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Exception Handling

Handling Errors during the Program Execution

C# Advanced

Telerik Software Academy

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What are Exceptions?

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What are Exceptions?

- The `exceptions` in .NET Framework are classic implementation of the OOP exception model
- Deliver powerful mechanism for centralized handling of errors and unusual events
- Substitute procedure-oriented approach, in which each function returns error code
- Simplify code construction and maintenance
- Allow the problematic situations to be processed at multiple levels
- Read more about exception handling in general on wikipedia

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Handling Exceptions

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Handling Exceptions

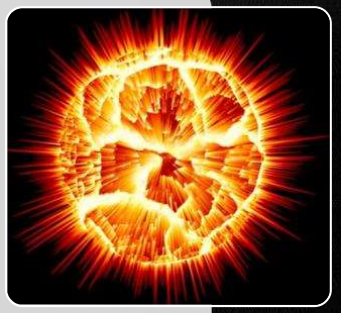
- In C# the exceptions can be handled by the `try-catch-finally` construction

```
try
{
    // Do some work that can raise an exception
}
catch (SomeException)
{
    // Handle the caught exception
}
```

- `catch` blocks can be used multiple times to process different exception types

Handling Exceptions – *Example*

```
static void Main()
{
  string s = Console.ReadLine();
  try
  {
    int.Parse(s);
    Console.WriteLine("Valid integer number {0}.", s);
  }
  catch (FormatException)
  {
    Console.WriteLine("Invalid integer number!");
  }
  catch (OverflowException)
  {
    Console.WriteLine("The number is too big for int!");
  }
}
```



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Handling Exceptions

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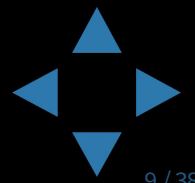
The System.Exception Class

- Exceptions in .NET are objects
- The `System.Exception` class is base for all exceptions in CLR
  - Contains information for the cause of the error / unusual situation in the form of the following properties:
    - `Message` – text description of the exception
    - `StackTrace` – the snapshot of the stack at the moment of exception throwing
    - `InnerException` – exception that caused the current exception (if any)



Exception Properties – *Example*

```
class ExceptionsExample
{
  public static void CauseFormatException()
  {
    string s = "an invalid number";
    int.Parse(s);
  }

  static void Main()
  {
    try
    {
      CauseFormatException();
    }
    catch (FormatException fe)
    {
      Console.Error.WriteLine("Exception: {0}\n{1}",
                              fe.Message, fe.StackTrace);
    }
  }
}
```

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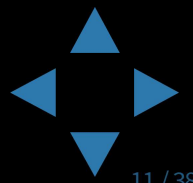
Exceptions Properties

- The `Message` property gives brief description of the problem
- The `StackTrace` property is extremely useful when identifying the reason caused the exception

```
Exception caught: Input string was not in a correct format.
   at System.Number.Parseint(String s, NumberStyles style, NumberFormatInfo i
   at System.int.Parse(String s)
   at ExceptionsTest.CauseFormatException() in c:\consoleapplication1\excepti
   at ExceptionsTest.Main(String[] args) in c:\consoleapplication1\exceptions
```

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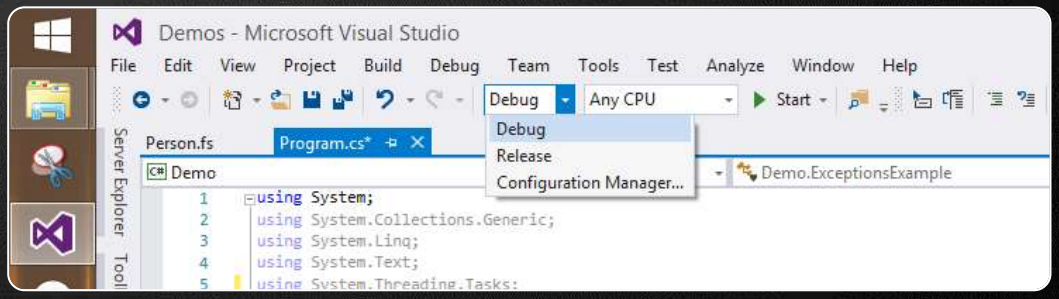
Exception Properties

