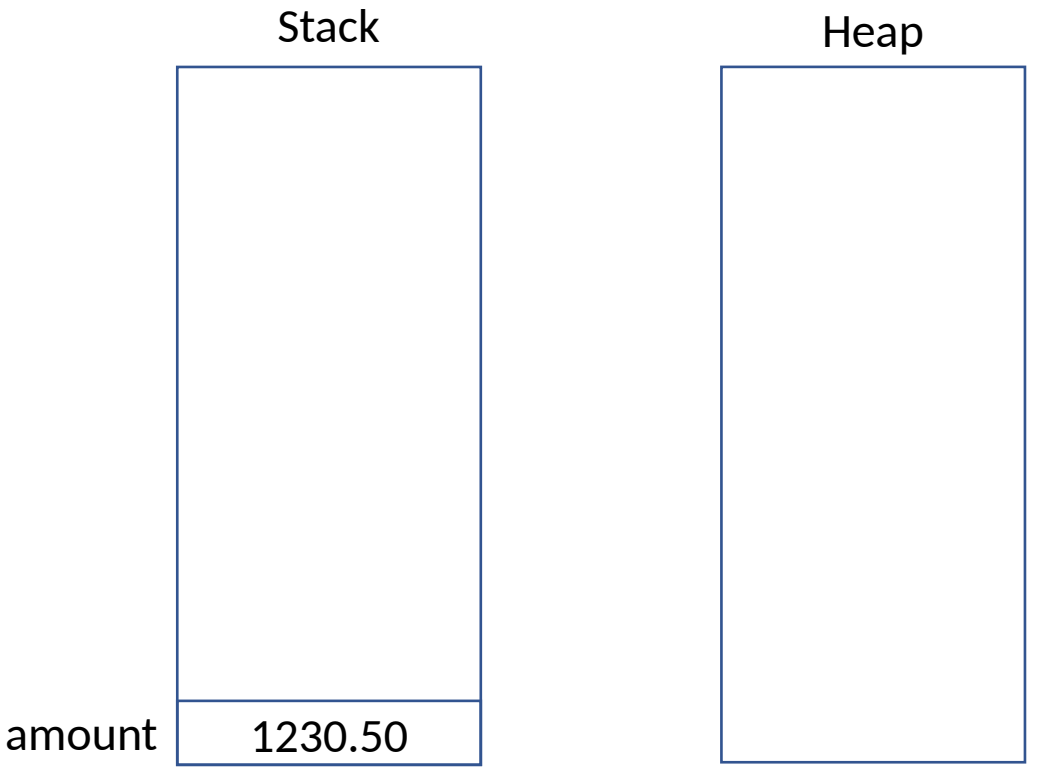
```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        string name = "Francesco";
    }
}
```



name now references the memory location of the **heap** that contains the string object

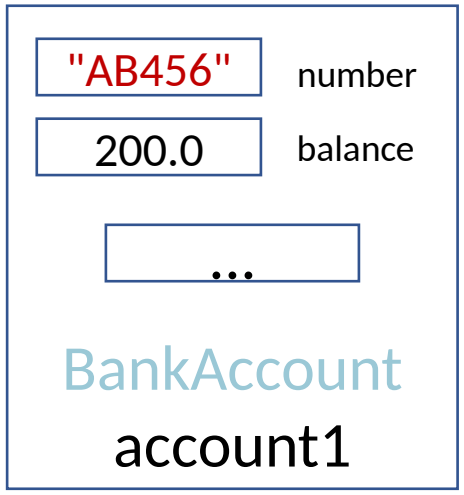
Example 3: double and *BankAccount*

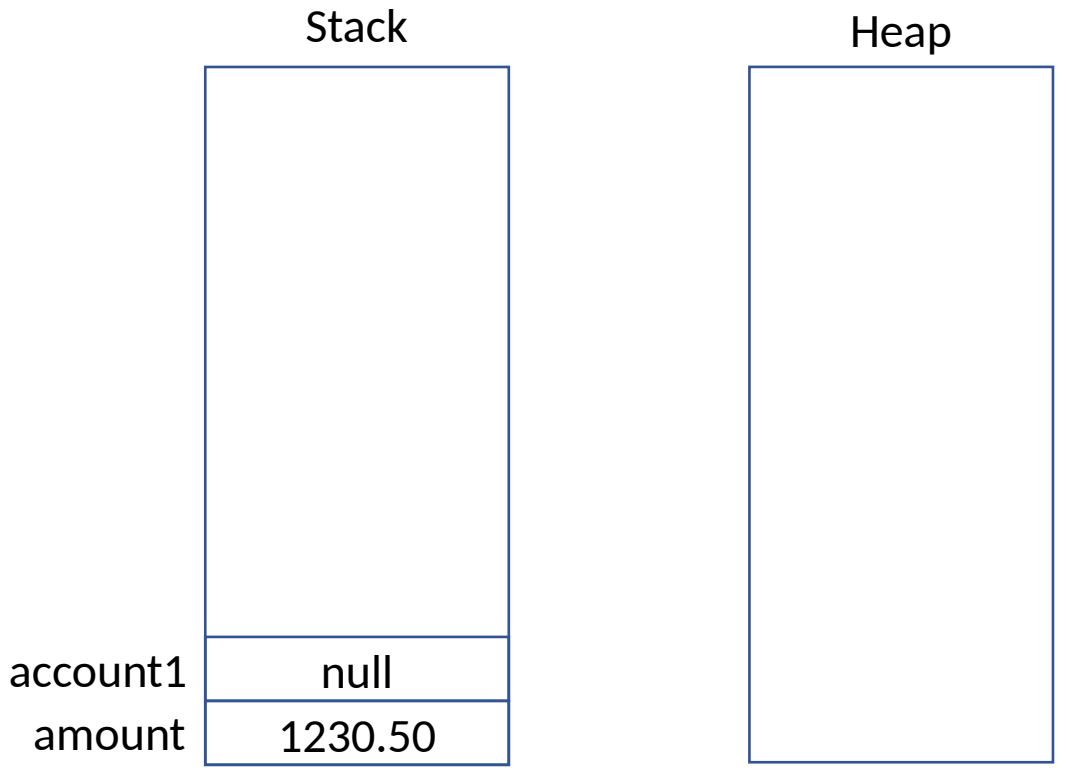
```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;


    }
}
```



