Reading and Writing Data Incrementally Using Streams

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Overview

An introduction to streams

The benefits of streams

.NET class hierarchy overview

Using streams to read and write text

Selectively processing part of stream

Using streams to read and write binary data

Using BinaryReader and BinaryWriter

Specifying text encodings

Using streams to append data

Random FileStream access

MemoryStream overview

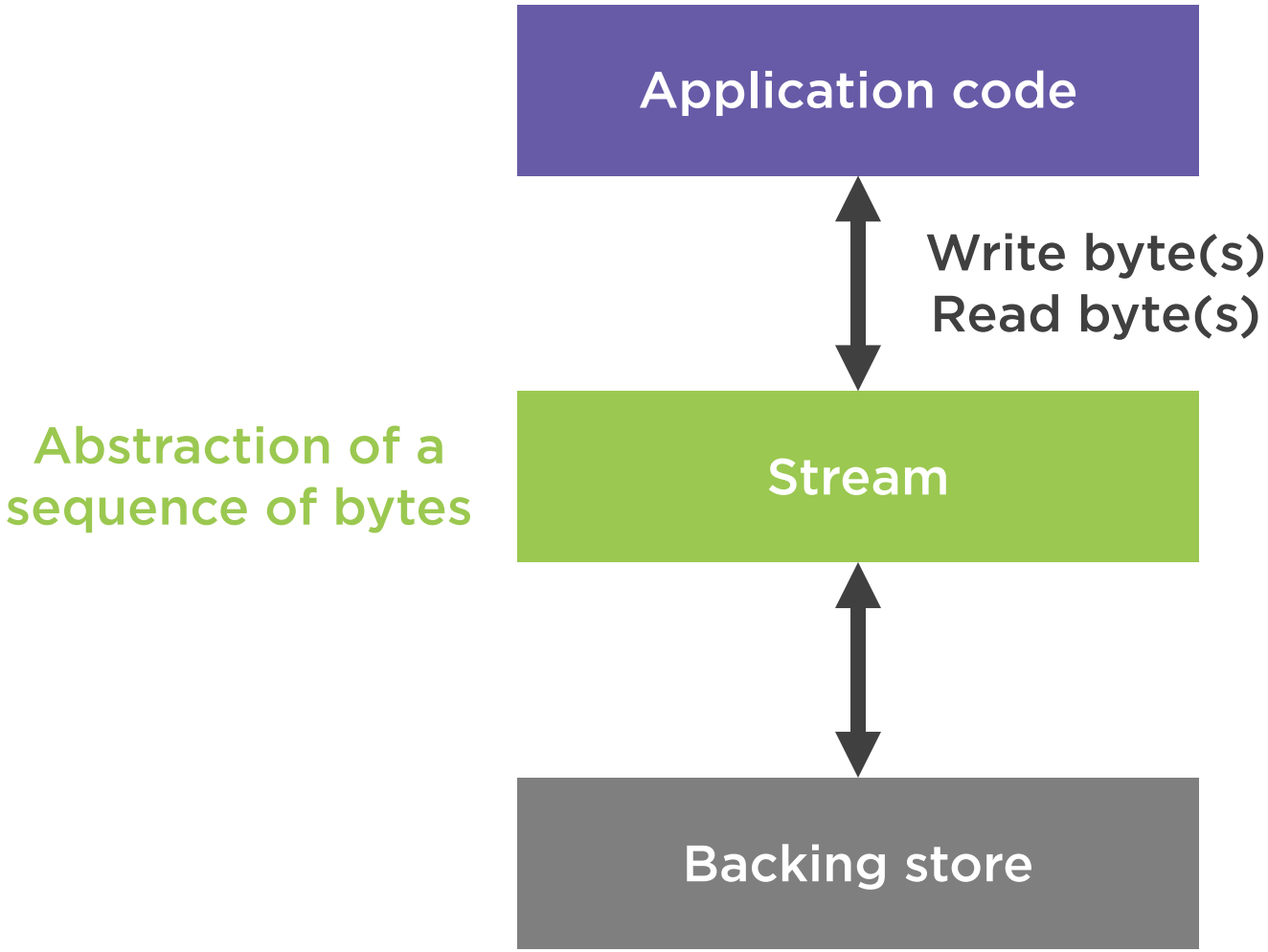
An Introduction to Streams

"...a stream is a sequence of bytes that you can use to read from and write to a backing store, which can be one of several storage mediums"

