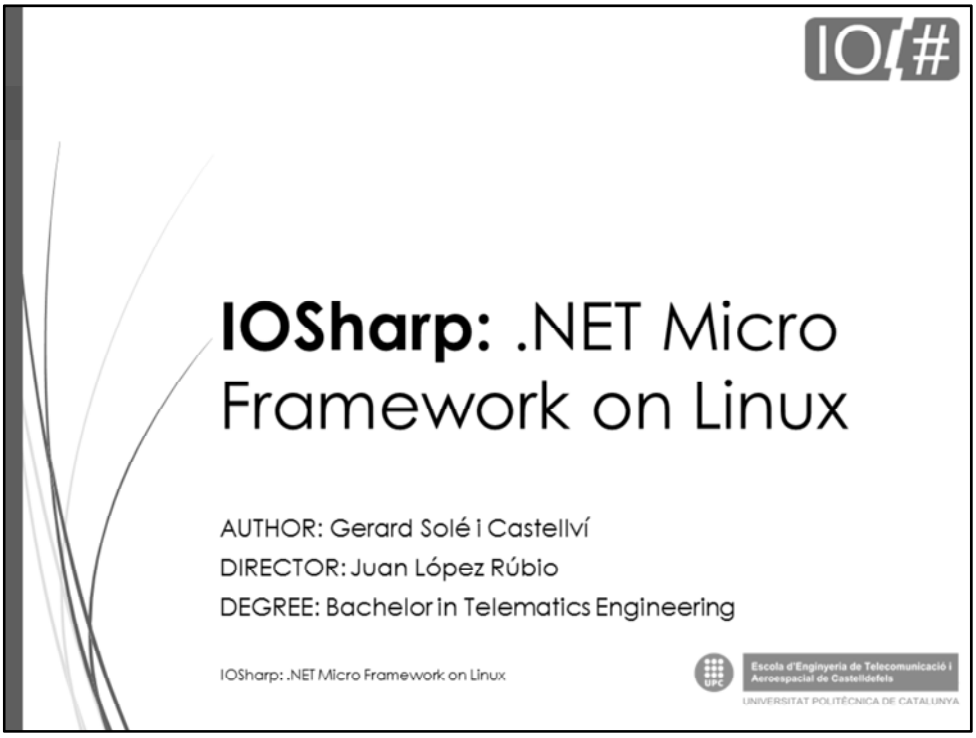
IOSharp: .NET Micro Framework on Linux
AUTHOR: Gerard Solé i Castellví
DIRECTOR: Juan López Rúbio
DEGREE: Bachelor in Telematics Engineering
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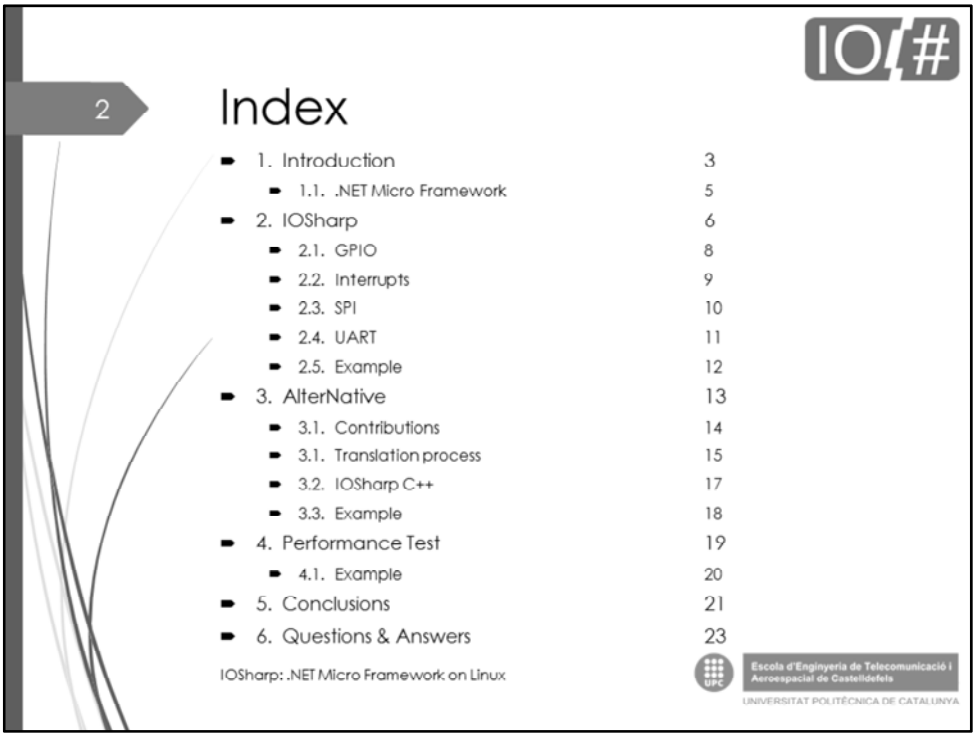
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1. Introduction