Example 3: double and *BankAccount*

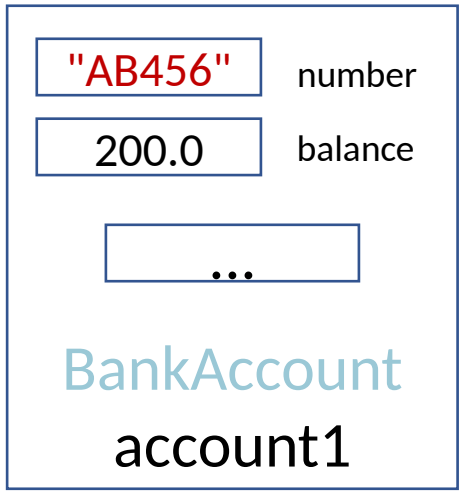
```
class Program
{
   public static void Main()
   {
      double amount = 1230.50;
      BankAccount  account1;

   }
}
```

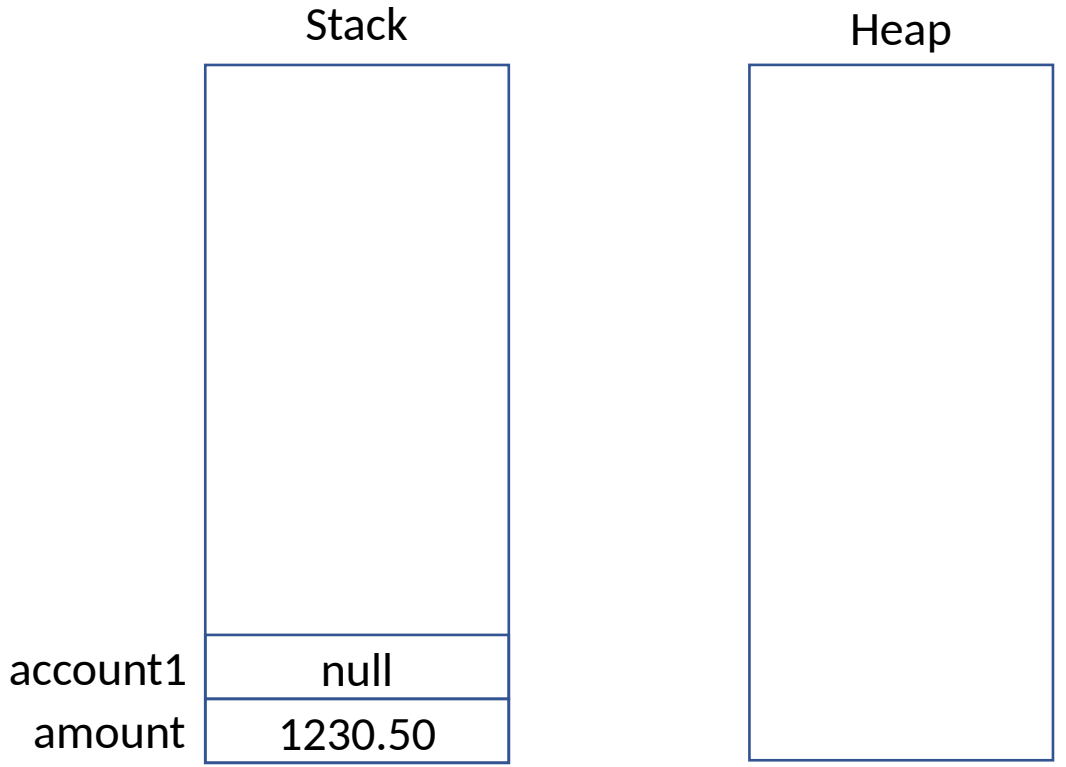




Example 3: double and *BankAccount*

```
class Program
{
   public static void Main()
   {
      double amount = 1230.50;
      BankAccount  account1;

   }
}
```