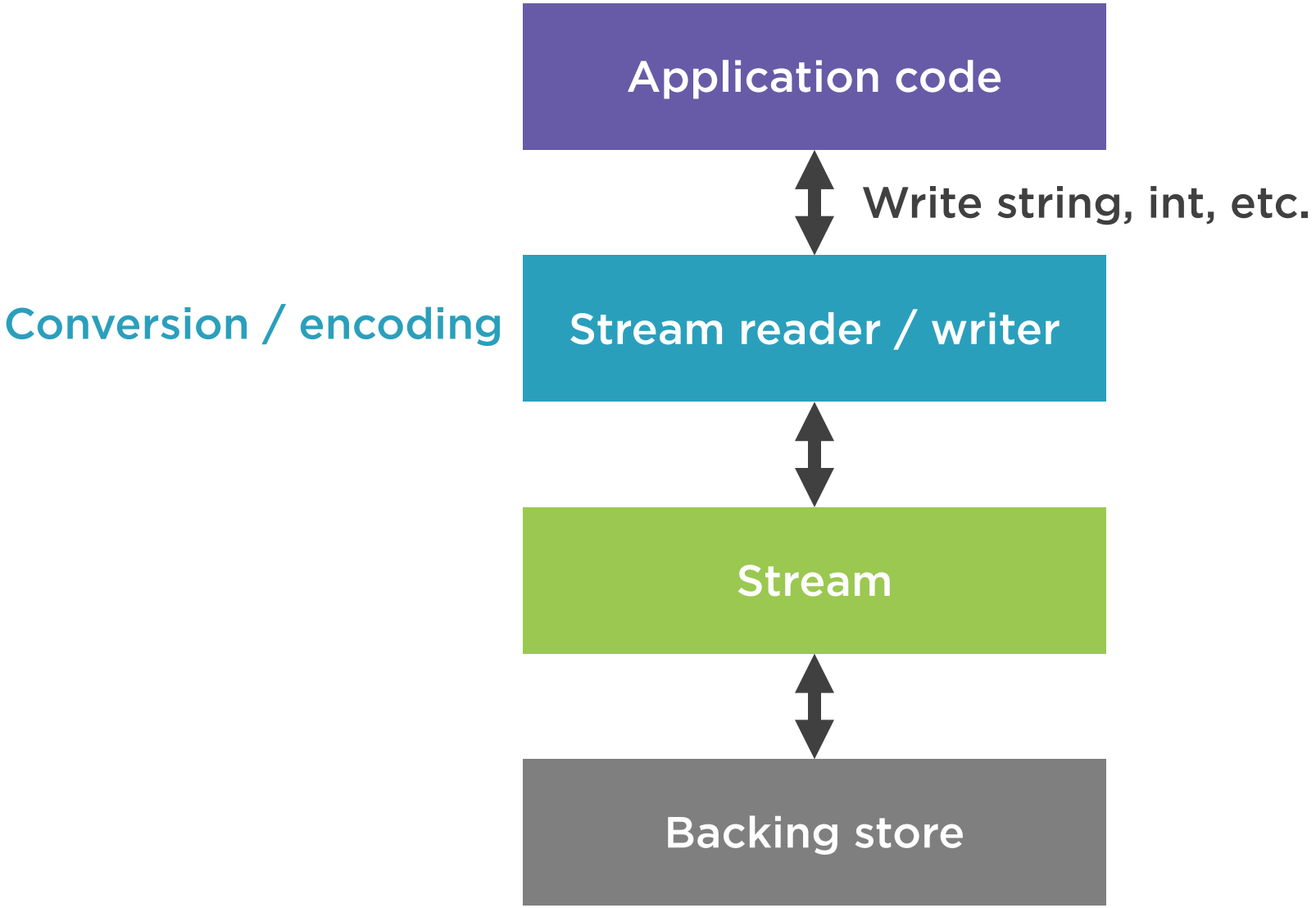
Microsoft Documentation

https://docs.microsoft.com/en-us/dotnet/standard/io/

An Introduction to Streams

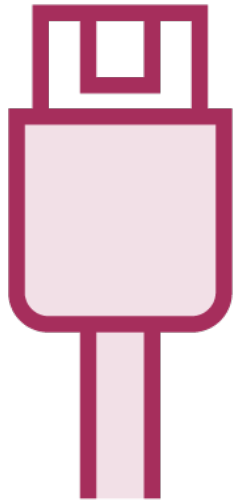


An Introduction to Streams

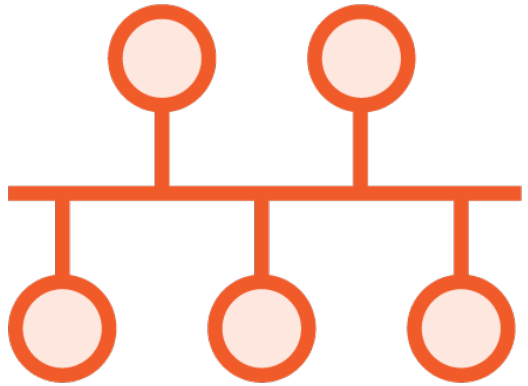


Examples of Backing Stores

Files

