Module 05:

"Tips 'n Tricks"

Agenda

- Introduction
- **Exceptions**
- Pattern Matching
- Collections
- LINQ
- Extensions
- Spans and Performance
- Tuples and Records
- Diagnostics and Debugging
- Summary

Exception Filters

- Exception filters facilitates the handling of exceptions matching a specific type and/or predicate

```
try
{
    Bank.TransferFunds(from, 200, to);
}
catch (InsufficientFundsException e) when (e.Account.IsVIP)
{
    // Handle VIP account
}
```

- Distinct clauses can match same exception type but with different conditions
- Pattern matching <3 <3 <3

Rethrowing Exceptions

```
try { ... }
catch (DivideByZeroException exception)
{
    throw exception;
}
```

or

```
try { ... }
catch (DivideByZeroException)
{
    throw;
}
```

.NET 6 Shorthands

- Keep an eye out for convenience methods being added as .NET evolves ☺

```
public class EmployeeRepository : IEmployeeRepository
{
    private readonly IList<Employee> _employees;
    ...
    public void Add(Employee employee)
    {
        ArgumentNullException.ThrowIfNull(employee);

        _employees.Add(employee);
    }
}
```

Throw Expressions

- In C# 6 one could not easily just throw an exception in an expression-bodied member
- C# 7 allows **`throw`** expressions as subexpressions
  - Also outside of expression-bodied members..!

```
public class EmployeeRepository : IEmployeeRepository
{
    private readonly IList<Employee> _employees;
    ...
    public void Add( Employee employee ) =>
        _employees.Add(employee ??
            throw new ArgumentNullException(nameof(employee)));
}
```

- Note that a **`throw`** expression does not have an expression type as such…

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To Be or Not To Be Null

- At last(!) we are allowed both positive and negative pattern assertions

```
Person p = new() { ...};

if (p is null)
{
    Console.WriteLine("p is null");
}
else
{
    Console.WriteLine("p is not null");
}
```

- This is in fact superior to ==

Positional Patterns

- Positional patterns use deconstructors for matching

```
Album album = new Album(
    "Depeche Mode",
    "Violator",
    new DateTime(1990, 3, 19)
);

string description = album switch
{
    Album(_, string s, int age) when age >= 25 => $"{s} is vintage <3",
    Album(_, string s, int age) when age >= 10 => $"{s} is seasoned",
    Album(_, string s, _) => $"{s} is for youngsters only! ;-)"
};
```

- Can be simplified using `var`

The Edge of Pattern Matching?

- What to do if pattern matching is clumsy and essentially “fails”?

```
List<object> mixOfObjects = new() { true, 87, "Hello World", 176.0 };

foreach (object o in mixOfObjects)
{
    // Perform distinct handling depending upon the runtime type of o
}
```

- Answer: **`dynamic`** to the rescue…! ☺

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PriorityQueue in System.Collection.Generic

- "New Collection on the Block" in .NET 6

```
PriorityQueue<Connection, TimeOnly> pq = new();
pq.Enqueue(new Connection("vm-dev-1"), new TimeOnly(15, 57, 46, 231));

while (pq.TryDequeue(out Connection? conn, out TimeOnly time))
{
    Console.WriteLine($"{conn} last connected at {time.ToLongTimeString()}");
}
```

- Implements the classical "Min-Heap" priority queue
  - Dequeues highest priority element
  - Can supply own priority and comparer if needed

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LINQ Additions in .NET 6 Overview

- **`ElementAt<T>`** and **`ElementAtOrDefault<T>`**
  - New support for **`Index`**
- **`Take<T>`**
  - New support for **`Range`**

- ***`Xxx`*`OrDefault<T>`**
  - New support for supplying default
- **`Zip<T>`**
  - New support for three enumerables

- New **`Chunk<T>`** method
- New **`DistinctBy<T>`**, **`MinBy<T>`** and **`MaxBy<T>`** methods
- New **`UnionBy<T>`**, **`IntersectBy<T>`**, and **`ExceptBy<T>`**
- New **`TryGetNonEnumeratedCount<T>`**

LINQ Additions in .NET 6 for Movie Lovers ☺

```
IEnumerable<Movie> movies = new List<Movie>
{
    new("Total Recall", 2012, 6.2f),
    new("Evil Dead", 1981, 7.5f),
    new("The Matrix", 1999, 8.7f),
    new("Cannonball Run", 1981, 6.3f),
    new("Star Wars: Episode IV - A New Hope", 1977, 8.6f),
    new("Don't Look Up", 2021, 7.3f),
    new("Evil Dead", 2013, 6.5f),
    new("Who Am I", 2014, 7.5f),
    new("Total Recall", 1990, 7.5f),
    new("The Interview", 2014, 6.5f)
};
```

“List the 20th to 30th Fibonacci Number which 4 divides”

- `Fib(1) = 1`
- `Fib(2) = 1`
- `Fib(i) = Fib(i-2) + Fib(i-1)` for `i > 2`

- Everybody loves LINQ, but…

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C# 3: "Good old" Extension Methods

- C# 3 introduced extension methods with LINQ

```
static class DateTimeExtensions
{
    public static string ToMyTimestamp(this DateTime dt) =>
        dt.ToString("yyyy-MM-dd HH:mm:ss.fff");
}
```

- Compiler allows syntactic sugar to "preserve illusion" that method is invoked on the extended type itself

```
DateTime dt = DateTime.Now;
Console.WriteLine(dt.ToMyTimestamp());
```

Extending Interfaces is Very Powerful!