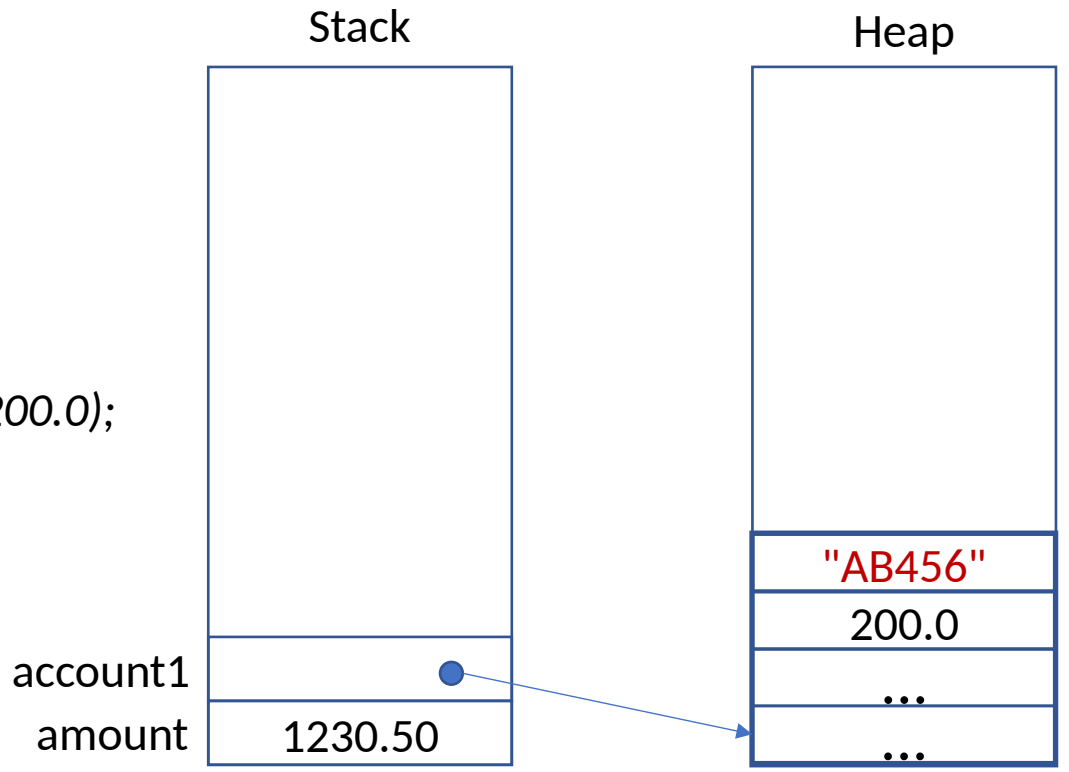




When the object is created, where will the *attributes* be stored?

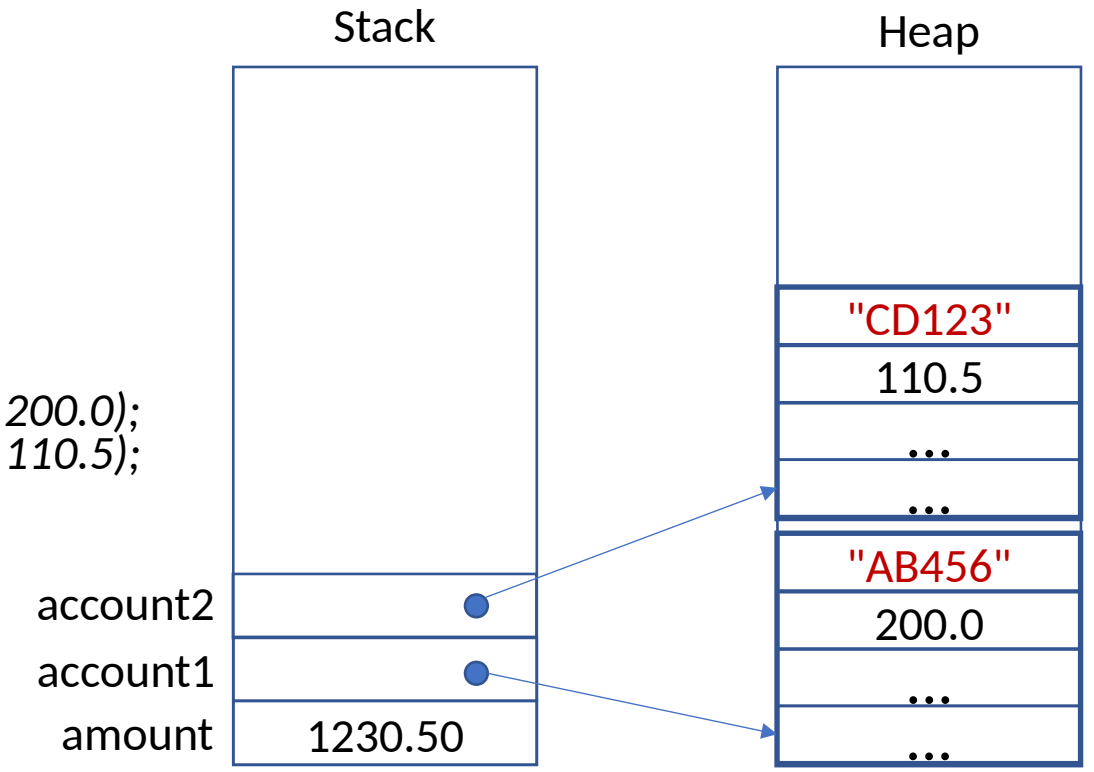
Example 3: double and *BankAccount*

```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        BankAccount  account1 = new BankAccount("AB456", 200.0);

    }
}
```