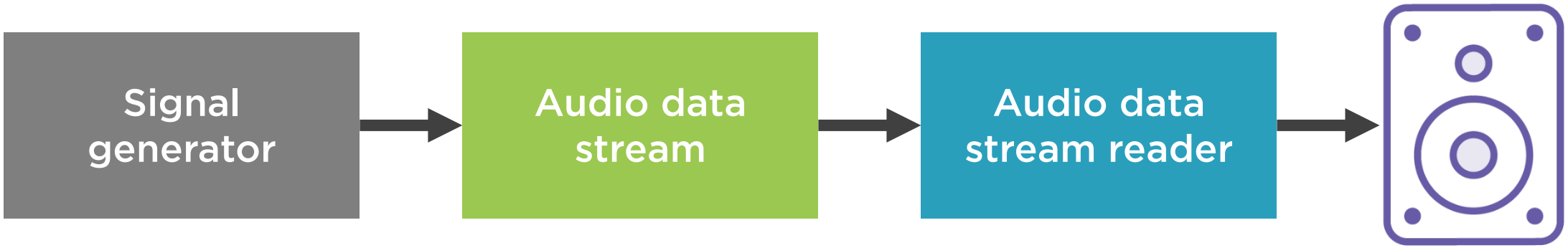


Input/output device/hardware



TCP/IP sockets

Non-Backing Store Streams



https://github.com/naudio/NAudio

The Benefits of Streams

Incremental data processing

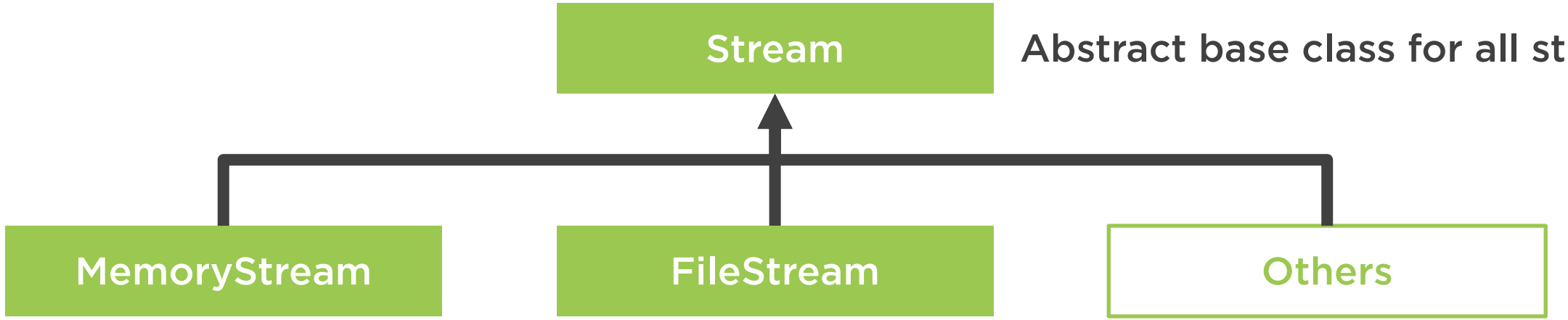
Abstraction of backing store

Flexibility / control

