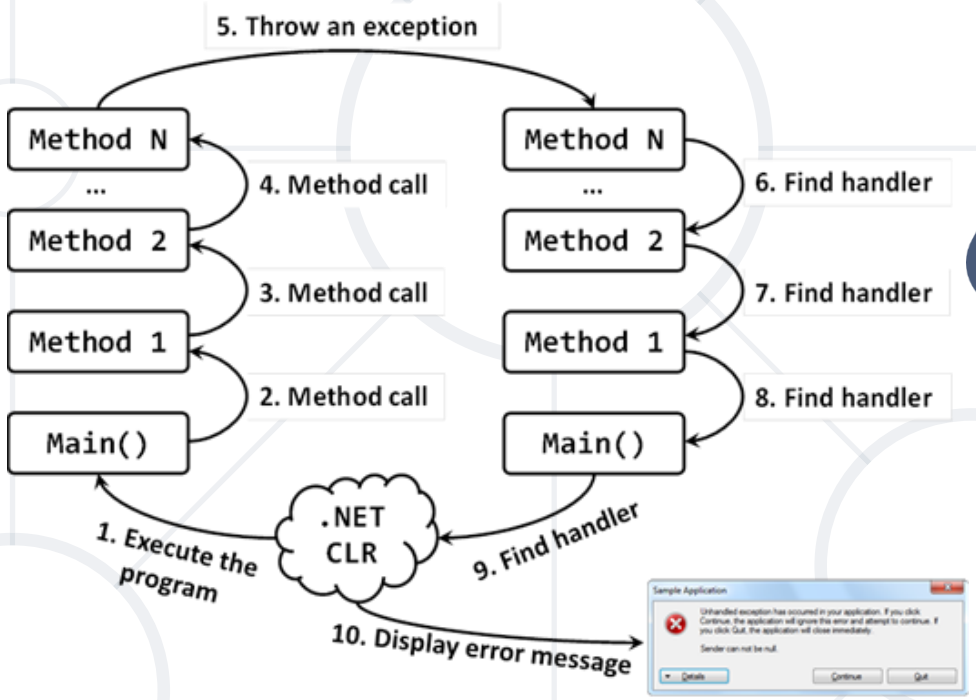
Exception Handling

Handling Errors During the Program Execution



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What Are Exceptions?

What Are Exceptions?

- **Exceptions** handle errors and problems at runtime
- **Throw** an exception to signal about a problem

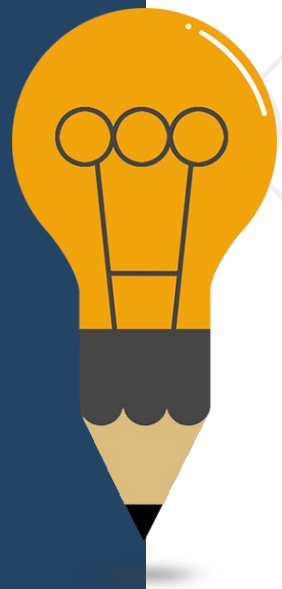
```
if (size < 0)
   throw new Exception("Size cannot be negative!");
```

- **Catch** an exception to handle the problem

```
try {
   size = int.Parse(text);
} catch (Exception ex) {
   Console.WriteLine("Invalid size!");
}
```

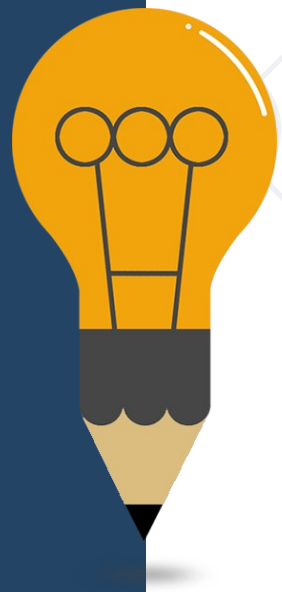
How Do Exceptions Work?