- File names and line numbers are accessible only if the compilation was in Debug mode
- When compiled in Release mode, the information in the property StackTrace is quite different:

```
Exception caught: Input string was not in a correct format.
   at System.Number.Parseint(String s, NumberStyles style, NumberForm
   at ExceptionsTest.Main(String[] args)
```



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Exceptions Properties

Demo

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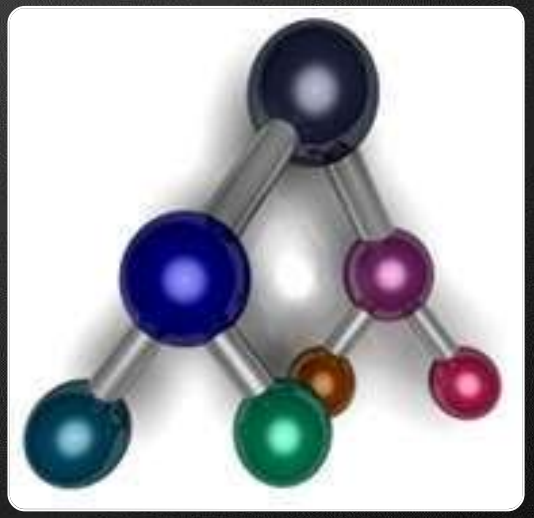
The Hierarchy of Exceptions



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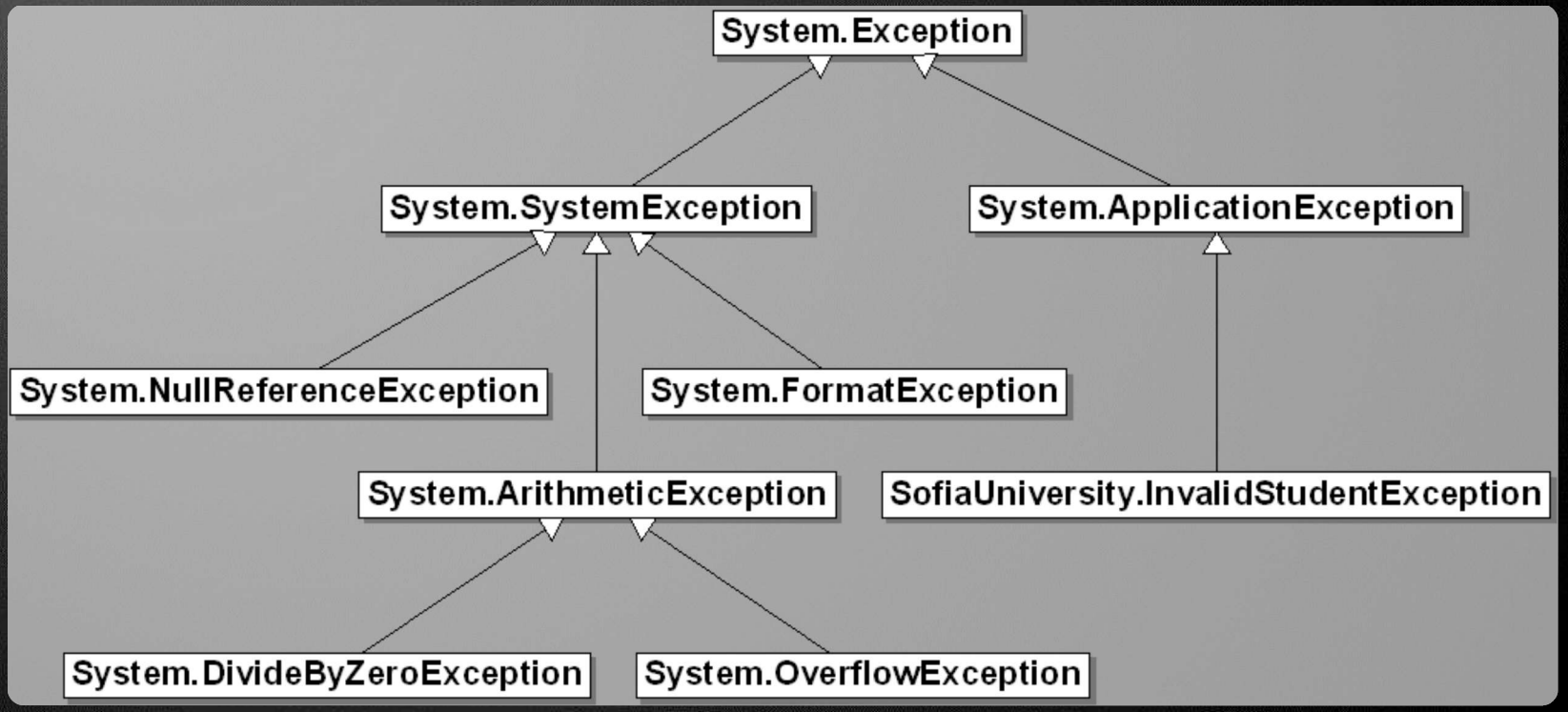
Exceptions Hierarchy

