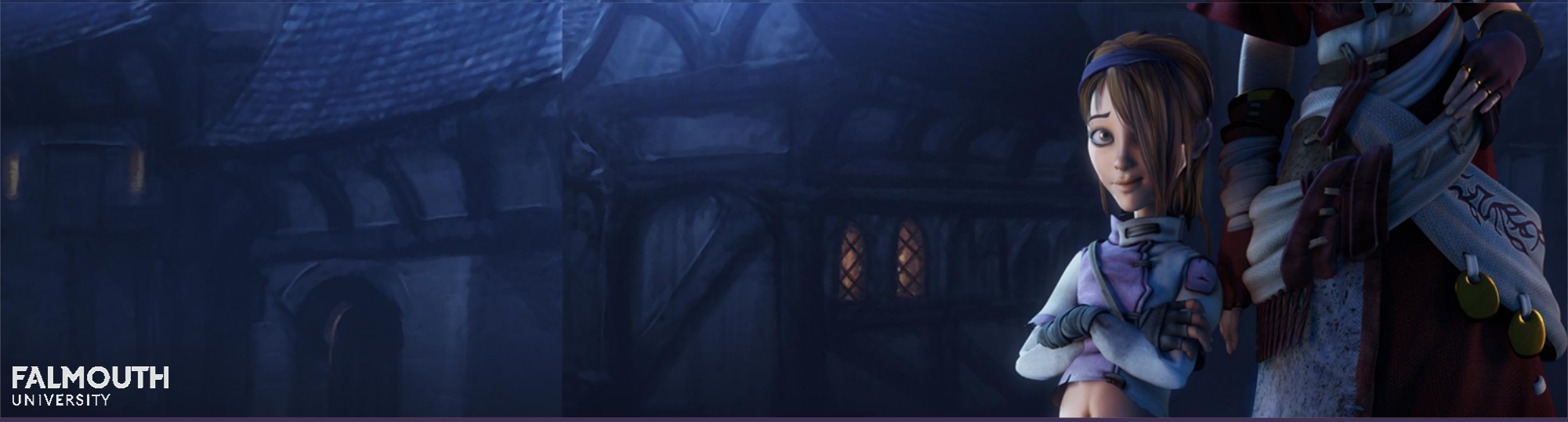

COMP110: Principles of Computing

9: Data Structures II

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Worksheet 6

Due **Monday 25th November**

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Generics in C#

The problem

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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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- To store a pair of `string`s we would need another class:

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

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class Pair<ElementType>
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- `ElementType` can be any type

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```
Pair<int> pairOfInts = new Pair<int>(12, 34);
Pair<string> pairOfStrings = new Pair<string>("hello", ↩
    "world");
```

Multiple parameters

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class Pair<Type1, Type2>
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    {
        first = f;
        second = s;
    }
}
```

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

Why generics?

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- Generics let us write type safe code which can be adapted to data of different types
- Standard libraries in .NET and Unity make use of generics for e.g. container 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**

IEnumerable

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- Anything implementing `IEnumerable` can be iterated over with a `foreach` loop

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- Use `myArray[i]` to get/set the `i`th element (starting at 0)
- Use `myArray.Length` to get the number of elements

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- Use `myArray[x, y]` to get/set elements
- 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;

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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>`

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- Hence building a long string by appending can be slow (appending strings is $O(n)$)
- C# has a **mutable** string type: `StringBuilder`

Dictionaries

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- A dictionary maps **keys** to **values**
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- A dictionary is implemented as a **hash table**

Using dictionaries

```
var age = new Dictionary<string, int> {
    ["Alice"] = 23,
    ["Bob"] = 36,
    ["Charlie"] = 27
};
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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 -- error if ↩
     already present
```

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foreach (var kv in age)
{
    Console.WriteLine("{0} is {1} years old", kv.Key,
        kv.Value);
}
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        kv.Value);
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- (Note the `var` keyword — automatically determines 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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Operation	List	Hash Set
Add element	Append: $O(1)$ Insert: $O(n)$	$O(1)$
Delete element	$O(n)$	$O(1)$
Contains element?	$O(n)$	$O(1)$

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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numbers.Add(36);
numbers.Remove(4);
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```

Test membership with `Contains`

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

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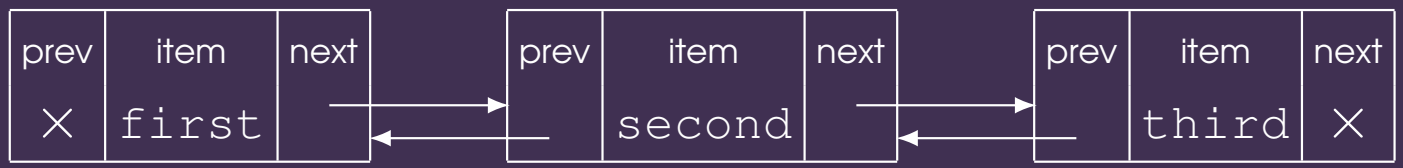

- In C#: `LinkedList<ElementType>`

Linked lists vs arrays

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- **Copy and experiment** with the sample code provided to ensure that you understand these data structures