- Power increase from 8 to 32 bits on microprocessors
- Cost reduction on hardware production
- Increasing usage of Linux in embedded devices

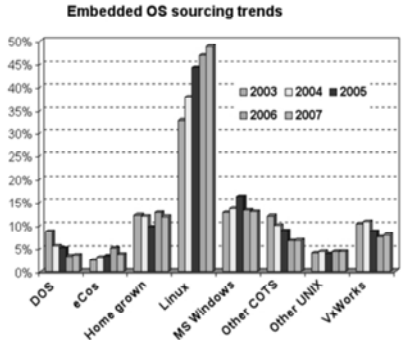

Fig. 1: Linux growth between 2003 and 2007

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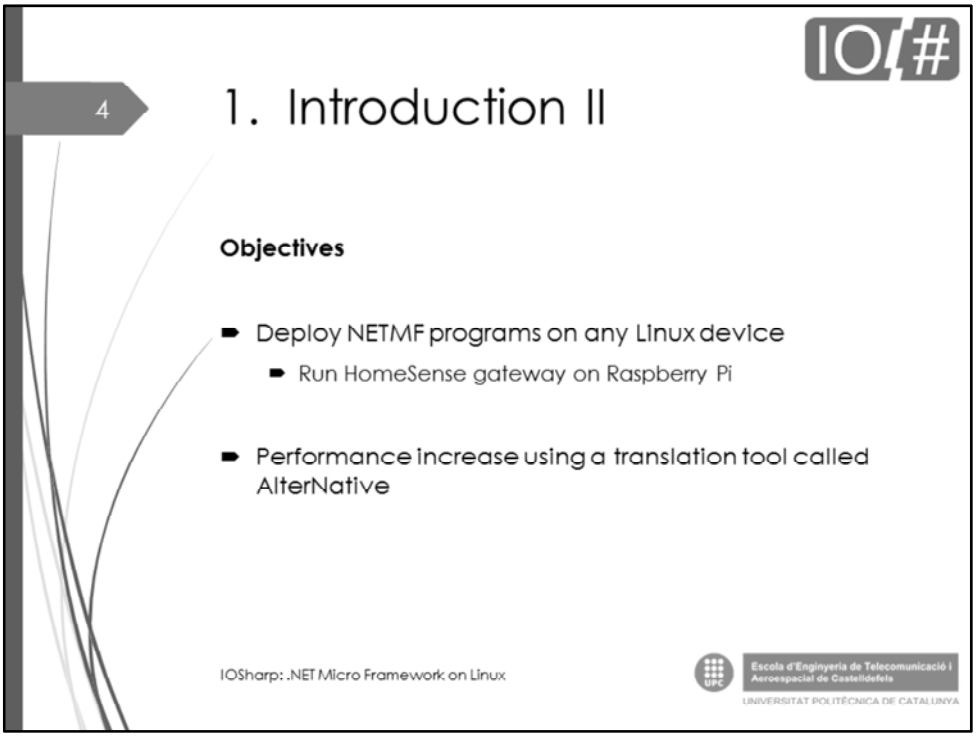
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1. Introduction II
Objectives
Deploy NETMF programs on any Linux device
Run HomeSense gateway on Raspberry Pi
Performance increase using a translation tool called AlterNative
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1.1. .NET Micro Framework

- Virtual Machine running on the bare metal
- Designed for resource-constrained devices
- Multiple I/O Ports and Protocols

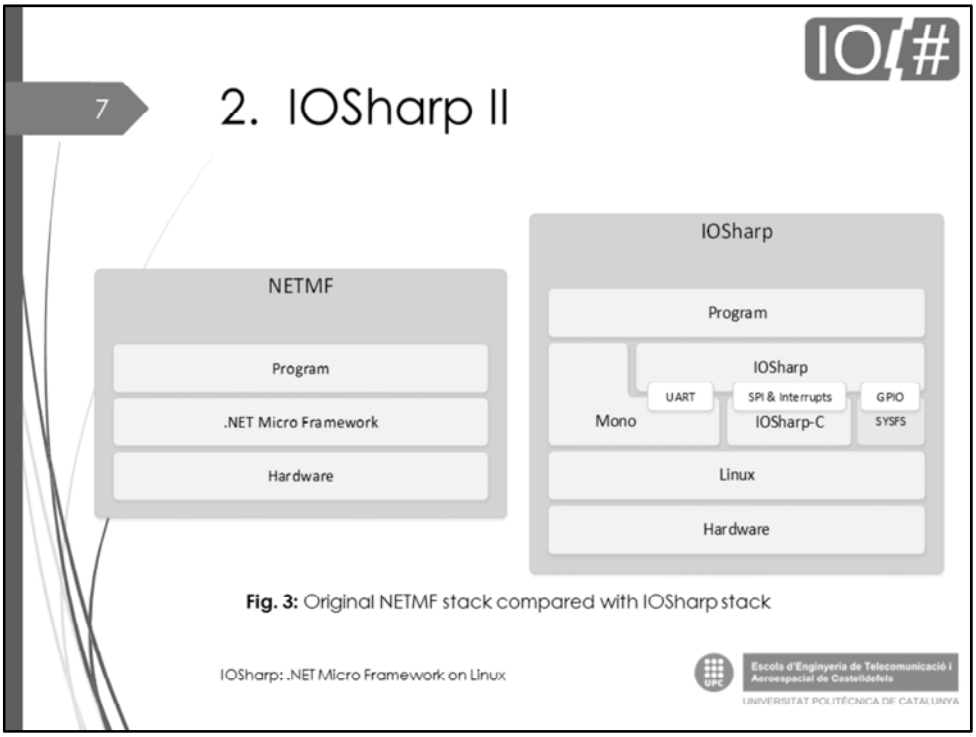
Fig. 2: Netudino Plus, Mini and FEZ Cerbuino. Arduino form factor