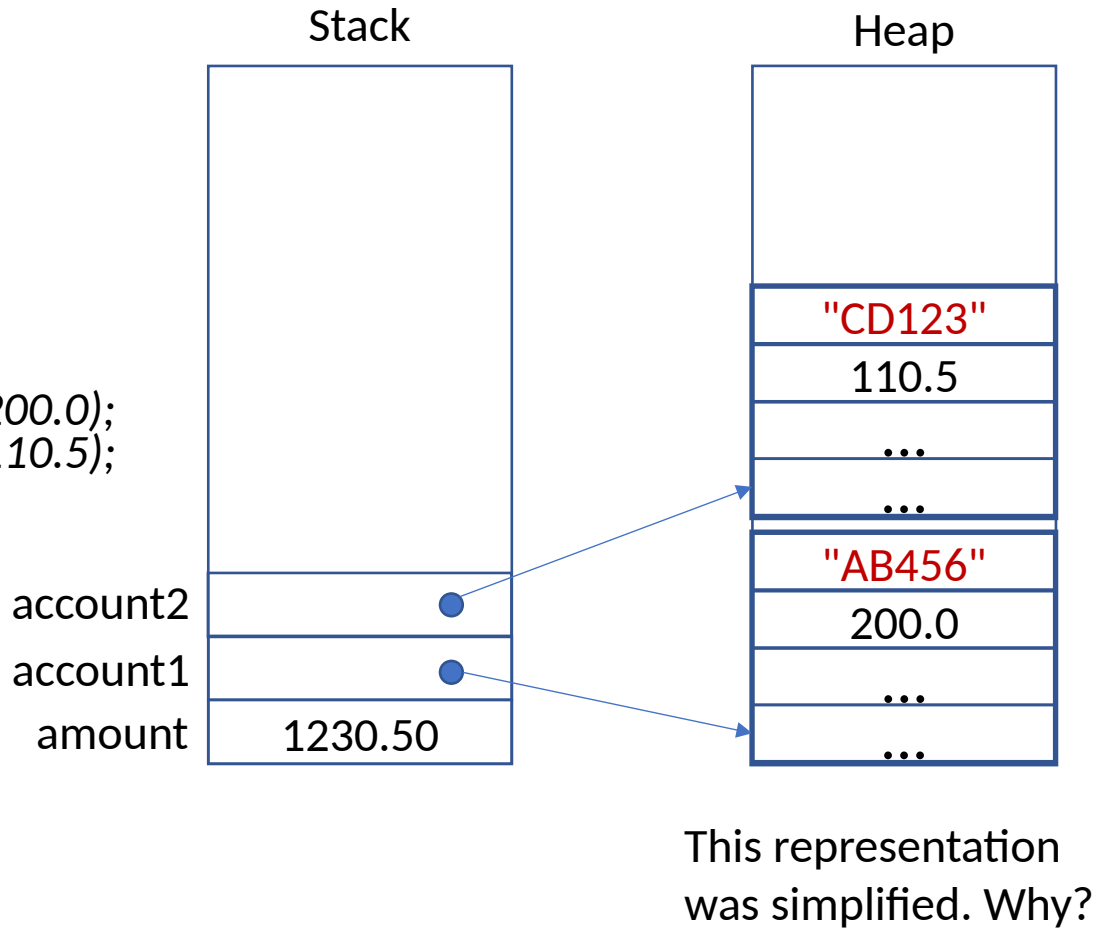
Example 3: double and *BankAccount*

```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        BankAccount  account1 = new BankAccount("AB456", 200.0);
        BankAccount  account2 = new BankAccount("CD123", 110.5);
    }
}
```



Example 3: double and *BankAccount*

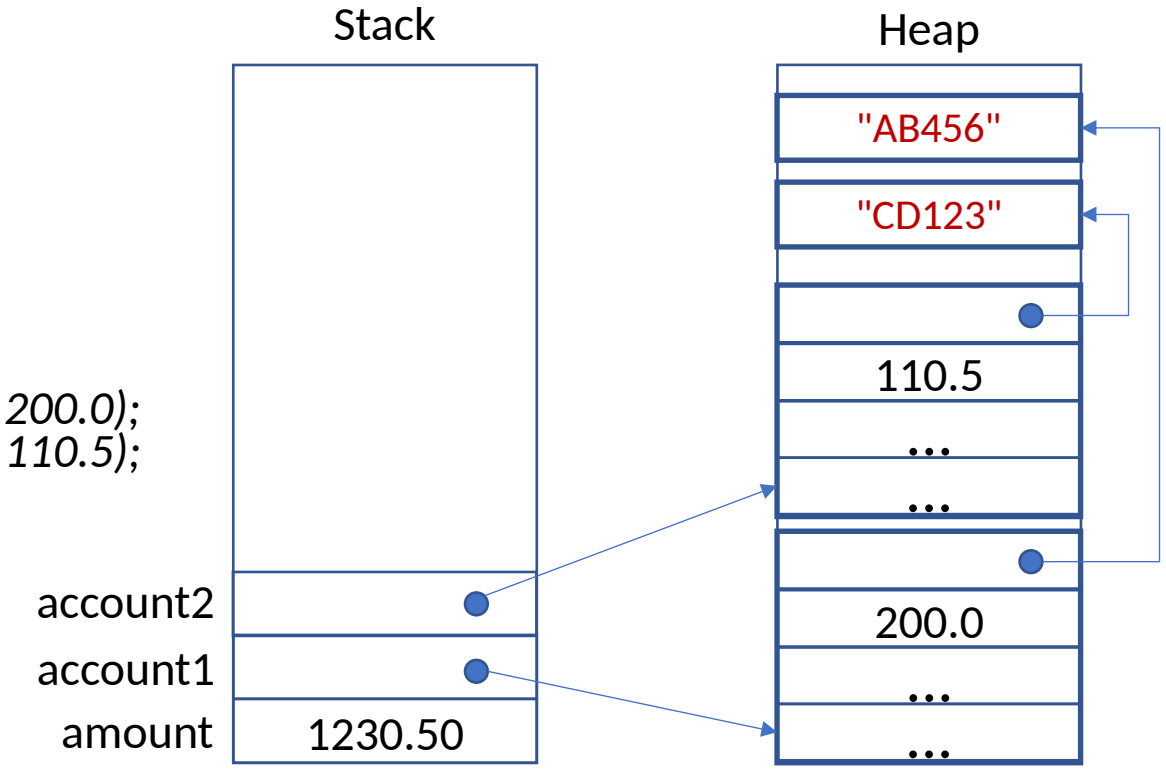
```
class Program
{
    public static void Main()
    {
        double amount = 1230.50;
        BankAccount  account1 = new BankAccount("AB456", 200.0);
        BankAccount  account2 = new BankAccount("CD123", 110.5);
    }
}
```



This representation was simplified. Why?

