ETH Zürich
Chair of Software Engineering

C# Programming in Depth

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March 2007 – May 2007

Lecture 6: Generics

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Overview

- Problems with untyped collections
- Generics
- Define generics
- Covariance

The problems with untyped collections

```
ArrayList list = new ArrayList();
double a;
list.Add(2);
a = (double)list[0];
```

Problems:

- Performence
- Type safety

```
.locals init ([0] class [mscorlib]System.Collections.ArrayList list,
         [1] float64 a)
...
newobj     instance void [mscorlib]System.Collections.ArrayList::.ctor()
...
box        [mscorlib]System.Int32
callvirt   instance int32 [mscorlib]System.Collections.ArrayList::Add(object)
...
callvirt   instance object
[mscorlib]System.Collections.ArrayList::get_Item(int32)
unbox.any  [mscorlib]System.Double
```

Generics

- Introduce the concept of type parameter
- Defer the specification of types until declaration or instantiation
- Avoid the cost of runtime boxing operation and type casts
- Avoid the risk of runtime casts
- Allow you to define a type-safe data structure or a utility helper class without committing to the actual data types used.

Generic namespace

Strongly typed collections

- Compare <T>
- Dictionary <K, T>
- SortedDictionary <K, T>
- List <T>
- Queue <T>
- Stack <T>

```
List<int> l = new List<int>();
double a;
l.Add(2);
a = list[0];
```

- No boxing and unboxing
- The compiler checks the type compatibility, if necessary, does implicit type conversion, otherwise reports errors

Define generic methods

access_mofifier return_type method_name <T> (arguments)

```
public static void Swap<T> (ref T a, ref T b)
{
    T temp;
     temp = a;
     a = b;
     b = temp;
}
```

```
static void Main (string[] args)
{
        int x, y;
        x = 0;
        y = 1;
        GenericClass.Swap(ref x, ref y);
}
```

Define generic classes

access_mofifier class_name <T> {: inheritance list}

```
public class Point<T>
{
    private T xPos;
    private T yPos;
    ...
    public Point (T xVal, T yVal)
    {
    ...
    }
    ...
}
```

default keyword in generic code

- In generic code, default keyword is used to set a type parameter to its default value
  - Numeric values have a default value of 0
  - Reference types have a default value of null

Creating a custom generic collection

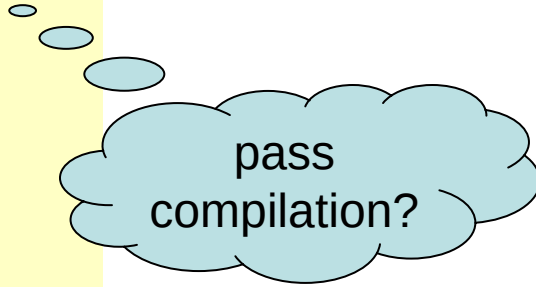
access_mofifier class_name <T> : IEnumerable <T>

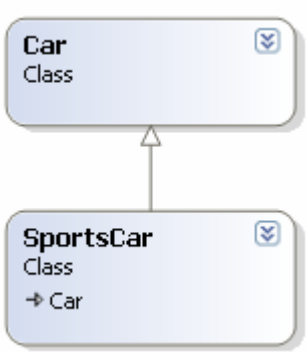
- IEnumerable<> extends the nongeneric IEnumerable interface
- The class that implements interface IEnumerable<T> should implement two versions of the GetEnumerator() method

```
public interface IPerson
{
        string Name { get;}
}
```

```
public class Person : IPerson
{
        private string _name;
        public Person()
        { }
        public string Name
        {
            get { return this._name; }
            set { this._name = value; }
        }
}
```

```
public static class PersonFactory
{
        public static List<IPerson> CreatePeople()
        {
            List<Person> people = new List<Person>();
            return people;
        }
 }
```






```
Car[] arrCar = new Car[10];
SportsCar[]  arrSportsCar = new SportsCar[10];
arrCar = arrSportsCar;
```

compiler error

```
List<Car> lCar = new List<Car>();
List<SportsCar> lSportsCar = new List<SportsCar>();
lCar = lSportsCar;
```

```
CarList<Car> colCar = new CarList<Car>();
CarList<SportsCar> colSportsCar = new CarList<SportsCar>();
colCar = colSportsCar;
```

compiler error

Covariance & Contravariance

substitution principle:

> any expression of type t can be substituted by an expression of type s if s ≤ t

(Here, ≤ denotes the subtype relationship)

- A covariant type operator in a type system preserves the ≤ ordering of types
- A contravariant type operator in a type system reverses the ≤ ordering of types

Subtyping relation for functional types

Contravariant rule (Cardelli [1998]):

if $T_1 \leq S_1$ and $S_2 \leq T_2$ then $S_1 \rightarrow S_2 \leq T_1 \rightarrow T_2$

- It sounds kind of counterintuitive
- It reflects the famous advice about the implementation protocols: "be liberal in what you accept, and conservative in what you send."
- It achieves the static type safety

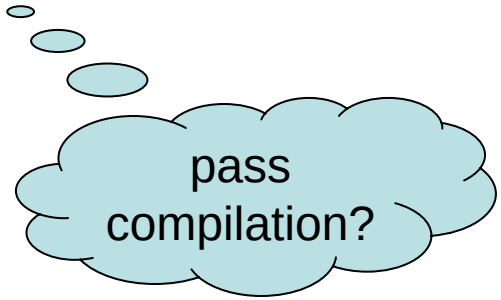
C# covariance

- Array of reference-types are covariant
  object[] b = new string[1];
- Array of value-types are invariant
  int[] is not a subtype of double[]
- Delegates are covariant
- Method overriding is not covariant

```
public delegate CarDelegate();

public static Car GetBasicCar()
{ return new Car(); }

public static SportsCar GetSportsCar()
{return new SportsCar();}
```

```
static void Main()
{
    CarDelegate targetA = new CarDelegate(GetBasicCar);
    Car c = targetA();

    CarDelegate targetB = new CarDelegate(GetSportCar);
    SportsCar sc = (SportsCar) targetB();
 }
```

```
class CarList<T>: IEnumerable<T>
{
        private List<T> arCars = new List<T>();
        ...
        public void PrintPetName(int pos)
        {
            Console.WriteLine(arCars[pos].Name);
        }
        ...
}
```



Type parameter constraints

Unbound generic

- when a type parameter is not constrained in any way, the generic type is said to be unbound

Bound generic

- use the keyword where to set the constraints of a generic type.
- the constraint list is placed after the generic type's base class and interface list.

Possible constraints for generic parameters

where T: struct

where T: class

where T: new ()

where T: NameOfBaseClass

where T: NameOfInterface

Examples

```
public class MyGenericClass<T> where T: new()
{ ... }

public class MyGenericClass<T> where T: class, IDrawable, new()
{ ... }

public class MyGenericClass<T> : MyBase, ISomeInterface
        where T: struct
{ ... }

public class MyGenericClass<K, T> where K: new()
        where T: IComparable<T>
```

Inherit generic class

- Generic class can be the base class to other classes
- If a nongeneric class inherits a generic class, the derived class must specify a type parameter
- If the derived type is generic as well, the child class can (optionally) reuse the type placeholder
- Any constraints placed on the base class must be honored by the derived type

```
public class MyList<T>
{
    ...
}

public class MyStringList: MyList<string>
{
    ...
}

public class MyList<T> where T: new()
{
    ...
}

public class MySubList<T> : MyList<T> where T: new()
{
    ...
}
```

Creating generic interface

```
public interface IBinaryOperations<T>
{
    T Add(T arg1, T arg2);
    T Subtract(T arg1, T arg2);

}
```

Creating generic delegates

```
public delegate void MyGenericDelegate<T> (T arg)
...
MyGenericDelegate<string> strTarget = new
MyGenericDelegate<string> (StringTarget);
```

Questions