2. IOSharp

- NETMF implementation on a High-Level basis
  - C# with Mono on Linux
  - C library for interfacing with communication protocols
- Cross-Platform → Board independent
- Requires an underlying Linux

- Download at

https://github.com/GerardSoleCa/IOSharp-netmf-Linux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2. IOSharp II
NETMF
Program
.NET Micro Framework
Hardware
IOSharp
Program
IOSharp
UART
SPI & Interrupts
GPIO
Mono
IOSharp-C
SYSFS
Linux
Hardware
Fig. 3: Original NETMF stack compared with IOSharp stack
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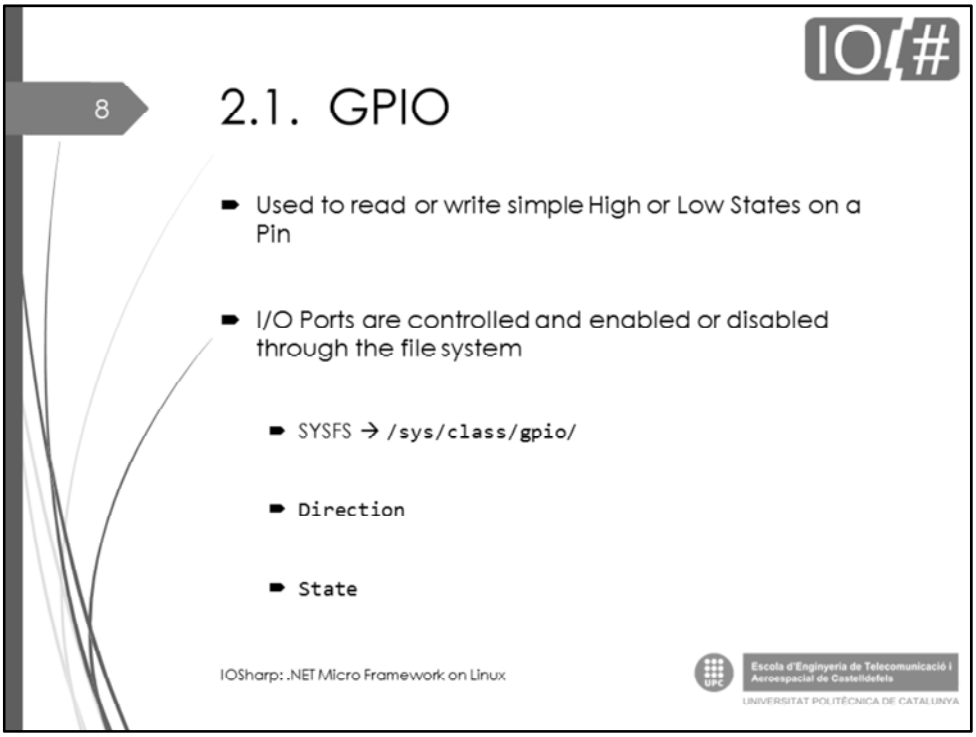
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2.1. GPIO
Used to read or write simple High or Low States on a Pin
I/O Ports are controlled and enabled or disabled through the file system
SYSFS → /sys/class/gpio/
Direction
State
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2.2. Interrupts

- Polling from a GPIO using the Poll function
- P/Invokes are required for cross-language calls

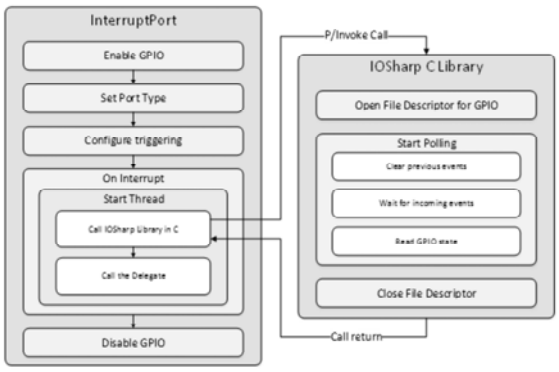

Fig. 4: flow diagram for an Interrupt Port

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2.3. SPI

- Implemented using the provided Linux Kernel function
  - Included on IOSharp-C library
  - P/Invoked from C#

