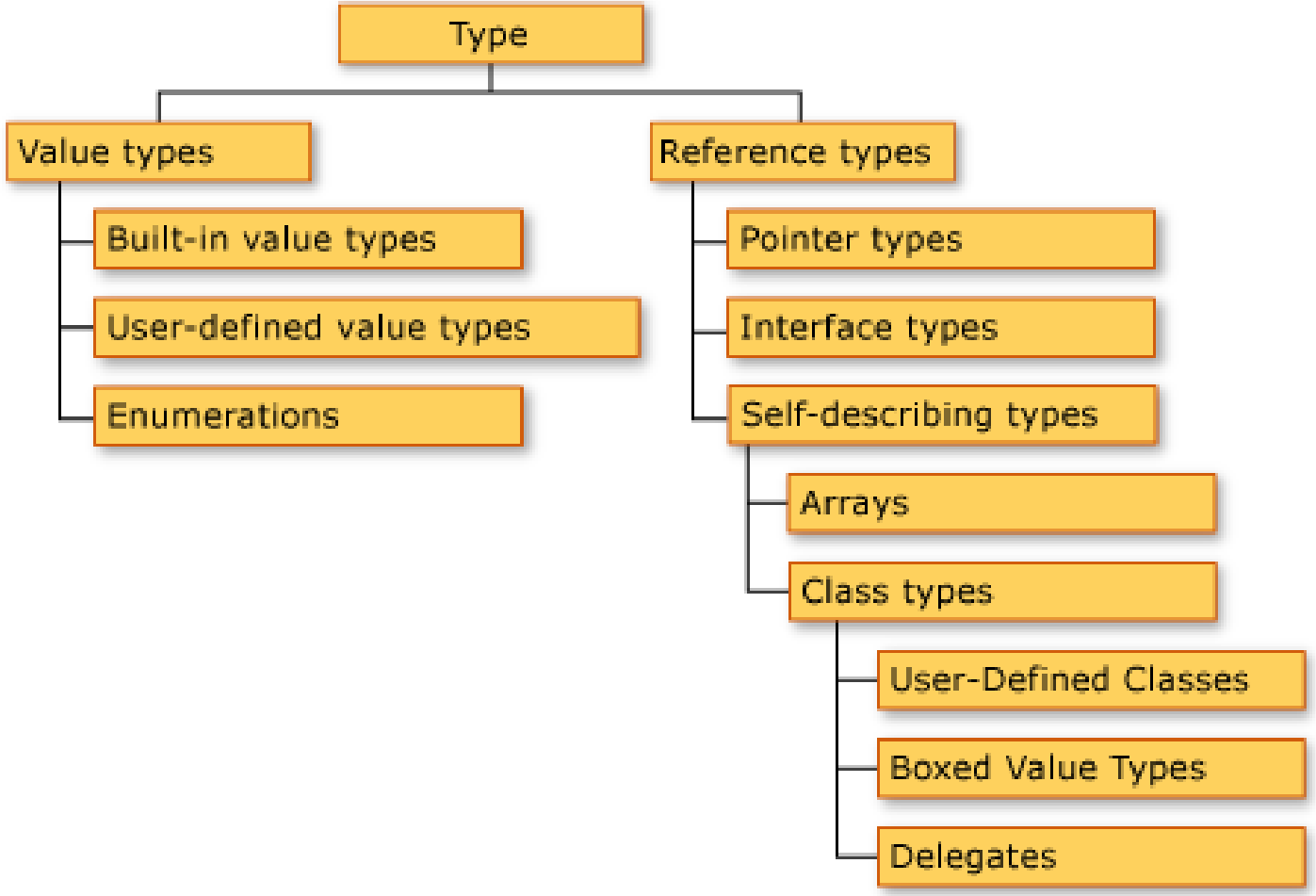
Industrial Programming

Lecture 3: C# Fundamentals

C# Types


Type
Value types
Reference types
Built-in value types
User-defined value types
Enumerations
Pointer types
Interface types
Self-describing types
Arrays
Class types
User-Defined Classes
Boxed Value Types
Delegates

Value Types

- Memory location contains the data.
- Integers:
  - Signed: sbyte, int, short, long
  - Unsigned: byte, uint, ushort, ulong
  - e.g. int count = 5;
- Floating points: float, double
- Examples
  - double average = 10.5;
  - float total = 34.88f;

Signed and Unsigned

- By default int, short, long are signed data types as they can hold a negative of a positive value of their ranges.

- Unsigned variable can only hold positive values of its range.