Example 3: double and *BankAccount*

```
class Program
{
   public static void Main()
   {
      double amount = 1230.50;
      BankAccount  account1 = new BankAccount("AB456", 200.0);
      BankAccount  account2 = new BankAccount("CD123", 110.5);
   }
}
```



the attribute *number* of *BankAccount* is a reference type (string)

its content may be stored somewhere else on the heap

Methods parameters: reference types

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }
        public int GetX() { ... }
        public int GetY() { ... }

        public double DistanceFrom(Point p)
        {
            double distance = Math.Sqrt(Math.Pow(p.x - x, 2) + Math.Pow(p.y - y, 2));
            return distance;
        }
}
```

Methods parameters: reference types

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }
        public int GetX() { ... }
        public int GetY() { ... }

        public double DistanceFrom(Point p)
        {
            double distance = Math.Sqrt(Math.Pow(p.x - x, 2) + Math.Pow(p.y - y, 2));
            return distance;
        }
}
```

*What happens when a **reference type** (e.g., a Point object) is passed by value to a method?*

Methods parameters: reference types

```
class Point
{
        private int x;
        private int y;

        public Point(int xarg, int yarg) { ... }

        public void Display() { ... }
        public void Move(int xm, int ym) { ... }
        public int GetX() { ... }
        public int GetY() { ... }

        public double DistanceFrom(Point p)
        {
            double distance = Math.Sqrt(Math.Pow(p.x - x, 2) + Math.Pow(p.y - y, 2));
            return distance;
        }
}
```

*A **copy of the reference** to the object, not a copy of the object, will be passed…*

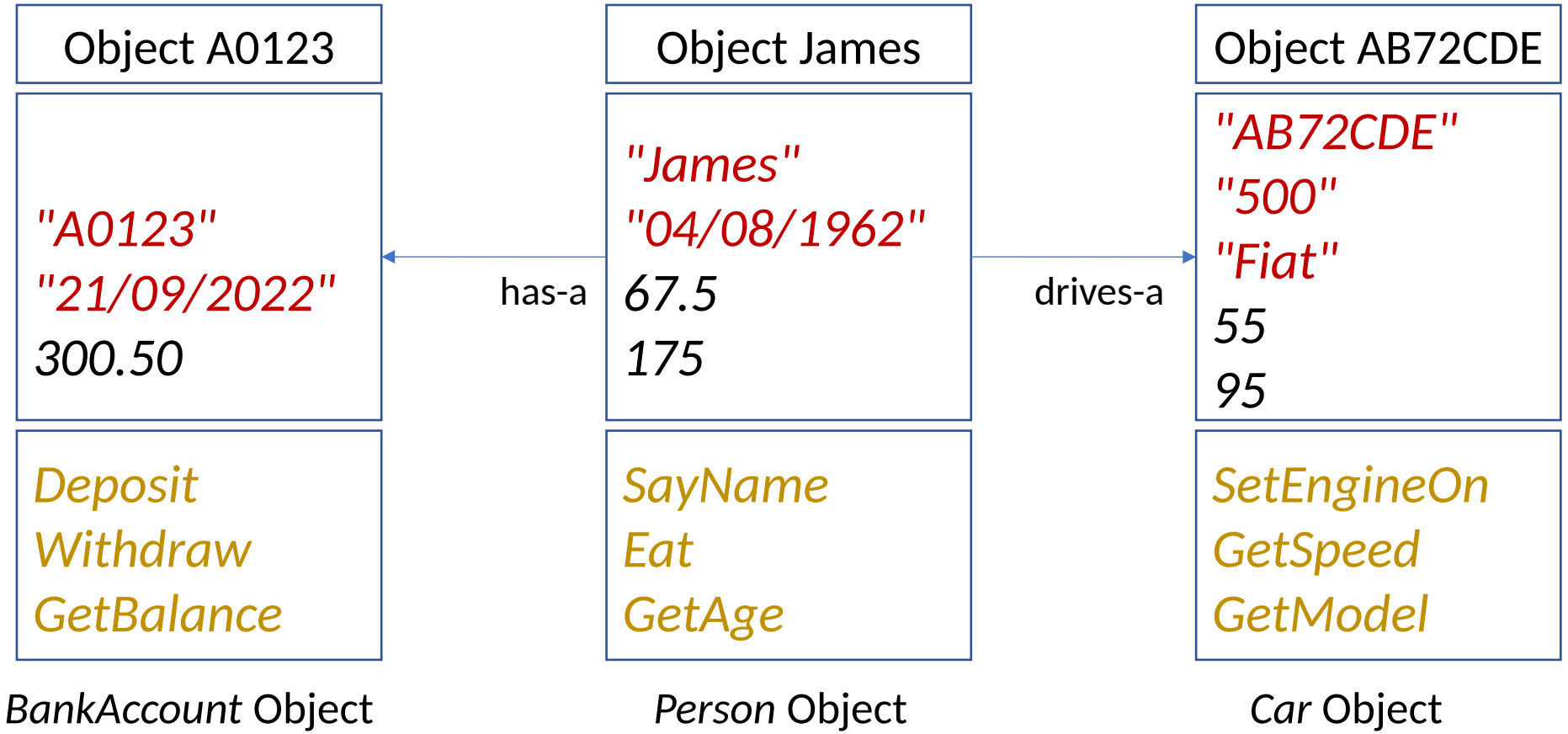
Reflect on the following (before week 7)