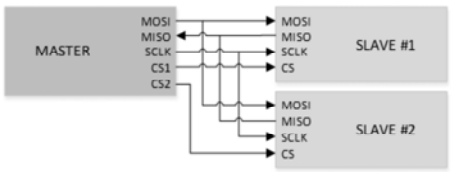
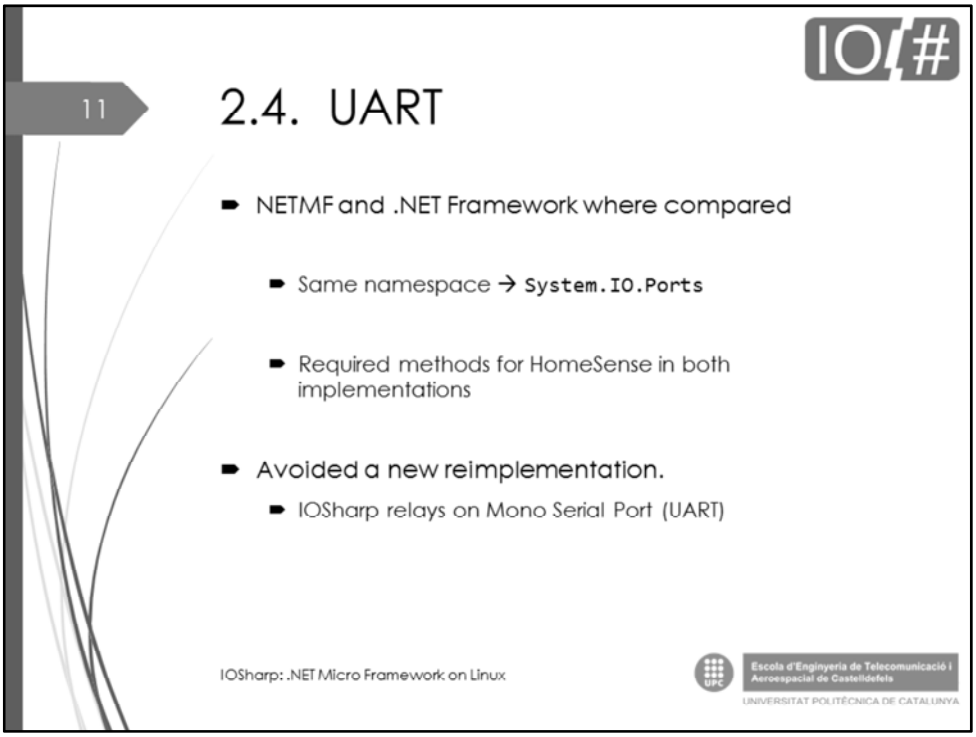


Fig. 5: Master-Slave SPI example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2.4. UART
NETMF and .NET Framework where compared
Same namespace → System.IO.Ports
Required methods for HomeSense in both implementations
Avoided a new reimplementation.
IOSharp relays on Mono Serial Port (UART)
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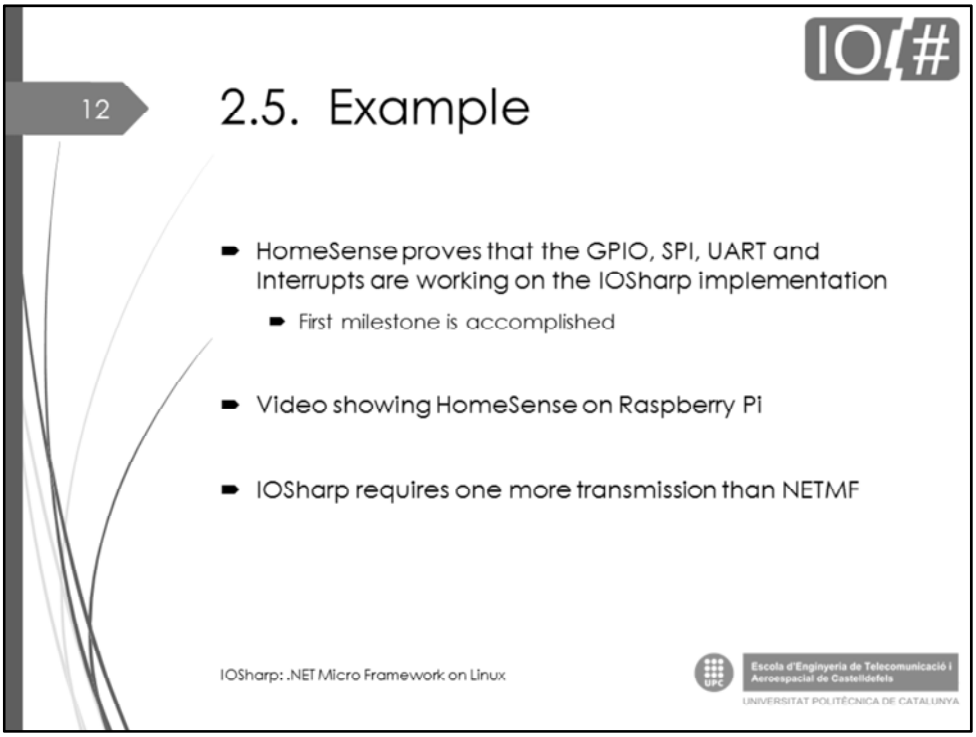
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2.5. Example
HomeSense proves that the GPIO, SPI, UART and Interrupts are working on the IOSharp implementation
First milestone is accomplished
Video showing HomeSense on Raspberry Pi
IOSharp requires one more transmission than NETMF
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3. AlterNative

