COMP110: Principles of Computing

9: Data Structures II

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Generics in C#

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class PairOfInts
{
    public int first;
    public int second;

    public PairOfInts(int f, int s)
    {
        first = f;
        second = s;
    }
}
```

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```
class PairOfStrings
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    public string first;
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- However this doesn't let us impose type safety

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- `ElementType` can be any type

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```
Pair<int> p1 = new Pair<int>(12, 34);
Pair<string> p2 = new Pair<string>("hello", "world");
```

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class Pair<Type1, Type2>
{
    public Type1 first;
    public Type2 second;

    public PairOfObjects(Type1 f, Type2 s)
    {
        first = f;
        second = s;
    }
}
```

```
Pair<int, string> x = new Pair<int, string>(123, "hello");
```

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- Standard libraries in .NET and Unity make use of generics for e.g. collection types
- Similar to **templates** in C++

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Basic data structures in C#

Classes and interfaces

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- An interface is a little like a fully abstract class
- A class in C# can only **inherit** from one **class**, but can **implement** several **interfaces**

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- This interface allows us to iterate through the elements in the collection, from beginning to end
- C# provides the **`foreach`** loop as a convenient way of using this
- $\Longrightarrow$ any class which implements `IEnumerable<ElementType>` can be used with a **`foreach`** loop

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- Use `myArray.Length` to get the number of elements

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- Use `myArray.GetLength(0)`,`myArray.GetLength(1)` to get the "width" and "height"
- Similarly `int[,,]` is a 3-dimensional array, etc.

Lists

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using System.Collections.Generic;

List<int> myList = new List<int>();
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- Append elements with `myList.Add()`
- Get the number of elements with `myList.Count`

Strings

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- In particular, it implements `IEnumerable<char>`
- So for example we can iterate over the characters in a string:

```
foreach (char c in myString)
{
    Console.WriteLine(c);
}
```

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- C# has a **mutable** string type: `StringBuilder`

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- A dictionary maps **keys** to **values**
- Takes two generic parameters: the **key type** and the **value type**
- A dictionary is implemented as a **hash table**

Using dictionaries

```
var age = new Dictionary<string, int> {
    ["Alice"] = 23,
    ["Bob"] = 36,
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Access values using `[]`:

```
Console.WriteLine(age["Alice"]);  // prints 23
age["Bob"] = 40;          // overwriting an existing item
age["Denise"] = 21;       // adding a new item
age.Add("Emily", 29); // adding a new item -- will raise
                          // an error if already present
```

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foreach (var keyValue in age)
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    Console.WriteLine("{0} is {1} years old",
                      kv.Key, kv.Value);
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- (C# tip: the `var` keyword lets the compiler automatically determine the appropriate type to use for a variable)
- Dictionaries are **unordered** — avoid assuming that `foreach` will see the elements in any particular order!

Hash sets

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- `HashSet`s are like `Dictionary`s without the values, just the keys
- As discussed in Week 5, certain operations are much more efficient (constant time) on hash sets than on lists

Using sets

```
var numbers = new HashSet<int>{1, 4, 9, 16, 25};
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Add and remove members with `Add` and `Remove` methods

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Test membership with `Contains`

```
if (numbers.Contains(9))
    Console.WriteLine("Set contains 9");
```

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- In C#: `LinkedList<ElementType>`

Operations on linked lists

Linked lists vs array-backed lists

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- **Finding the *i*th element** of an array list is simple pointer arithmetic, which is $O(1)$
- In a linked list we have to count along the "next" pointers, which is $O(i)$
- So which data structure is more efficient? It depends what operations we need to do more often

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- Reconvene here at **5:45pm** to compare notes