- Exceptions in .NET Framework are organized in a hierarchy



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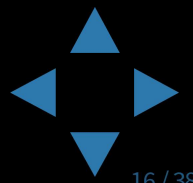
Types of Exceptions

- .NET exceptions inherit from `System.Exception`
- The system exceptions inherit from `System.SystemException`, e.g.
  - `System.ArgumentException`
  - `System.NullReferenceException`
  - `System.OutOfMemoryException`
  - `System.StackOverflowException`
- User-defined exceptions should inherit from `System.Exception` (more info)



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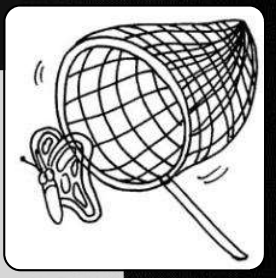
Handling Exceptions

- When catching an exception of a particular class, all its inheritors (child exceptions) are caught too
- *Example*:



```
try
{
  // Do some works that can cause an exception
}
catch (System.ArithmeticException)
{
    // Handle the caught arithmetic exception
}
```

- Handles `ArithmeticException` and its descendants `DivideByZeroException` and `OverflowException`

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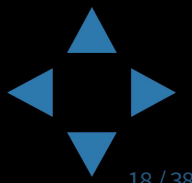
Find the Mistake!

```
static void Main()
{
    string s = Console.ReadLine();
    try
    {
        int.Parse(s);
    }
    catch (Exception) // this catch should come last
    {
        Console.WriteLine("Can not parse the number!");
    }
    catch (FormatException) // unreachable block
    {
        Console.WriteLine("Invalid integer number!");
    }
    catch (OverflowException) // unreachable block
    {
        Console.WriteLine("The number is too big to fit in int!");
    }
}
```

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Handling All Exceptions

- All exceptions thrown by .NET managed code inherit the `System.Exception` exception
- Unmanaged code can throw other exceptions
- For handling all exceptions (even unmanaged) use the construction:

```
try
{
    // Do some works that can raise any exception
}
catch
{
    // Handle the caught exception
}
```

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Throwing Exceptions

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Throwing Exceptions

- Exceptions are thrown (raised) by `throw` keyword in C#
  - Used to notify the calling code in case of error or unusual situation
- When an exception is thrown:
  - The program execution stops
  - The exception travels over the stack until a suitable `catch` block is reached to handle it
- Unhandled exceptions display error message