- Source code translator written in C#
- Translate a .NET Assembly to native C++
- Use cases:
  - Performance
  - Cross-Platform development

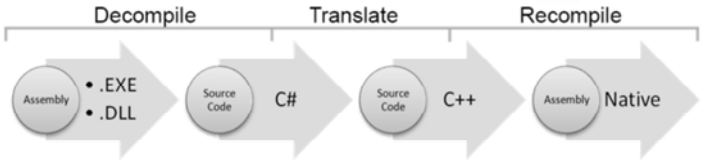
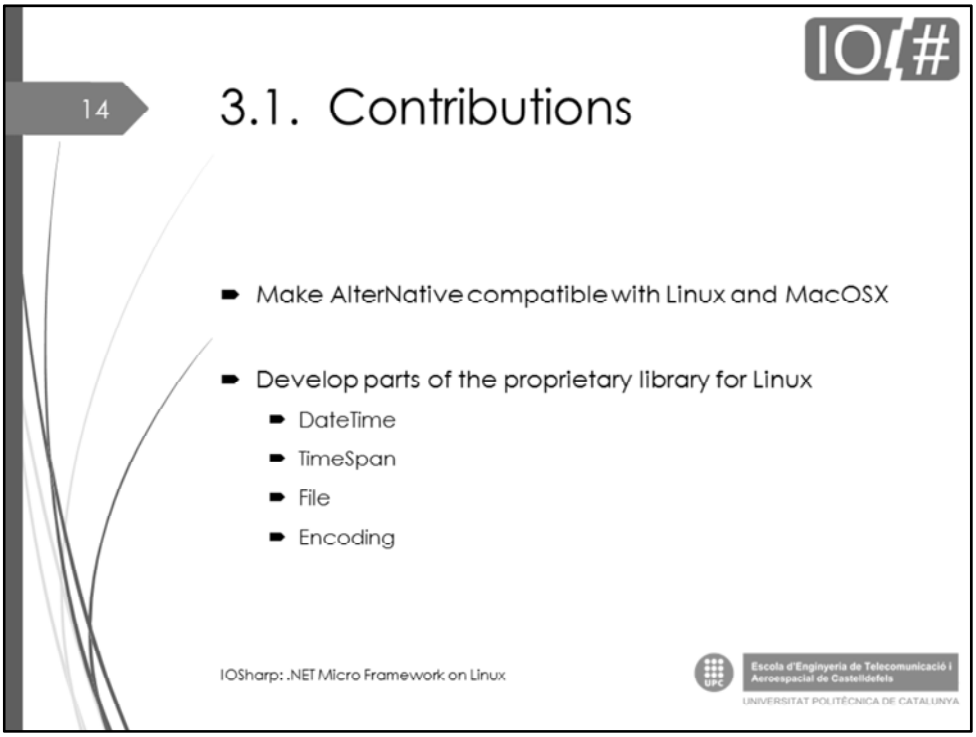


Fig. 6: AlterNative translation process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3.1. Contributions
Make AlterNative compatible with Linux and MacOSX
Develop parts of the proprietary library for Linux
DateTime
TimeSpan
File
Encoding
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3.2. Translation process

```
void Main(string[] args){
        Console.WriteLine("Write a String");
        string line = Console.ReadLine();
        Console.WriteLine("Read line: " + line);
        byte[] b = new byte[2];
        b[0] = 0;
        b[1] = 255;
        Console.WriteLine(Encoding.UTF8.GetString(b));
}
```

```
void Main(String args[]){
        Console::WriteLine(new String("Write a String"));
        String* line = Console::ReadLine();
        Console::WriteLine(new String("Read line: ") + line);
        Array<char>* b = new Array<char>(2);
        b->SetData(0, 0);
        b->SetData(1, 255);
        Console::WriteLine(Encoding::UTF8->GetString(b));
}
```