- LINQ works by extending **`IEnumerable<T>`**

```
static class EnumerableExtensions
{
    public static IEnumerable<T> Sample<T>(
        this IEnumerable<T> sequence,
        int frequency
    )
    { ... }
}
```

- *Any* sequence now has this capability…
- "Roll you own LINQ"

C# 6: Collection Initializer Extensions

- Collection initializers work if
  - Type implements `IEnumerable<T>`
  - Type has an `Add()` method
- But what about `Queue<T>`, `Stack<T>`, …, custom types from libraries?
- C# 6 answered our prayers by *extension collection initializers*..!

C# 9 Extension Enumerables

- In C# 9 it is possible to create an "extension implementation" of **IEnumerable<T>** for a third-party type
  - **foreach** now respects extension **GetEnumerator<T>** methods

```
static class SequenceExtensions
{
    public static IEnumerator<T> GetEnumerator<T>( this Sequence<T> t )
    {
        SequenceElement<T>? current = t.Head;
        while (current != null)
        {
            yield return current.Data;
            current = current.Next;
        }
    }
}
```

C# 7 Extension Deconstructors

- A perfect companion to pattern matching third-party type:

```
static class MyPersonExtensions
{
    public static void Deconstruct(this Person person,
        out int length, out string fullName)
    {
        fullName = $"{person.FirstName} {person.LastName}";
        length = fullName.Length;
    }
}
```

- Excellent for constructing custom, reusable query pattern matches

Supported Types

`string`	Indices	Ranges
`Array`	Indices	Ranges
`List<T>`	Indices	
`Span<T>`	Indices	Ranges
`ReadOnlySpan<T>`	Indices	Ranges

- Any type that provides an indexer with a `System.Index` or `System.Range` parameter (respectively) explicitly supports indices or ranges
  - Not possible via extension methods, however
- Compiler will implement some implicit support for indices and ranges

Example: Custom Data Structure

- `SequencePacker<T>` stores sequences of elements of type T in a compressed form. More precisely, the sequence

  42 87 87 87 87 11 22 22 87 99

- is stored internally as a list of `Node<T>` elements as follows:

  (**42**,1) (**87**,4) (**11**,1) (**22**,2) (**87**,1) (**99**,1)

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Span<T> and ReadOnlySpan<T>

- Ref-like types to avoid allocations on the heap
  - Don't have own memory but points to someone else's
  - Essentially: "ref for sequence of variables"

```
int[] array = new int[10];
...
Span<int> span = array.AsSpan();
Span<int> slice = span.Slice(2, 5);
foreach (int i in slice)
{
    Console.WriteLine( i );
}
```

```
string s = "Hello, World";
ReadOnlySpan<char> span = s.AsSpan();
ReadOnlySpan<char> slice =
   span.Slice(7, 5);
foreach (char c in slice)
{
    Console.Write(c);
}
```

Performance Results

Method	Mean	Error	StdDev	Ratio	Rank	Gen0	Allocated	Alloc Ratio
UsingSpans	110.9 ns	2.22 ns	4.53 ns	0.58	1	-	-	0.00
UsingArrays	191.3 ns	3.84 ns	8.34 ns	1.00	2	0.0336	424 B	1.00