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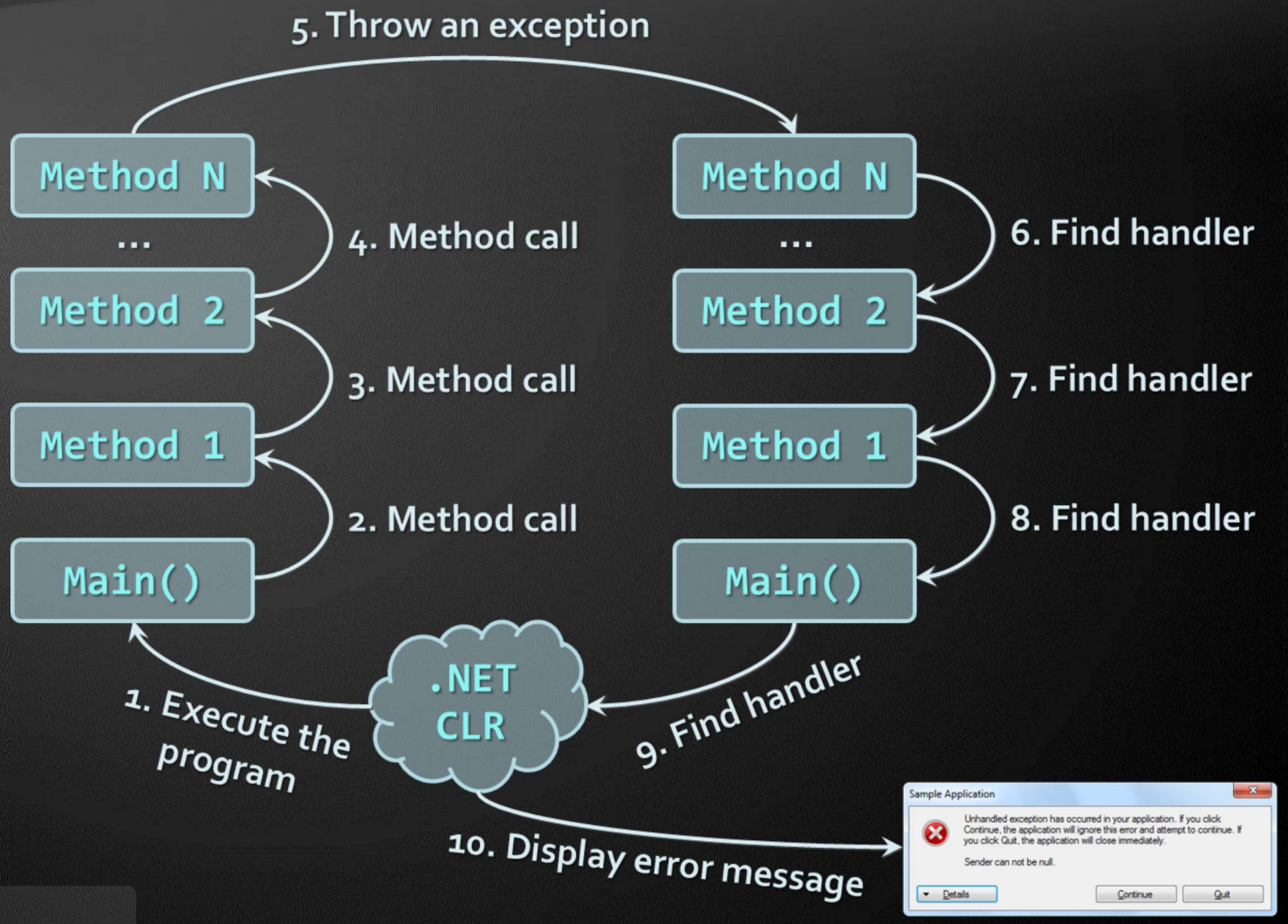
How Exceptions Work?



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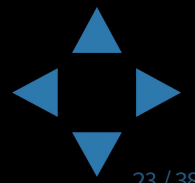
Using throw Keyword

- Throwing an exception with an error message:

```
throw new ArgumentException("Invalid amount!");
```

- Exceptions can accept message and cause:
- *Note*: if the original exception is not passed the initial cause of the exception is lost

```
try
{
  int.Parse(str);
}
catch (FormatException fe)
{
  throw new ArgumentException("Invalid number", fe);
}
```

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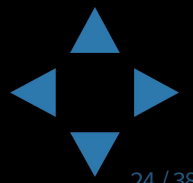
Re-Throwing Exceptions

- Caught exceptions can be re-thrown again:

```
try
{
    int.Parse(str);
}
catch (FormatException fe)
{
    Console.WriteLine("Parse failed!");
    throw fe; // Re-throw the caught exception
}
```

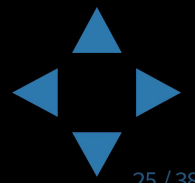
```
catch (FormatException)
{
    throw; // Re-throws the last caught exception
}
```