3.2. Translation process II

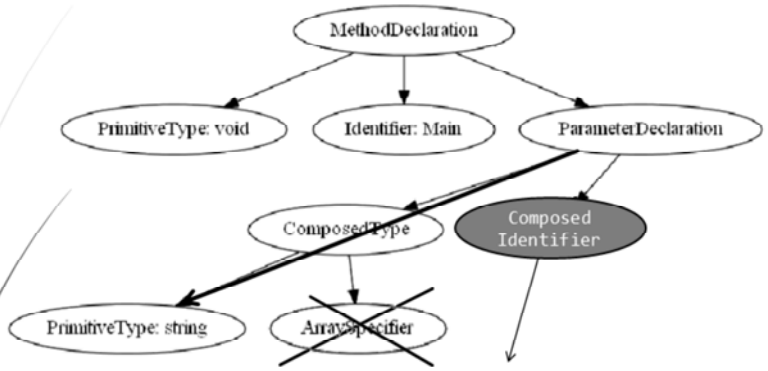

Fig. 7: AST conversions from C# to C++

```
void Main(string[] args){}   ⇒   void Main(string args[]){}
```

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3.3. IOSharp C++

- IOSharp is translated using AlterNative
- AlterNative System Library replaces Mono runtime

Fig. 8: NETMF, IOSharp and IOSharp C++ Stacks

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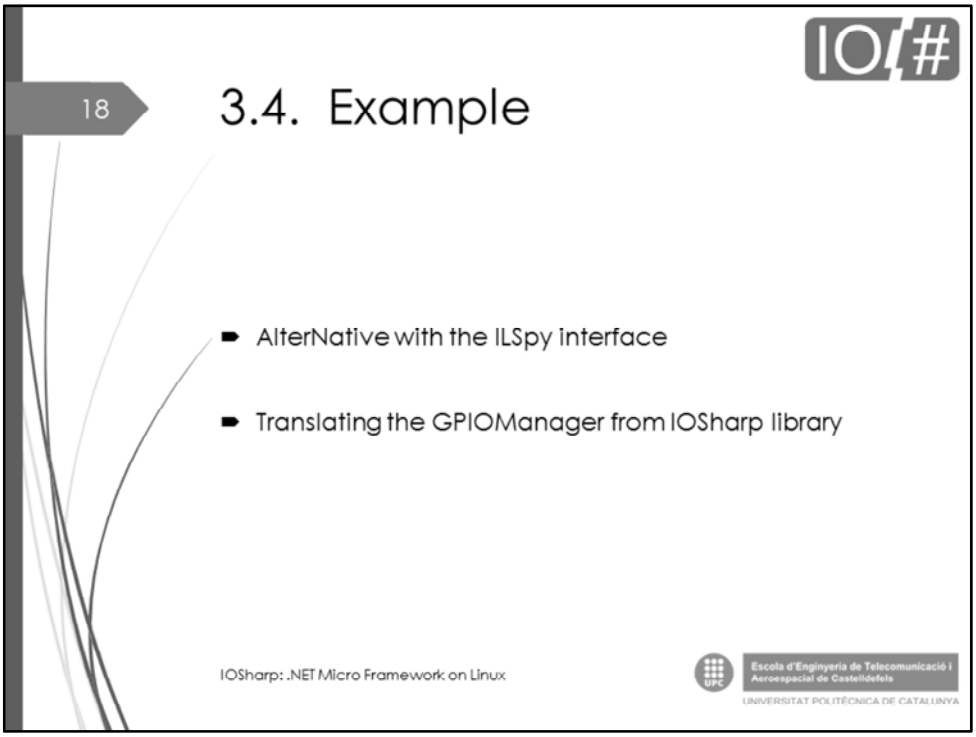
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3.4. Example
AlterNative with the ILSpy interface
Translating the GPIOManager from IOSharp library
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4. Performance Test

- Evaluate the increased performance using AlterNative

Fig. 9: Graph showing the speedup of the C++ version in front of the Mono one. 62% of gain.