Types and Values

Table 1, The Size and Range of C# Integral Types

Type	Size (in bits)	Range
sbyte	8	-128 to 127
byte	8	0 to 255
short	16	-32768 to 32767
ushort	16	0 to 65535
int	32	-2147483648 to 2147483647
uint	32	0 to 4294967295
long	64	-9223372036854775808 to 9223372036854775807
ulong	64	0 to 18446744073709551615
char	16	0 to 65535

Table 2. The Floating Point and Decimal Types with Size, precision, and Range

Type	Size (in bits)	precision	Range
float	32	7 digits	1.5×10^{-45} to 3.4×10^{38}
double	64	15-16 digits	5.0×10^{-324} to 1.7×10^{308}
decimal	128	28-29 decimal places	1.0×10^{-28} to 7.9×10^{28}

Value Types (cont'd)

- Decimal types: appropriate for storing monetary data. Provides greater precision.
  - decimal profit = 2211655.76M;
- Boolean variables: true or false.
  - bool student = true;

Value Types (cont'd)

- Enum Types:
- The **enum** keyword is used to declare an enumeration, a distinct type consisting of a set of named constants called the enumerator list.
- Every enumeration type has an underlying type, which can be any integral type except char.

Value Types (cont'd)

- The default underlying type of the enumeration elements is **int**. By default, the first enumerator has the value 0, and the value of each successive enumerator is increased by 1, eg

```
enum Days {Sat, Sun, Mon, Tue, Wed, Thu, Fri};
```

- In this enumeration, Sat is 0, Sun is 1, Mon is 2, and so forth.
- Enumerators can have initialisers to override the default values, eg

```
enum Days {Sat=1, Sun, Mon, Tue, Wed, Thu, Fri};
```

- In this enumeration, the sequence of elements is forced to start from 1 instead of 0.

Value Types (cont'd)

- Example of enum types:

```
enum Fruit
{
  apple,
  banana,
  peach
}
Fruit f = Fruit.apple
```

Value Types (cont'd)

- Struct types:
  - User-defined types.
  - Can contain data members of different types.
  - Can’t be extended.

```
struct Person
{
  public String fName, lName;
  public Person(String fName, String lName)
    {
       this.fName = fName;
       this.lName = lName;
     }
}
Person p = new Person(“John”, “Smith”);
```

Structs vs Classes

Classes	**Structs**
Reference type	*Value type*
Used w/ dynamic instantiation	Used with static instantiation
Ancestors of class Object	Ancestors of class Object
Can be extended by inheritance	Cannot be extended by inheritance
Can implement one or more interfaces	Can implement one or more interfaces
Can initialize fields with initializers	Cannot initialize fields with initializers
Can have a parameterless constructor	Cannot have a parameterless constructor

Reference Types

- A variable of reference type contains a reference to a memory location where data is stored (as pointers in C/C++).
- Direct inheritance from *Object.*
- Can implement many interfaces.
- Two predefined reference types in C#: String and Object.
  - E.g. string name = “John”;
  - Object, root of all types.

Value vs Reference Type

- If x and y are of value type, the assignment

x = y

- Copies the contents of y into x.
- If x and y are of reference type, the assignment

x = y

- Causes x to point to the same memory location as y.

Boxing and Unboxing

- Boxing is the conversion of a value type to a reference type. Unboxing is the opposite process.
- Using boxing, an int value can be converted to an object to be passed to a method (that takes an object as argument).

```
int n = 5;
object nObject = n;       //boxing
int n2 = (int) nObject;   //unboxing
```

Casting

- There are 2 ways of changing the type of a value in the program
  - *Implicit conversion* by assignment e.g.

```
short myShort = 5;
int myInt = myShort;
```

  - *Explicit conversion* using the syntax `(type)expression`

```
double myDouble = 4.7;
int myInt = (int)myDouble;
```

Nullable types

- Variables of reference type can have the value `null`, if they don't refer to anything.
- Variables of value type cannot have the value `null`, because they represent values.
- Sometimes it is useful to have a variable of value type that may have “no value”.
- To this end, a nullable type can be used:

```
int? i;
```

- Here, i is of type int, but may have the value `null`

Arrays

- C# supports one- and multi-dimensional arrays.
- One-dimensional array
  - Declaring:

    ```
    string[] names = new string[30];
    ```
  - Starts at index 0 up to index 29.
  - Accessing: `names[2] = “john”;`
- Multi-dimensional array
  - `int[,] numbers = new int[5,10];`

Some useful methods on arrays

`Length`

- Gives the number of elements in an array.

`Rank`

- Gives the number of dimensions of the array.

