COMP110: Principles of Computing

8: Data Structures I

Administration

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- Final deadline is **soon (check MyFalmouth)**

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Arrays and lists

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- The program owns that block until it frees it
- Blocks can be allocated and deallocated at will, but can **never grow or shrink**

Collection types

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  - Hide the details of memory allocation, and allow the programmer to write simpler code
- Collections are an **encapsulation**
  - Bundle together the data's representation in memory along with the algorithms for accessing it

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- Accessing an array element is **constant time** $O(1)$

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- A **list** is a variable size array
- When the list needs to change size, it **creates** a new array, **copies** the contents of the old array, and **deletes** the old array

Arrays and lists in C#

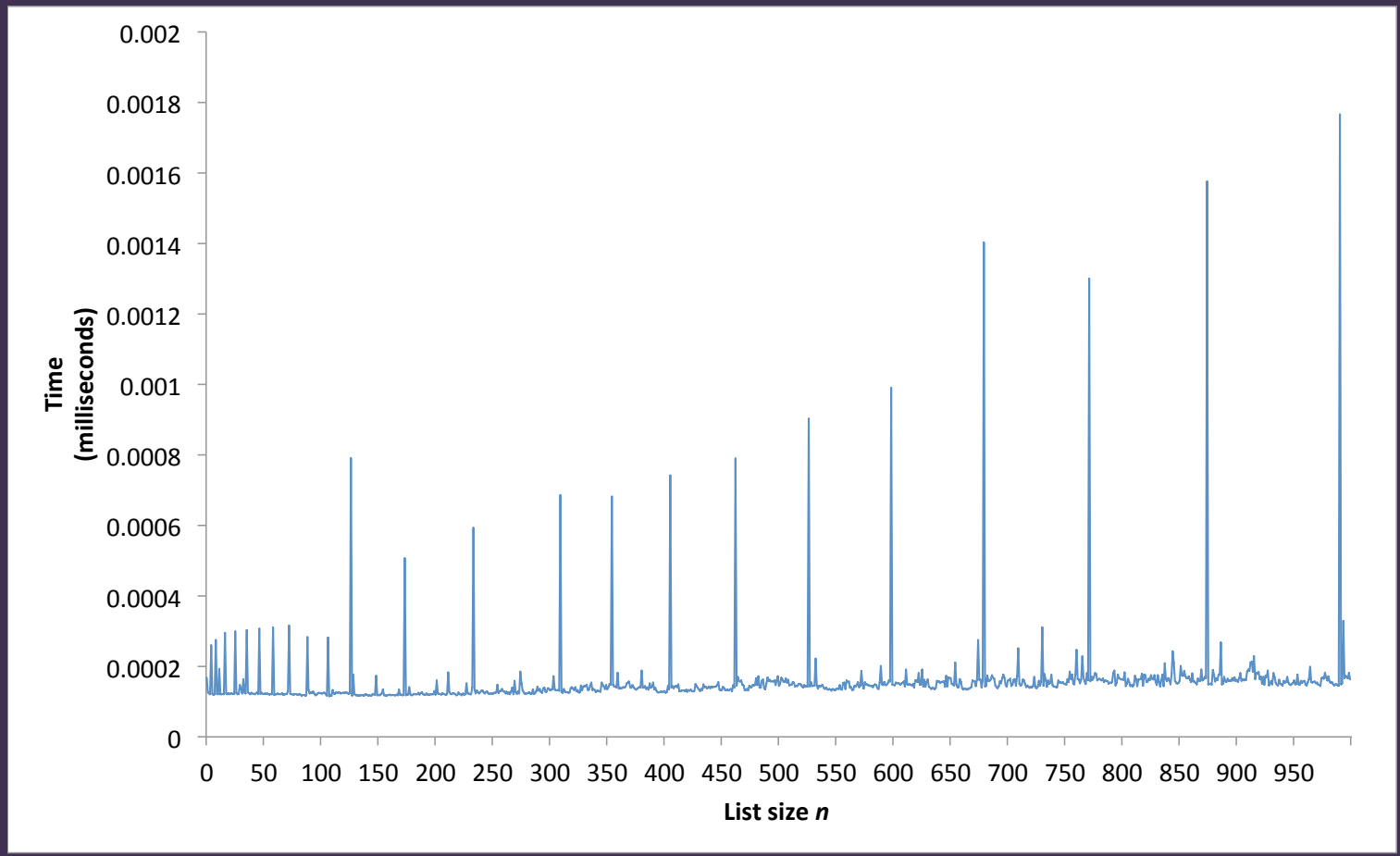
```
int[] myArray = new int[10];

int[] myOtherArray = new int[] { 2, 3, 5, 7, 11 };

List<int> myList = new List<int>();

List<int> myOtherList = new List<int> { 2, 3, 5, 8, 13 };
```

Time taken to append an element to a list of size *n*



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  - Can't just insert new bytes into a memory block — need to move all subsequent list elements to make room
- Similarly, **deleting** anything other than the last element is **linear time**

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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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- Similarly `int[,,]` is a 3-dimensional array, etc.

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- Get the number of elements with `myList.Count`

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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 is implemented as a **hash table**

Using dictionaries

```
var age = new Dictionary<string, int> {
    ["Alice"] = 23,
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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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- (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

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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);
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Test membership with `Contains`

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

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- Enqueue using `Insert(0, x)` — $O(n)$ complexity

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- C# has `Stack` and `Queue` classes which you should use instead of trying to use a list
- Python has `deque` (double-ended queue) which can work as either a stack or a list

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- Hence the term **stack trace** when using the debugger or looking at error logs