4.1. Example

- Performance test using the10K GPIO iterations

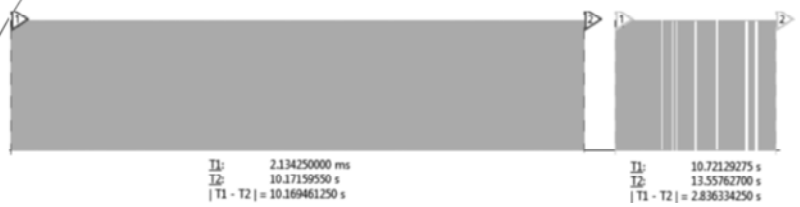
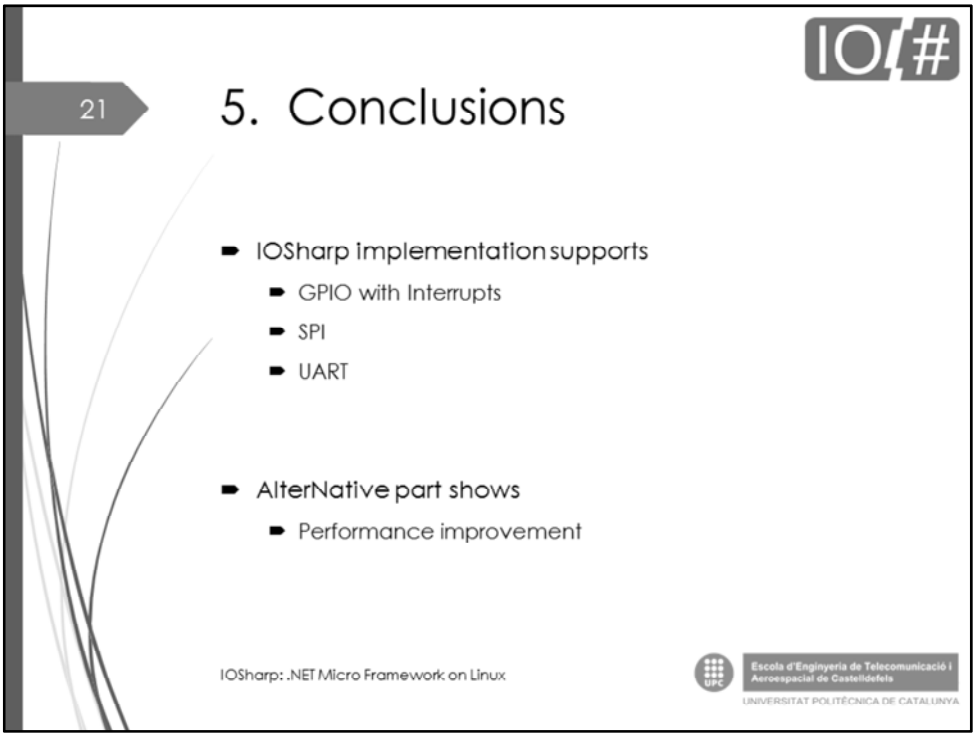


