C# Types

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Announcement

- Reminder: Office Hours
  - When: Wednesdays after class until 2pm
  - Where: 4161 Upson Hall
- Homework 1 will be emailed to you tonight
  - If you do not receive it by 5pm, send me an email!
    - hussam@cs.cornell.edu
  - Due next Friday 1/30
  - Submit through CMS
  - Write a small C# Program
    - Takes in web page HTML code
    - Produce a list of all hypertext links
    - Count number of links pointing to the same website

Today's Agenda

- C# Types
  - Reference types
  - Value types
  - Boxing and unboxing
- Basic C# Features
  - Arrays
    - Example: Sudoku Maker
  - OO features
  - Iterators

Value Types

- Examples:
  - Integer types:
    - Signed: `sbyte, int, short, long`
    - Unsigned: `byte, uint, ushort, ulong`
  - Floating point: `float, double, decimal`
- Traditionally, value types are stored outside dynamic memory allocation range.
  - Stored in *stack* rather than *heap*

Value Types

- Value types in C# are of two main categories:
  - Structs
  - Enumerations
- Structs fall into these categories:
  - Numeric types
    - Integer, floating point, decimal
  - Bool
  - User-defined structs

Value Types

- All value types have default constructors assigning them values
- Generally can not be assigned `null`
  - Except in special cases
    - Won't be discussed in this class

Reference Types

- Reference types are always dynamically allocated
- Variables based on reference types (called objects) store *references* to the actual data
- The following keywords are used to declare a reference type
  - `class, interface, delegate`
- Example:
  - String type: `string`

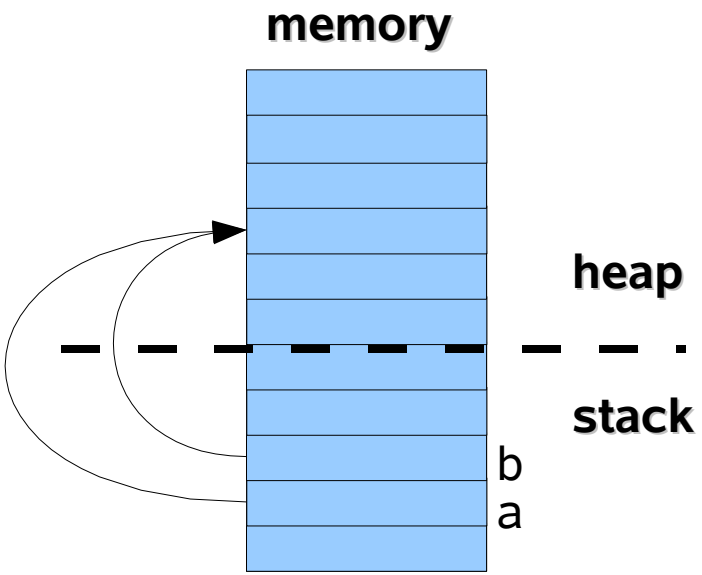
Comparison of Types

- Value type variables directly contain values
- Inheritance:
  - Value types inherit from `System.ValueType`
    - Treated specially by runtime; no subclassing
  - Inherit from `System.object`
- Assignment:
  - Assigning one value type to another copies the contained value
  - Assigning one reference type object to another duplicates the reference but not the actual value!

Memory Layout

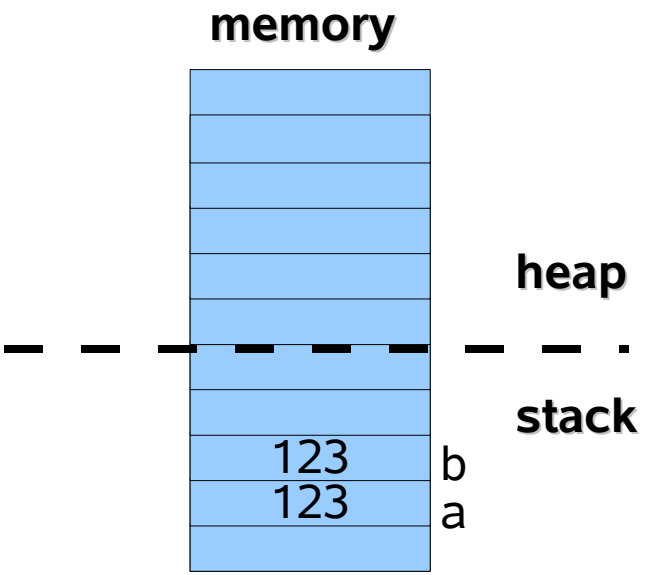
- Reference Types

```
{
  A a = new A();
  A b = a;
}
```