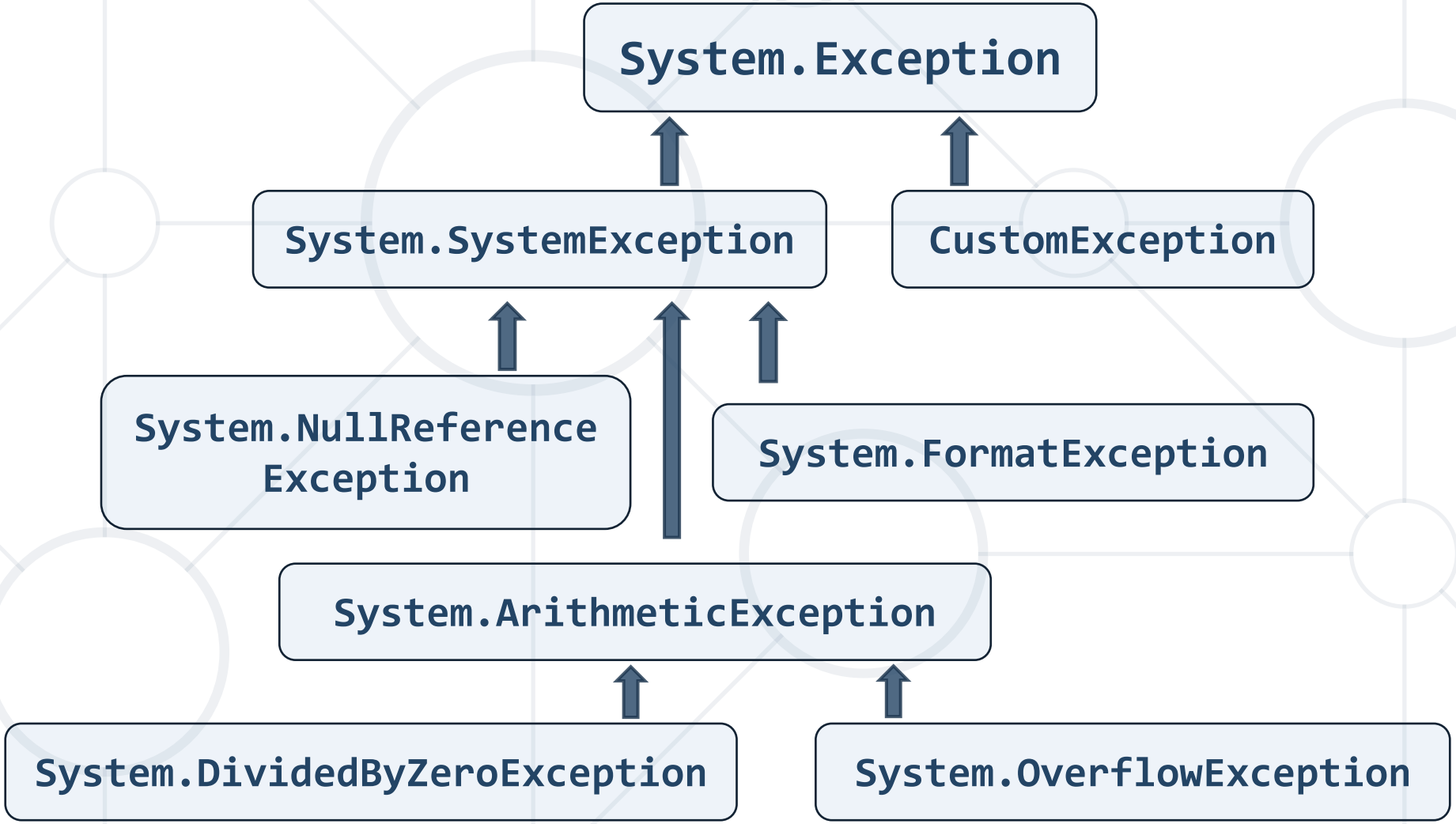
The System.Exception Class



- Exceptions in C# are **objects**
- The **System.Exception** class is a base for all exceptions in CLR
  - Holds information about the **error**
  - **Message** – a 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 Hierarchy in .NET