`GetLength(n)`

- Gives the number of elements in the n-th dimension

Jagged Arrays

- A jagged array is a multi-dimensional array, where the “rows” may have different sizes. It is declared like this

```
int [][] myJaggedArray = new int[4][];
```

- The rows are filled in separately

```
myJaggedArray[0] = new int[5];
```

- Access to array elements works like this:

```
myJaggedArray[0][2];
```

Decision Making

- The *if statement:*

If *(expression)*

statement 1

*[**else***

statement 2]

- The expression must evaluate to *bool.* If *expression* is true, flow of control is passed to *statement 1,* otherwise, control is passed to *statement 2.*
- Can have multiple else clauses (using *else if*).

Logical Operators

- For comparing values these operators exist:

==, !=, <=, >=, <, >

- **NB:** = is for assignment, not for equality test
- These operators combine boolean values:

&&, ||, !

- Operators over int and float: +, -, *, /, % (int only)
- A conditional expression is written like this:

boolean_expr ? expr_true : expr_false

Decision Making (cont'd)

- The switch statement.

```
switch (switch_expression)
{
    case constant-expression:
     statement
     jump statement
     .
     .
    case constant-expressionN:
     statementN
      jump statement
    [default]
}
```

Decision Making (cont'd)

- *Switch_expression* must be of type *sbyte, byte, short, ushort, int, uint, long, ulong, char or string.*
- Each *case clause* must include a *jump-statement (e.g. break statement)* apart from the last *case* in the switch.
- *Case clauses* can be combined by writing them directly one after the other.
- The *switch_expression* is evaluated and compared to each of the *constant-expressions.*
- On finding a match, control is passed to the first line of code in the matching *case* statement.
- If no match is found, control is passed to the *default clause.*

Iteration

- The while statement: boolean expression is evaluated before the *statement* is executed, which is iterated while the boolean expression remains true.

  while *(boolean_expression)*

  statement

- The do/while statement: boolean expression is evaluated after the *statement* is executed, which is iterated.

  do

  statement

  while *(boolean_expression)*

Iteration (cont'd)

- The for statement

for *(initialization; boolean_expression; step)*

statement

- The foreach statement
  - Specifically designed for the iteration over arrays and collections.

foreach *(type identifier* ***in*** *expression)*

statement

Functions

- Functions (or static methods) encapsulate common sequences of instructions.
- As an example, this function returns the n-th element of an array, e.g.

```
static int Get (int[] arr, int n) {
   return arr[n]; }
```

- This static method is called directly, e.g.

```
i = Get(myArr, 3);
```

- Exercise: check that n is in a valid range

Function Parameters

- All objects, arrays and strings are passed by reference, i.e. changes effect the argument that is passed to the function:

```
static void Set (int[] arr, int n, int x) {
  arr[n] = x; }
```

- But, value types are copied. The keyword ref is needed for passing by reference:

```
static void SetStep (int[] arr, ref int n, int x)
    {
      arr[n] = x;
      n += 1 ;
 }
```

Example: nullable types

```
public static int? Min(int[] sequence){
   int theMinimum;
   if (sequence.Length == 0)
     return null;
   else {
     theMinimum = sequence[0];
     foreach(int e in sequence)
       if (e < theMinimum)
          theMinimum = e;
   }
   return theMinimum;
 }
```

Discussion

- The type `int?` is a nullable int type.
- The value `null` of this type is used to indicate that there is no minimum in the case of an empty sequence.
- The method `HasValue` can be use to check whether the result is null:

```
int? min = Min(seq); if (min.HasValue) {…}
```

- The combinator `??` can be used to select the first non-`null` value:

```
min ?? 0
```

- Is `min`, if its value is non-null, 0 otherwise.

Example: nullable types (cont'd)

```
public static void ReportMinMax(int[] sequence){
    if (Min(sequence).HasValue && Max(sequence).HasValue)
      Console.WriteLine("Min: {0}. Max: {1}",
                        Min(sequence), Max(sequence));
    else
      Console.WriteLine("Int sequence is empty");
  }

  public static void Main(){
    int[] is1 = new int[] { -5, -1, 7, -8, 13};
    int[] is2 = new int[] { };

    ReportMinMax(is1);
    ReportMinMax(is2);
  }
```

Exercises

(a) Define weekday as an enumeration type and implement a NextDay method

(b) Implement a WhatDay method returning either WorkDay or WeekEnd (use another enum)

(c) Write a method calculating the sum from 1 to n, for a fixed integer value n

(d) Write a method calculating the sum over an array (one version with foreach, one version with explicit indexing)

Exercise (cont'd)

(a) Use the SetStep method to implement a method Set0, which sets all array elements to the value 0.

(b) Implement a method, reading via ReadLine, and counting how many unsigned short, unsigned int and unsigned long values have been read.

(c) Define complex numbers using structs, and implement basic arithmetic on them.

(d) Implement Euclid's greatest common divisor algorithm as a static method over 2 int parameters.

(e) **Implement matrix multiplication as a static method taking 2 2-dimensional arrays as arguments.**