- What happens with ***reference type*** *variables* when:
  - They are checked for ***equality*** (==)
  - They are used in ***assignment*** (=) instructions
  - They are ***passed by value*** to a *method*

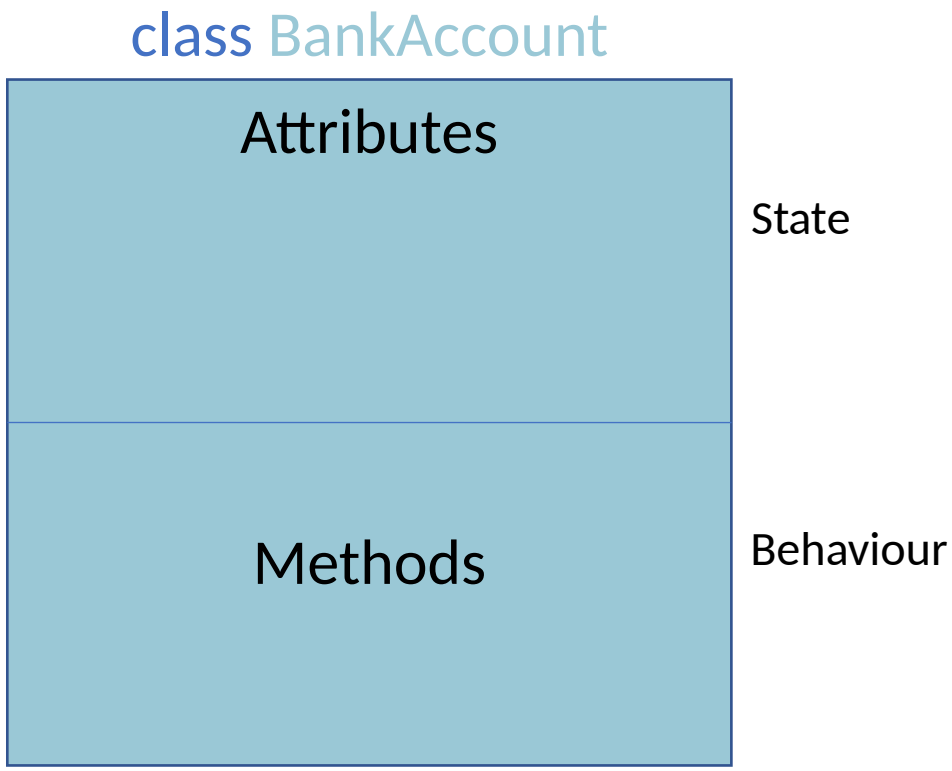
Outline

- Summary of last week and more on methods
- Value types and Reference types, Stack and Heap
- UML class diagrams