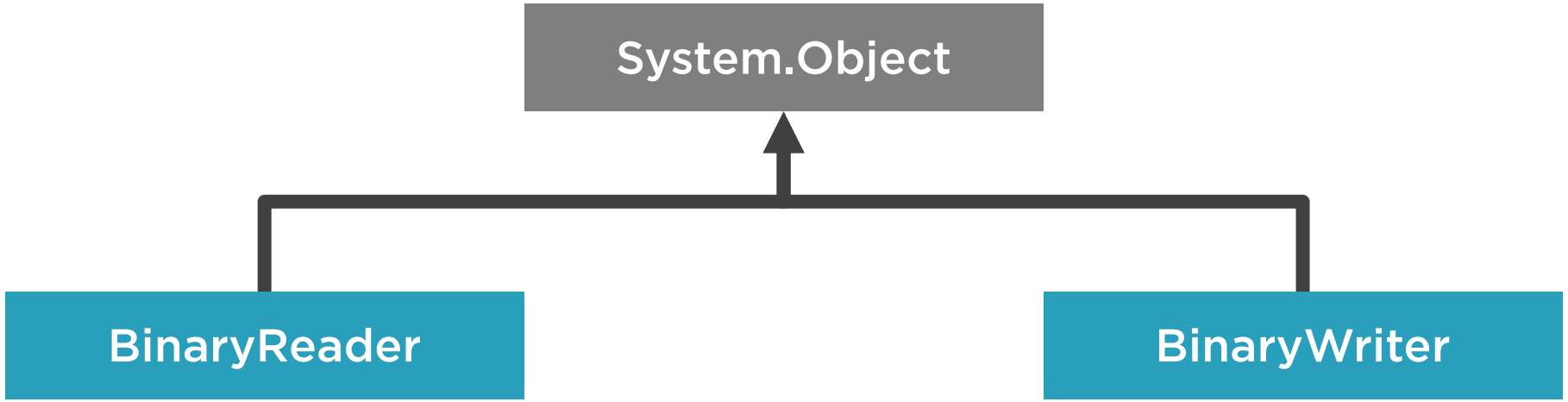
Random access / seeking

Composability / pipelines

Stream Classes



Binary Reader and Writer



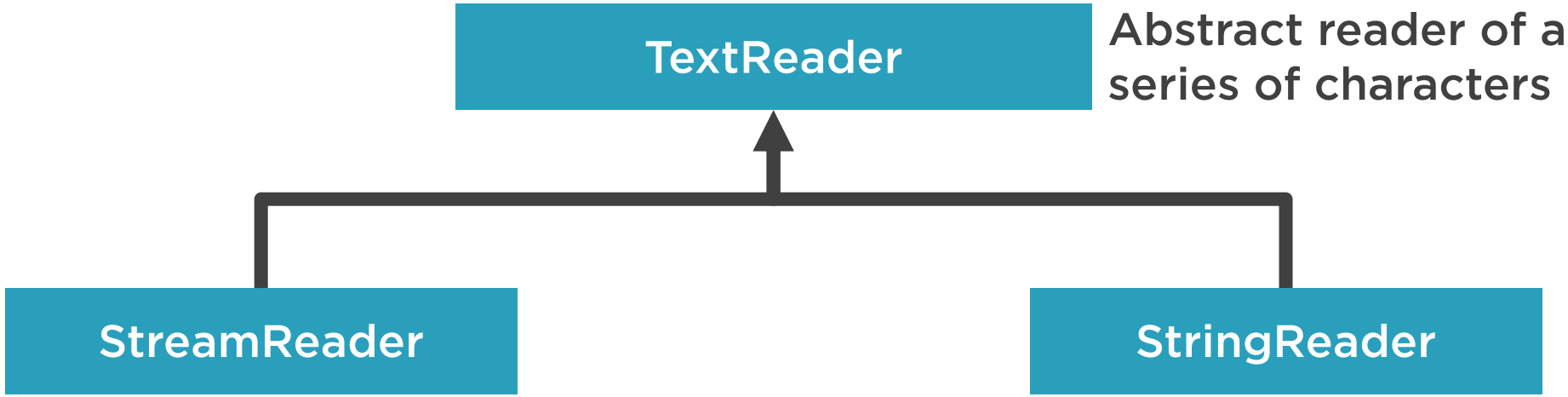
Read primitive types

bool ReadBoolean()
decimal ReadDecimal()
short ReadInt16()
char ReadChar()
Etc.