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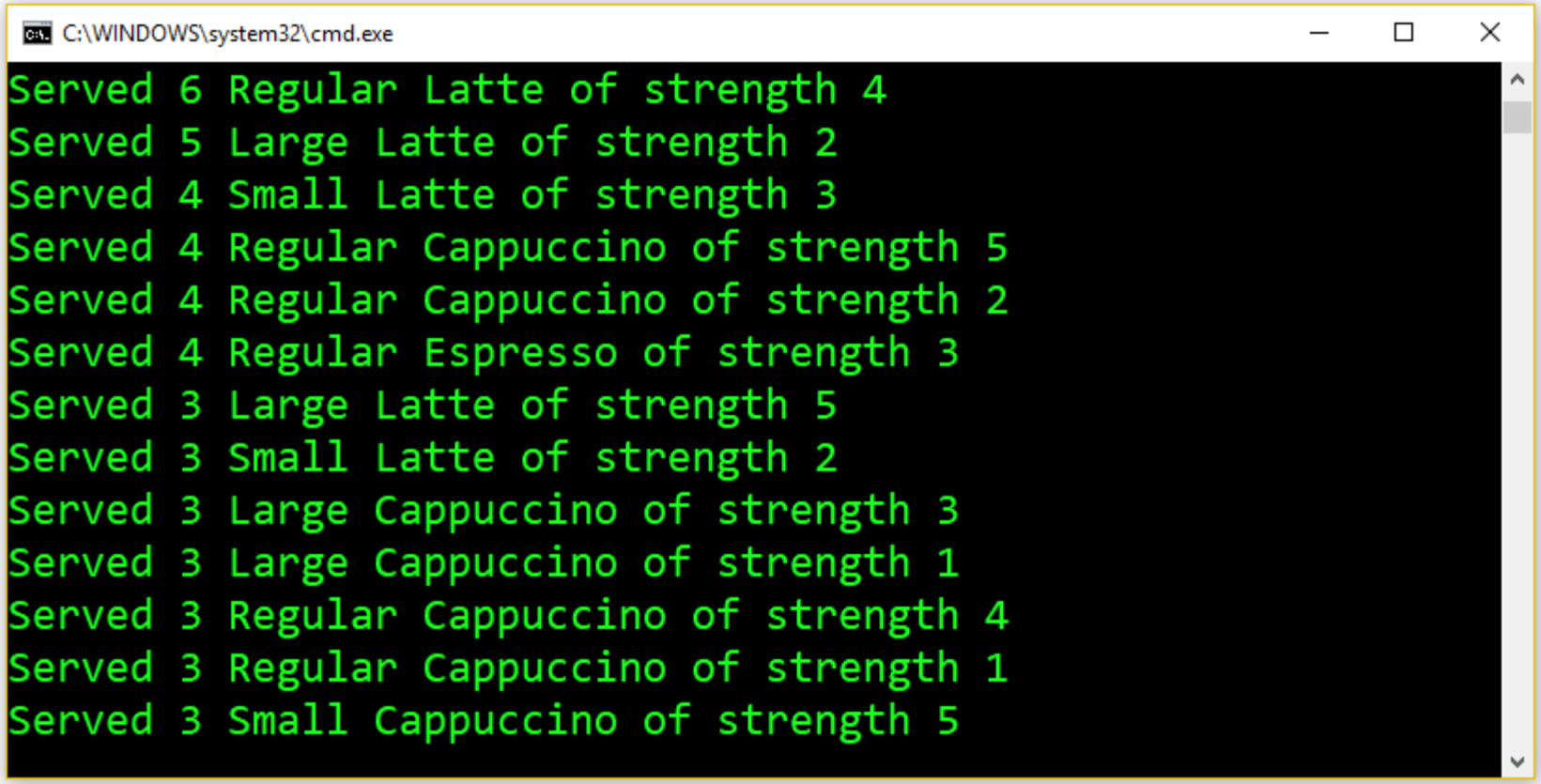
Dictionary Problems?

- Do a `PrintSummary()` method which provides a summary like:



Solution: Records as Keys

- Define a `PrintSummary()` method outputting a number of strings to the console as illustrated, i.e.:
  - Sort *first* by the count of specific coffee combinations served (from high to low)
  - Sort *secondly* by kind (from first to last)
  - Sort *thirdly* by size within that kind (from largest to smallest)
  - Use the strength as the *final* sort criterion (from strongest to weakest).

Use Records for DTOs and Value Objects

- We already saw records as value objects earlier

- For DTOs in e.g. ASP.NET Core Web API (or similar):
  - Make request DTOs records
    - Allows comparing requests easily
    - Required properties play well with request serialization
  - Make response DTOs records

Are Tuples Dead Then…?

- Errr… Yes, but no ☺

- Tuples for deconstructions
- Tuples for "full" expression-bodied members
  - E.g. constructors
- Tuples for swapping etc.
- Tuples replacing anonymous methods in LINQ

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Caller Info Attributes Revisited

- C# 5.0 introduced three types of caller info attributes
  - [CallerMemberName]
  - [CallerFilePath]
  - [CallerLineNumber]

```
void Log(
     [CallerMemberName] string? callerName = null,
     [CallerFilePath] string? callerFilePath = null,
     [CallerLineNumber] int callerLine = -1
)
{ ... }
```

- Applicable to default parameters
  - Compiler replaces values at compilation time

Caller Argument Expressions

- C# 10 adds a `CallerArgumentExpression` attribute

```
void Validate( bool condition,
    [CallerArgumentExpression("condition")] string? message = null)
{
    if (!condition)
    {
        throw new InvalidOperationException(
            $"Argument failed validation: {message}"
        );
    }
}
```

- Excellent for developer-centric logs etc.

Controlling Appearance in Debugger

- Many interesting way of visualizing data

- Easy-to-use and very simple are:
  - Overriding **`ToString()`**
  - **`[DebuggerDisplay]`**
    - **`nq`**

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