Telerik Academy Throwing Exceptions – *Example*

```
public static double Sqrt(double value)
{
    if (value < 0)
        throw new System.ArgumentOutOfRangeException(
            "Sqrt for negative numbers is undefined!");

    return Math.Sqrt(value);
}
static void Main()
{
    try
    {
        Sqrt(-1);
    }
    catch (ArgumentOutOfRangeException ex)
    {
        Console.Error.WriteLine("Error: " + ex.Message);
        throw;
    }
}
```

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Throwing Exceptions

Demo

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Choosing the Exception Type

- When an invalid parameter is passed to a method:
  - `ArgumentException`, `ArgumentNullException`, `ArgumentOutOfRangeException`
- When requested operation is not supported
  - `NotSupportedException`
- When a method is still not implemented
  - `NotImplementedException`
- If no suitable standard exception class is available
  - Create own exception class (inherit `System.Exception`)

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Using Try-Finally Blocks

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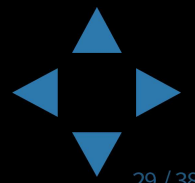
The try-finally Statement

- The statement:

```
try
{
    // Do some work that can cause an exception
}
finally
{
    // This block will always execute
}
```

- Ensures execution of given block in all cases
  - When exception is raised or not in the `try` block
- Used for execution of cleaning-up code, e.g. releasing resources



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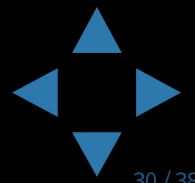
try-finally – *Example*

```
static void TestTryFinally()
{
  Console.WriteLine("Code executed before try-finally.");

  try
  {
    int.Parse(Console.ReadLine());
    Console.WriteLine("Parsing was successful.");
    return; // Exit from the current method
  }
  catch (FormatException)
  {
    Console.WriteLine("Parsing failed!");
  }
  finally
  {
    Console.WriteLine("This cleanup code is always executed.");
  }

  Console.WriteLine(
    "This code is after the try-finally block.");
}
```



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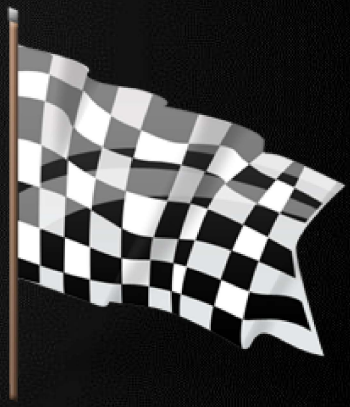
try-finally

Demo



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Exceptions: Best Practices

Don't be a codemonkey!

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Exceptions – Best Practices

- `catch` blocks should begin with the exceptions lowest in the hierarchy
  - And continue with the more general exceptions
  - Otherwise a compilation error will occur
- Each `catch` block should handle only these exceptions which it expects
  - If a method is not competent to handle an exception, it should be left unhandled
  - Handling all exceptions disregarding their type is popular bad practice (anti-pattern)!

Telerik Academy Exceptions – Best Practices

- When raising an exception always pass to the constructor good explanation message
- When throwing an exception always pass a good description of the problem
  - `Exception message` should explain what causes the problem and how to solve it
  - Good: "Size should be integer in range [1…15]"
  - Good: "Invalid state. First call Initialize()"
  - Bad: "Unexpected error"
  - Bad: "Invalid argument"

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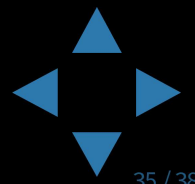
Exceptions – Best Practices

- Exceptions can decrease the application performance
  - Throw exceptions only in situations which are really `exceptional` and should be handled
  - Do not throw exceptions in the normal program control flow (e.g. for invalid user input)
- CLR could throw exceptions at any time with no way to predict them
  - E.g. `System.OutOfMemoryException`



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Summary

- Exceptions provide flexible error handling mechanism in .NET Framework
  - Allow errors to be handled at multiple levels
  - Each exception handler processes only errors of particular type (and its child types)
    - Other types of errors are processed by some other handlers later
  - Unhandled exceptions cause error messages
- Try-finally ensures given code block is always executed (even when an exception is thrown)

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Exception Handling

Questions?