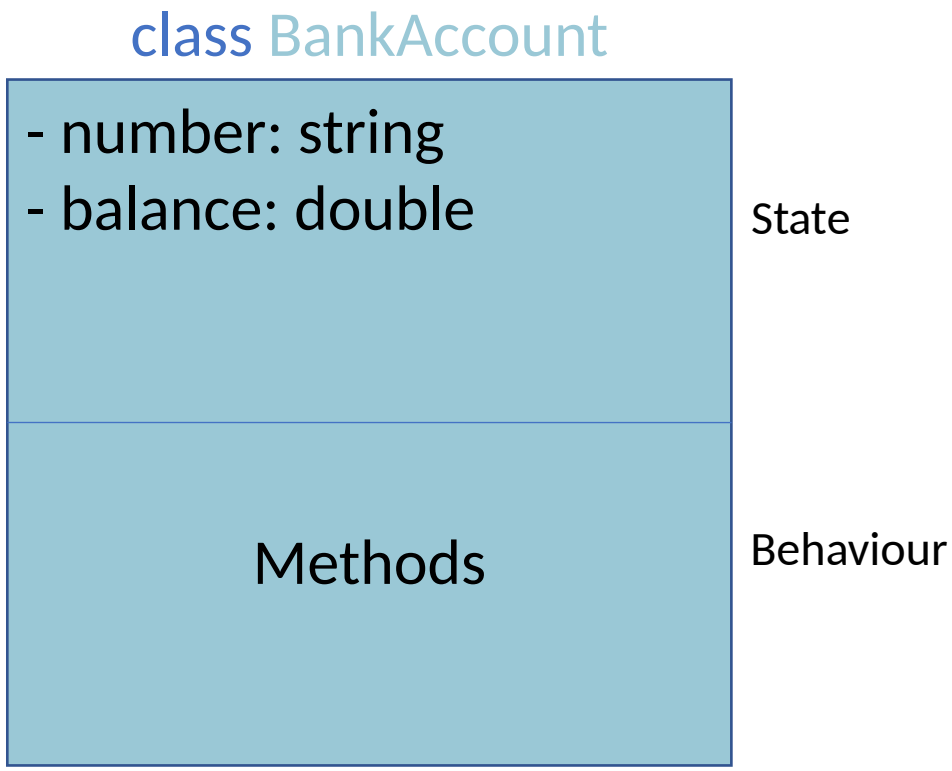
Objects Representation



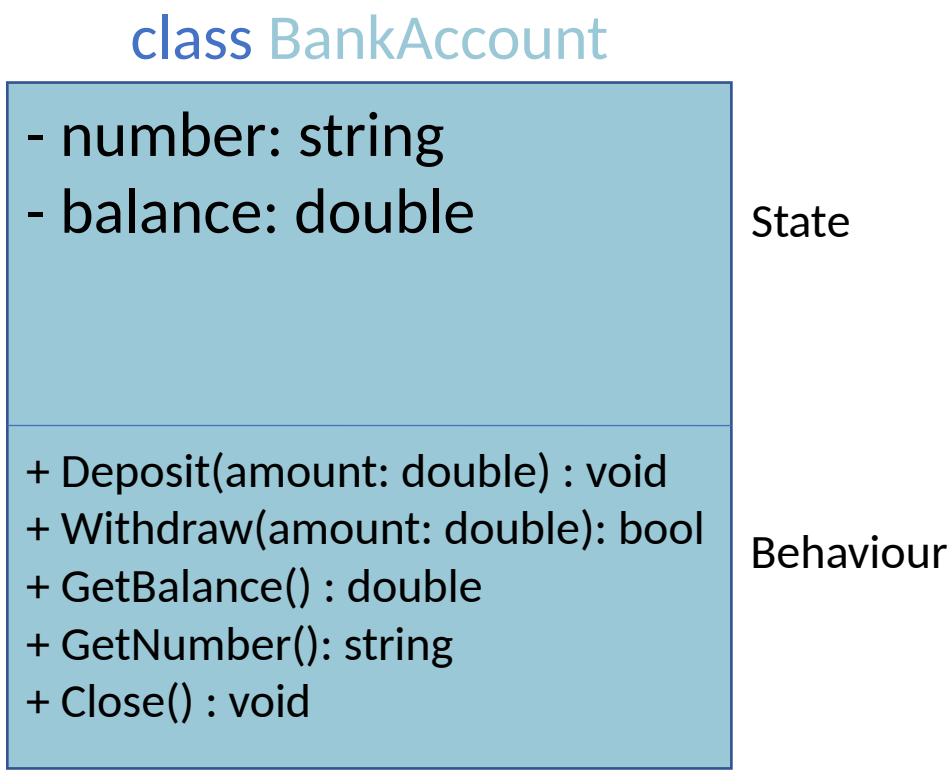
Bank account



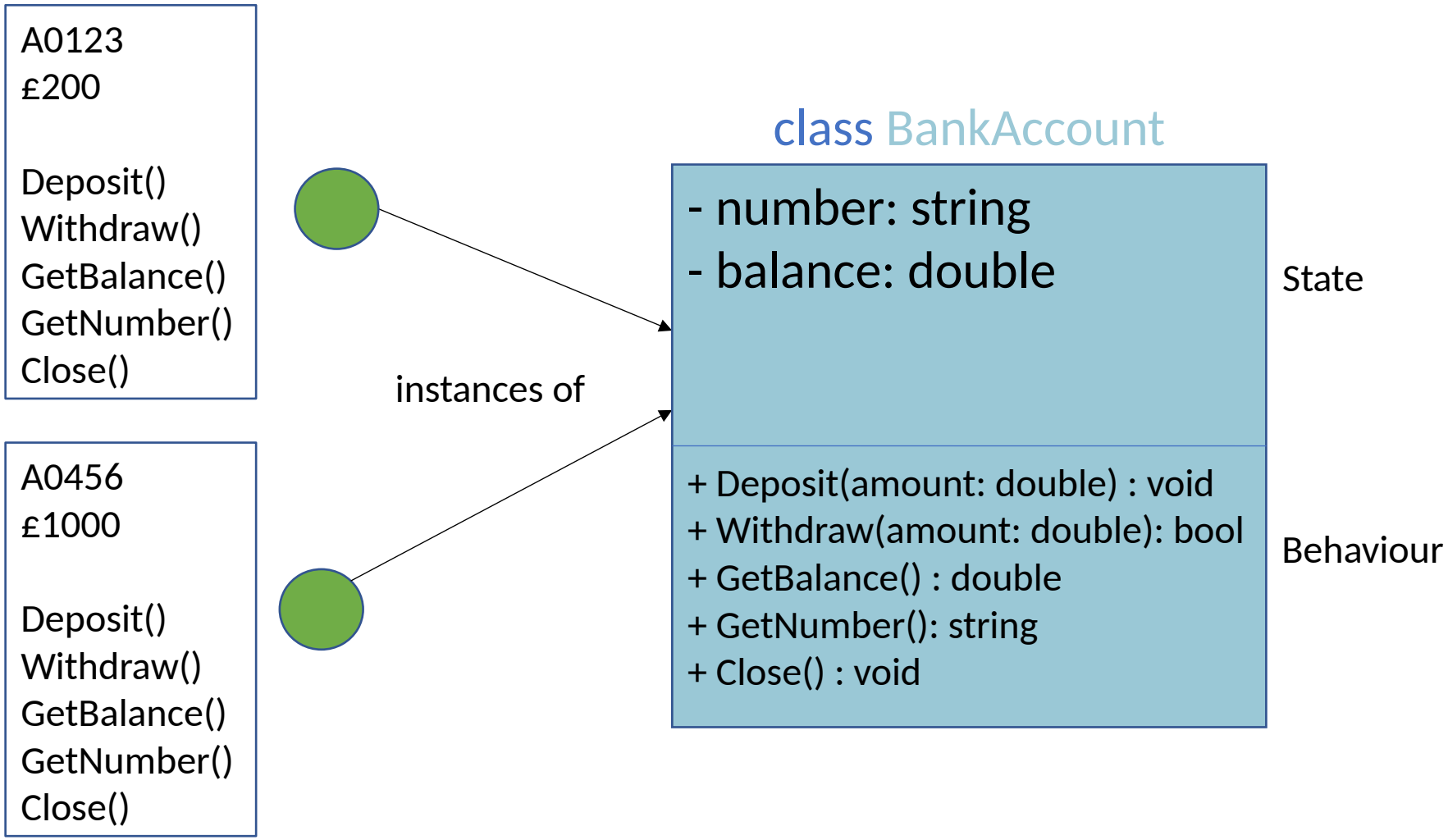
Bank account: attributes



Bank account: methods



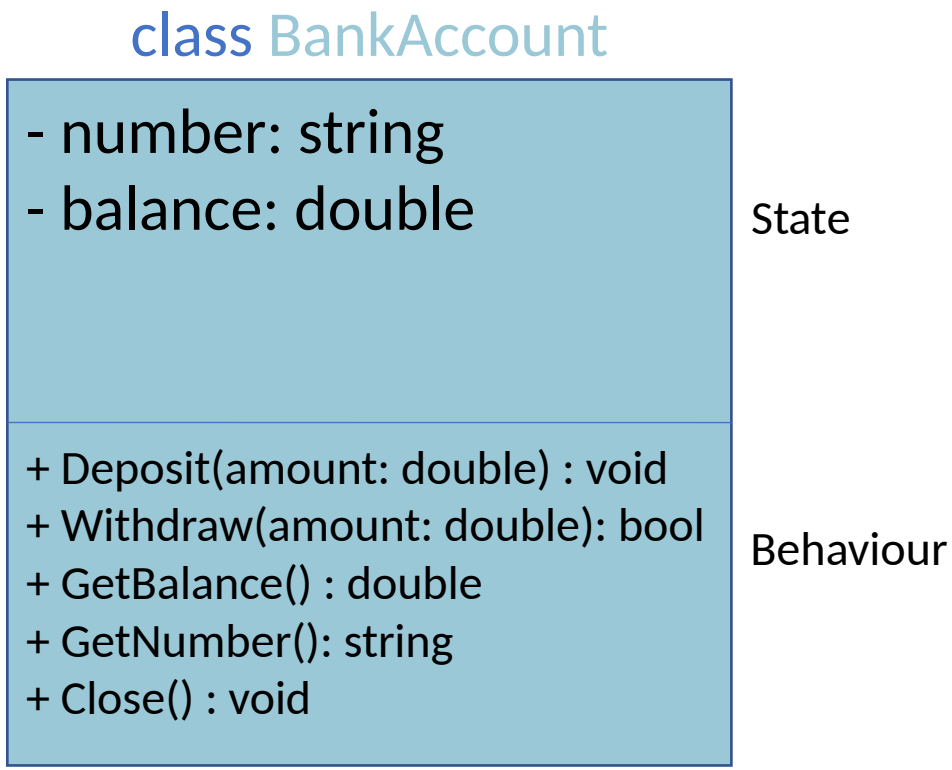
Bank account: object instances



Bank account: Class Diagram