Write primitive types

Write(bool)
Write(decimal)
Write(short)
Write(char)
Etc.

TextReaders



Abstract reader of a sequential series of characters

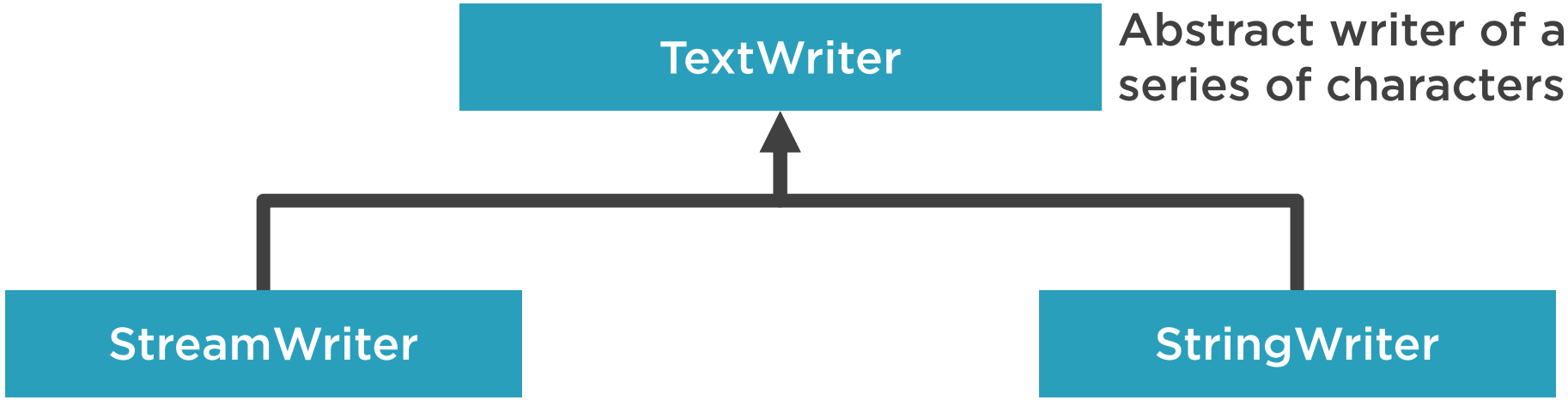
Reads characters from a byte stream using an encoding

string ReadLine()
string ReadToEnd()

Reads from a string object

int Read()
string ReadLine()
string ReadToEnd()

TextWriters



Abstract writer of a sequential series of characters

Writes characters to a stream using an encoding

Write(bool)
Write(decimal)
Write(int)
Write(char)
Etc.

Writes to a string (StringBuilder)

Write(bool)
Write(decimal)
Write(int)
Write(char)
Etc.

Specifying Text Encodings

```
new StreamReader(inputFileStream, Encoding.UTF32)
new StreamReader(inputFileStream, new UTF8Encoding(true))
new StreamWriter(OutputFilePath, Encoding.UTF32)
new StreamWriter(OutputFilePath, new UTF8Encoding(true))

// No explicit encoding overload
// Expects file to be UTF-8
File.OpenText(InputFilePath)
File.CreateText(OutputFilePath) // UTF-8 output encoding
```

Specifying Text Encodings

```
new BinaryReader(inputFileStream, Encoding.UTF32)
new BinaryWriter(outputFileStream, Encoding.UTF32)

// UTF-8 encoding
new BinaryReader(inputFileStream)
new BinaryWriter(outputFileStream)
```

Using Streams to Append Data

```
var streamWriter = new StreamWriter(@"C:\data.txt", true))


streamWriter.Write("Content to append...");
streamWriter.WriteLine("Content to append with new line...");
```