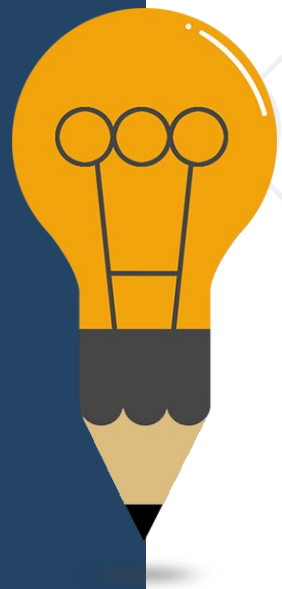


Handling Exceptions

Handling Exceptions

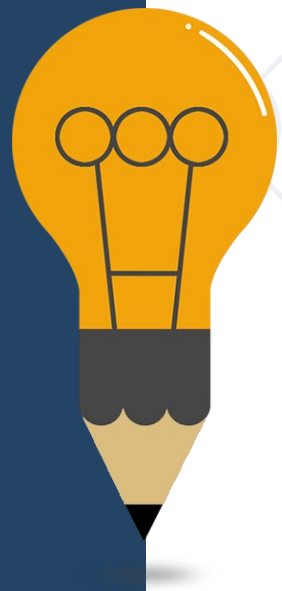
- In C# exceptions can be handled by the `try-catch` construction

```
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

Multiple Catch Blocks – Example



```
string s = Console.ReadLine();
try {
  int.Parse(s);
  Console.WriteLine(
    "You entered a valid Int32 number {0}.", s);
}
catch (FormatException) {
  Console.WriteLine("Invalid integer number!");
}
catch (OverflowException) {
  Console.WriteLine(
    "The number is too big to fit in Int32!");
}
```

Handling Exceptions

- When catching an exception of a particular class, all its inheritors (child exceptions) are caught too, e.g.

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

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

Find the Mistake!

```
string str = Console.ReadLine();
try {
  Int32.Parse(str);
}
catch (Exception) {
  Console.WriteLine("Cannot parse the number!");
}
catch (FormatException) {
  Console.WriteLine("Invalid integer number!");
}
catch (OverflowException) {
  Console.WriteLine("The number is too big to fit in Int32!");
}
```

Should be last

Unreachable code

Unreachable code

Handling All Exceptions

- For **handling all exceptions** (disregarding the exception type, even unmanaged) use the construction:

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

The Try-finally Statement

- The **try-finally** statement ensures the **finally** block is **always executed** (with or without exception):

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

- Used for execution of **cleanup code**, e. g. releasing resources

Try-finally – Example

```
static void TestTryFinally() {
  Console.WriteLine("Code executed before try-finally.");
  try {
    string str = Console.ReadLine();
    int.Parse(str);
    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.");
}
```

Using the "Throw" Keyword

Using Throw Keyword

- **Throwing an exception** with an error message:

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

- Exceptions can accept **message** + **another exception** (cause):

```
try {
   …
}
catch (SqlException sqlEx) {
   throw new InvalidOperationException("Cannot save invoice.",
sqlEx); }
```

- This is called "**chaining**" exceptions

Throwing Exceptions

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- Exceptions are thrown (raised) by the `throw` keyword
- Notify the calling code in case of an error or problem
- When an exception is thrown:
  - The program execution stops
  - The exception travels over the stack
    - Until a matching `catch` block is reached to handle it
- Unhandled exceptions display an error message

Re-Throwing Exceptions

- Caught exceptions can be **re-thrown** again:

```
try {
  Int32.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
}
```

Throwing Exceptions – Example

```
public static double Sqrt(double value) {
  if (value < 0)
    throw new System.ArgumentOutOfRangeException("value",
      "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;
  }
}
```

Best Practices for Exception Handling

Using Catch Block

- `Catch` blocks should:
  - Begin with the exceptions lowest in the hierarchy
  - 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 leave it unhandled
  - Handling all exceptions disregarding their type is a popular **bad practice** (anti-pattern)!

Choosing the Exception Type

- When an invalid parameter value 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 `Exception`)

Exceptions – Best Practices (1)

- When raising an exception, always pass to the constructor a **good explanation message**
- When throwing an exception always pass a good description of the problem
  - The 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*"

Exceptions – Best Practices (2)

- 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
  - The .NET runtime could throw exceptions at any time with no way to predict them
    - E. g. `System.OutOfMemoryException`

Creating Custom Exceptions

- Custom exceptions inherit an exception class (e. g. **`System.Exception`**)

```
public class PrinterException : Exception
{
  public PrinterException(string msg)
    : base(msg) { … }
}
```

- Thrown just like any other exception

```
throw new PrinterException("Printer is out of paper!");
```

Summary

- Exceptions provide a **flexible** error handling mechanism

```
throw new Exception("Invalid size!");
```

- **Try-catch** allows exceptions to be handled

```
try { … } catch (Exception ex) { … }
```

- Unhandled exceptions cause error messages
- **Try-finally** ensures a given code block is always executed

Questions?

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