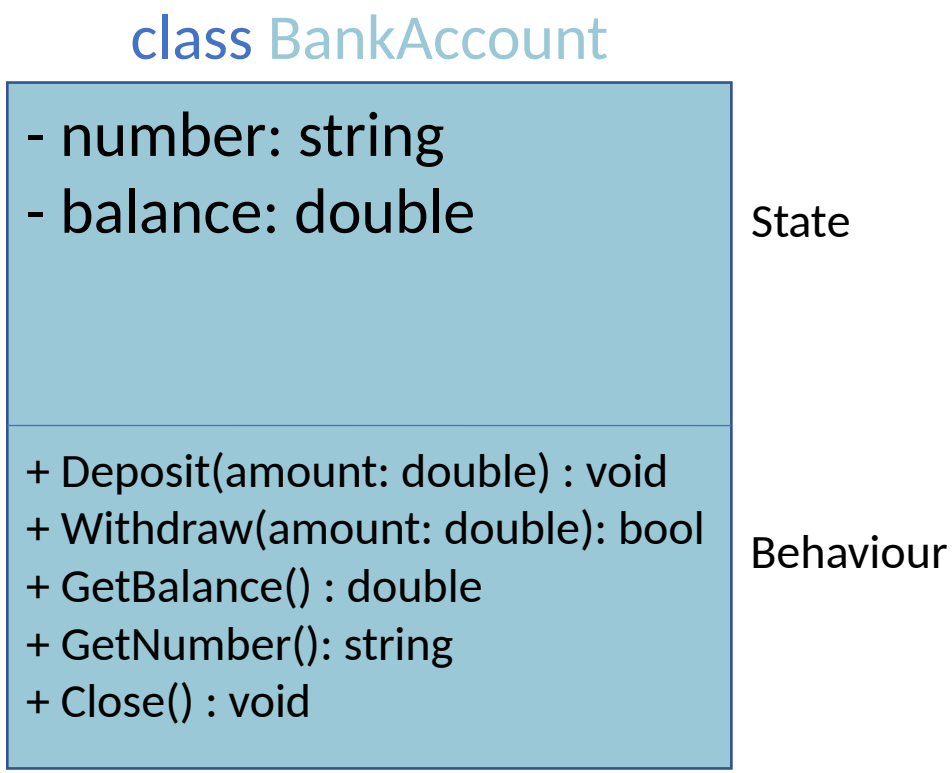
UML (Unified Modelling Language)

Class Diagram



Bank account: Class Diagram

+ denotes a public member
- denotes a private member



Bank account: Class Diagram

Think about a possible definition of a BankAccount class based on this diagram.

More on this later in the lab!