Fig. 10: Time comparison between Mono and C++ in 10K iterations of an Output Port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5. Conclusions
IOSharp implementation supports
GPIO with Interrupts
SPI
UART
AlterNative part shows
Performance improvement
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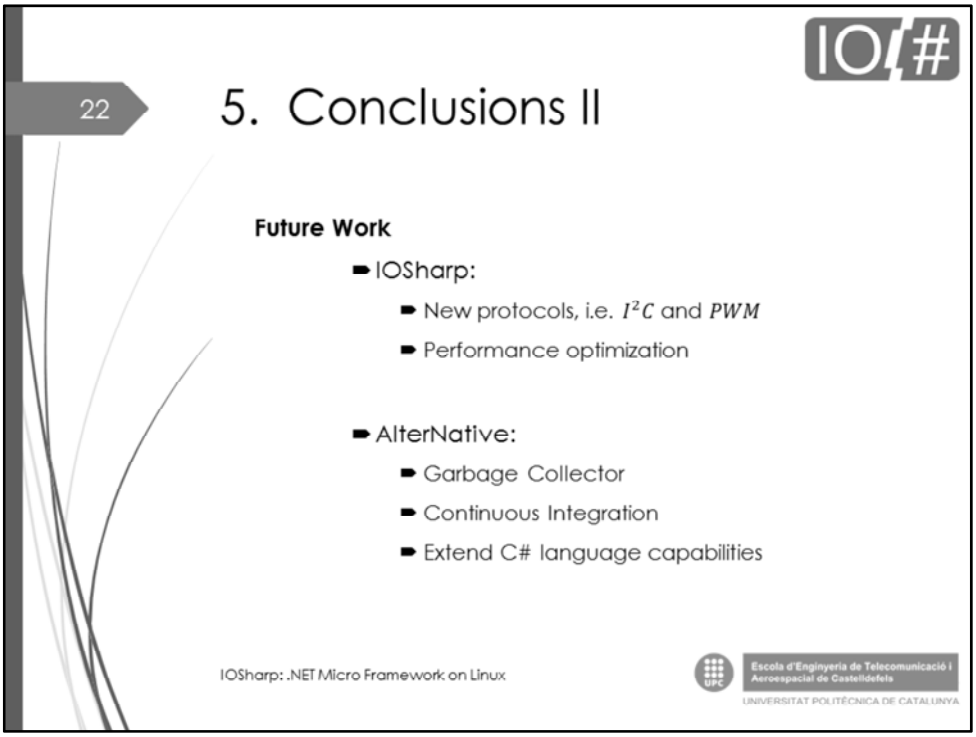
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5. Conclusions II
Future Work
IOSharp:
New protocols, i.e. I^2C and PWM
Performance optimization
AlterNative:
Garbage Collector
Continuous Integration
Extend C# language capabilities
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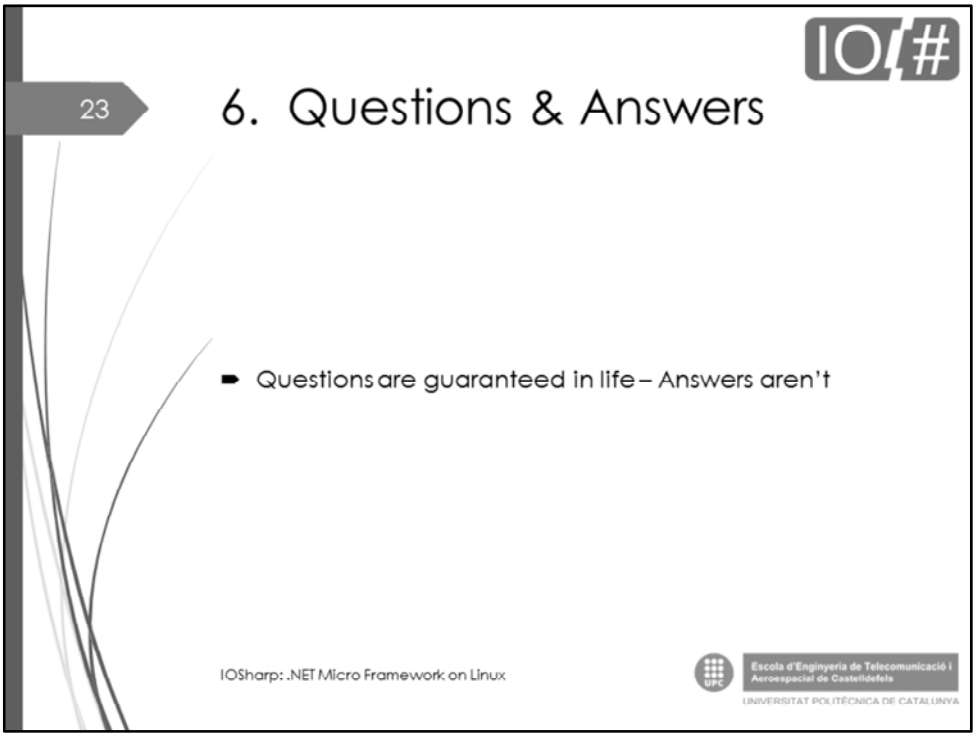
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6. Questions & Answers
Questions are guaranteed in life – Answers aren't
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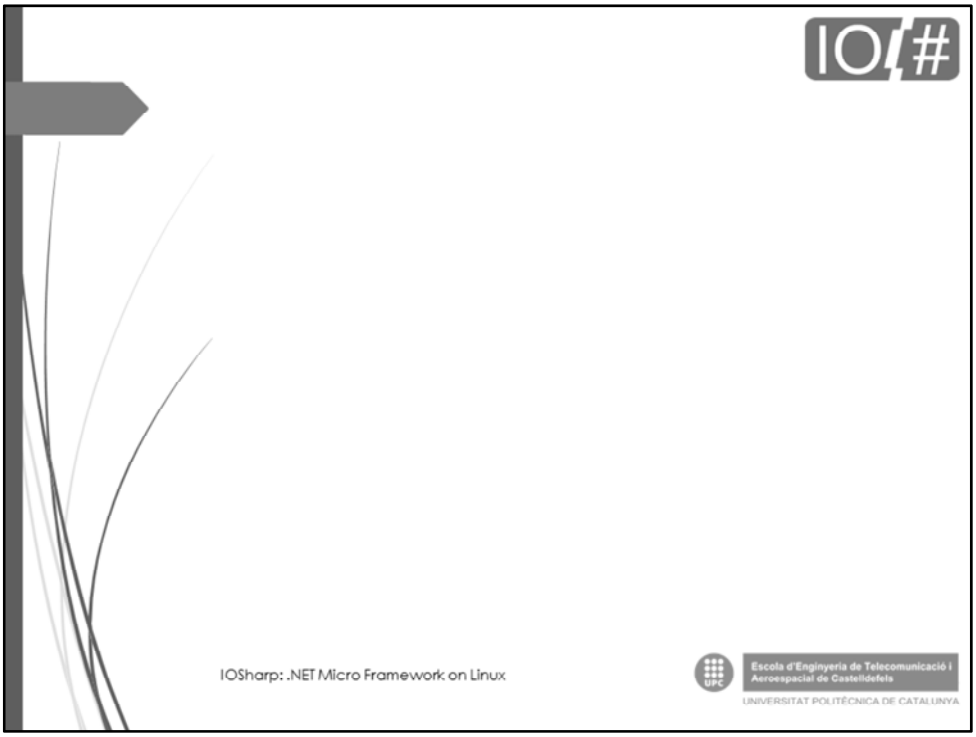
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