Using Streams to Append Data

```
FileStream fs = File.Open(@"C:\data.data", FileMode.Append));
var binaryWriter = new BinaryWriter(fs));

binaryWriter.Write(42); // append to end of file
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Position = 0; // zero-based

int firstByte = fileStream.ReadByte(); // 05
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Position = 0; // zero-based

int firstByte = fileStream.ReadByte(); // 05
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Position = 2;
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Position = 2;

int thirdByte = fileStream.ReadByte(); // FF
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Position = 2;

int thirdByte = fileStream.ReadByte(); // FF
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(2, SeekOrigin.Begin);
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(2, SeekOrigin.Begin);

thirdByte = fileStream.ReadByte(); // FF
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(2, SeekOrigin.Begin);

thirdByte = fileStream.ReadByte(); // FF
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(1, SeekOrigin.Current);
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Seek(1, SeekOrigin.Current);

int fifthByte = fileStream.ReadByte(); // 2A
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(1, SeekOrigin.Current);

int fifthByte = fileStream.ReadByte(); // 2A
```

Random FileStream Access

```
05 0F FF 5E 2A 00
```

```
fileStream.Seek(-3, SeekOrigin.End);
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Seek(-3, SeekOrigin.End);

int threeFromEnd = fileStream.ReadByte(); // 5E
```

Random FileStream Access

05 0F FF 5E 2A 00

```
fileStream.Seek(-3, SeekOrigin.End);

int threeFromEnd = fileStream.ReadByte(); // 5E
```

Not all streams support random access / seeking.

Stream.CanSeek

MemoryStream Overview

```
using (var memoryStream = new MemoryStream())
using (var memoryStreamWriter = new StreamWriter(memoryStream))
using (var fileStream = new FileStream(@"C:\data.txt", FileMode.Create))
{
    memoryStreamWriter.WriteLine("Line 1");
    memoryStreamWriter.WriteLine("Line 2");

    // Ensure everything written to memory stream
    memoryStreamWriter.Flush();

    memoryStream.WriteTo(fileStream);
}
```

Asynchronous Streams

```
string currentLine = inputStreamReader.ReadLine();
string currentLine = await inputStreamReader.ReadLineAsync();

outputStreamWriter.Write(currentLine);
await outputStreamWriter.WriteAsync(currentLine);

outputStreamWriter.WriteLine(currentLine);
await outputStreamWriter.WriteLineAsync(currentLine);
```

Asynchronous Streams

```
int nextByte = inputFileStream.ReadByte();
int nextByte = inputFileStream.ReadByteAsync(); // ERROR

public Task<int> ReadAsync(byte[] buffer,
                           int offset,
                           int count,
                           CancellationToken cancellationToken);

public ValueTask<int> ReadAsync(Memory<byte> buffer,…);

public Task WriteAsync(byte[] buffer, …);
public ValueTask WriteAsync(ReadOnlyMemory<byte> buffer, …);
```

Asynchronous Streams in C# 8.0

```
// Don't confuse with System.IO streams
// "Asynchronous enumerables"
// Get a "stream" of results

public interface IAsyncEnumerable<out T>
{
    IAsyncEnumerator<T> GetAsyncEnumerator(
                            CancellationToken cancellationToken = default);
}
```

```
public static async IAsyncEnumerable<int> TakeSensorReadings()
{
    var rnd = new Random();

    for (int i = 0; i < 10; i++)
    {
        await Task.Delay(1_000);


        int temp = rnd.Next(minValue: -10, maxValue: 50);


        yield return temp;
    }
}
```

```
public static async IAsyncEnumerable<int> TakeSensorReadings()
{
    var rnd = new Random();

    for (int i = 0; i < 10; i++)
    {

        await Task.Delay(1_000);


        int temp = rnd.Next(minValue: -10, maxValue: 50);


        yield return temp;
    }
}
```

```
await foreach (var reading in TakeSensorReadings())
{
    Console.WriteLine($"Sensor reading: {reading}");
}
```

Perform processing during enumeration and return multiple values asynchronously in a pull-based fashion.

Summary

An introduction to streams

The benefits of streams

.NET class hierarchy overview

new StreamReader(inputFileStream)

File.OpenText(InputFilePath)

Selectively processing part of stream

Using streams to read and write binary data

outputFileStream.WriteByte(...)

new BinaryReader(inputFileStream)

Text encodings & appending data

Random access & MemoryStreams

Up Next:

Reading and Writing CSV Data