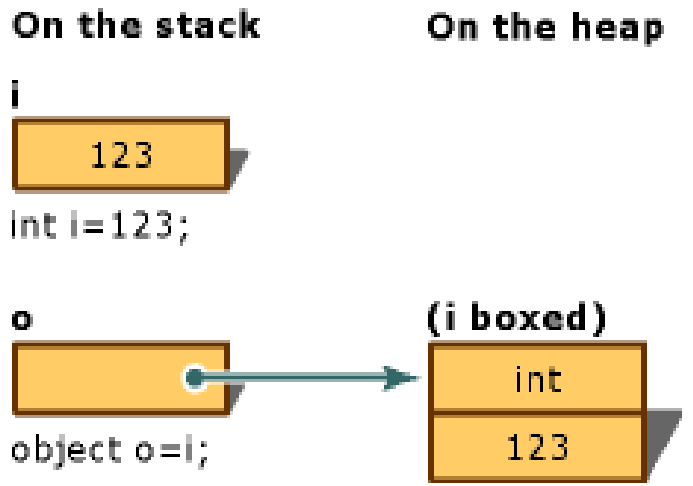
- Value Types

```
{
  int a = 123;
  int b = a;
}
```



Boxing and Unboxing

- Value types variables are not objects
  - This gives performance gain in most cases
  - But value variables can become objects on demand
  - Called “boxing”; reverse is called “unboxing”
- ```
  {
      int i = 123;
      object o = i;
      // object o = (object) i;
  }
  ```


  ```

Quiz: what will happen?

- ```
  Foo a = new Foo();
  Foo b = a;
  b.X = 10;
  Console.WriteLine(a.X); // output ?
  ```
- ```
  int a = 1;
  int b = a;
  b = 10;
  Console.WriteLine(a);   // output ?
  ```
- This is important for parameter passing

Enum Example

- Definition

```
enum ClassDay
{
   Monday,
   Wednesday,
   Friday
}
```

- Instantiation

```
ClassDay today = ClassDay.Friday;
```

Structs

- A `struct` is a user-defined value type
- Contains a collection of fields, methods, and properties
- Suitable for representing lightweight objects such as Point, Rectangle ..etc
  - You can define a Point as a `class` (reference type)
  - However, `struct` can be less expensive in terms of memory
  - Example, array of 100 struct points is less expensive than an array of 100 `class` points. Why ?

Struct Example

- Definition

```
struct Point {
  public int x, y;
  public Point (int x, int y) {
    this.x = x;
    this.y = y;
  }
}
```

- Instantiation

```
Point a = new Point(10, 20);
a.x = 30;
```

Default Values for C# Variables

- Often variables in C# are given default values even if not assigned explicitly
  - `string s;  // s == null`
  - `double x;  // x == 0.0`
- Default values are only given to:
  - Instance variables, static variables, array elements
- Class example
  - `DefaultValues.cs`

C# Arrays

- Simple definition
  - `int[] array = new int[30];`
- “Jagged” Arrays
  - ```
    int[][] array = new int[2][];
    array[0] = new int[100];
    array[1] = new int[5];
    ```
  - The “outer” array with two elements will be stored consecutively. However, the inner arrays (`array[0]` & `array[1]`) will not be stored consecutively in heap.
    - Recall that arrays are reference-type objects
  - Can have arbitrary dimensions
    ```

C# Arrays

- Multidimensional Arrays
  - Stored sequentially
  - Visually look like a rectangle (or a cube or a hypercube depending on the number of dimensions)
- Example
  - ```
    int[,] array = new int[9, 9];
    array[3,8] = 100;
    ```
- Class Example
  - SudokuMaker.cs
    ```