Using WebAssembly to run, extend, and secure your .NET application

Niels Tanis

VERACODE

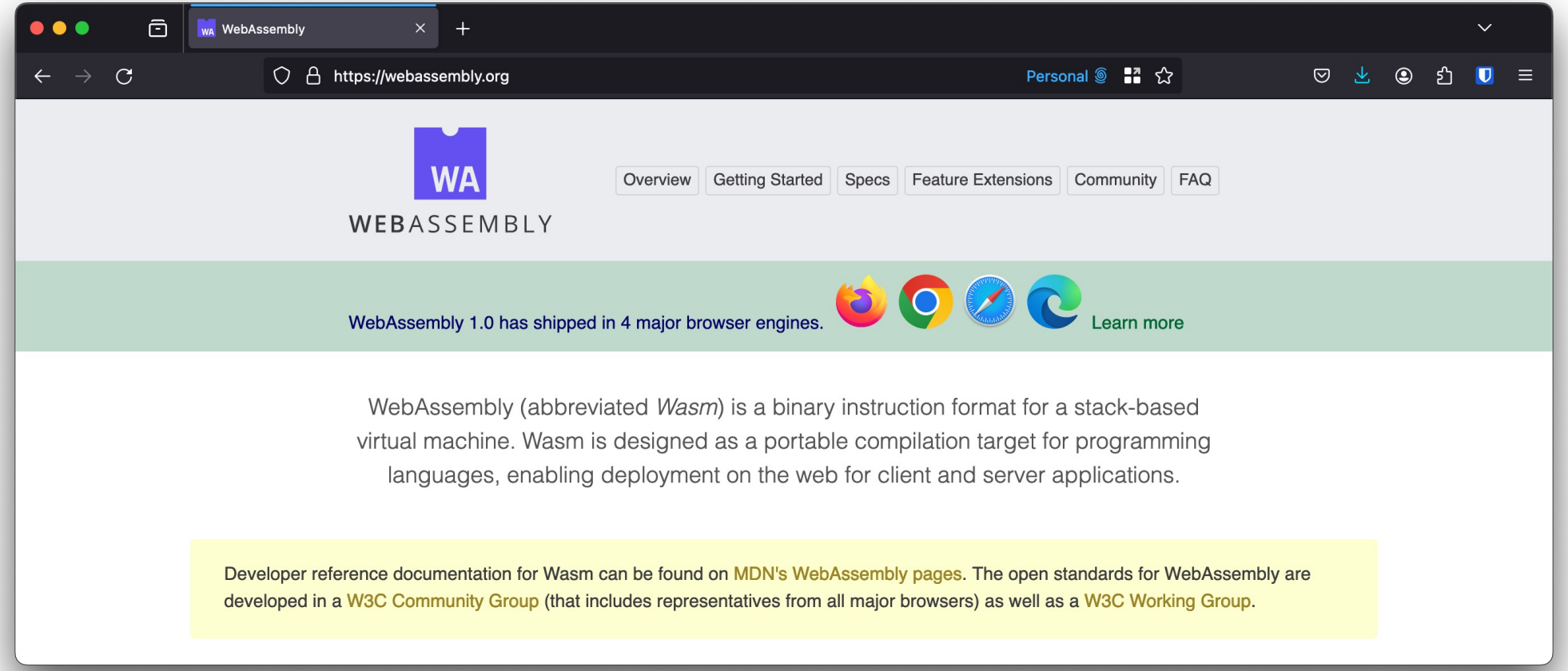
Who am I?

- Niels Tanis
- Sr. Principal Security Researcher
  - Background .NET Development, Pentesting/ethical hacking, and software security consultancy
  - Research on static analysis for .NET apps
  - Enjoying Rust!
- Microsoft MVP – Developer Technologies

dotnet friday

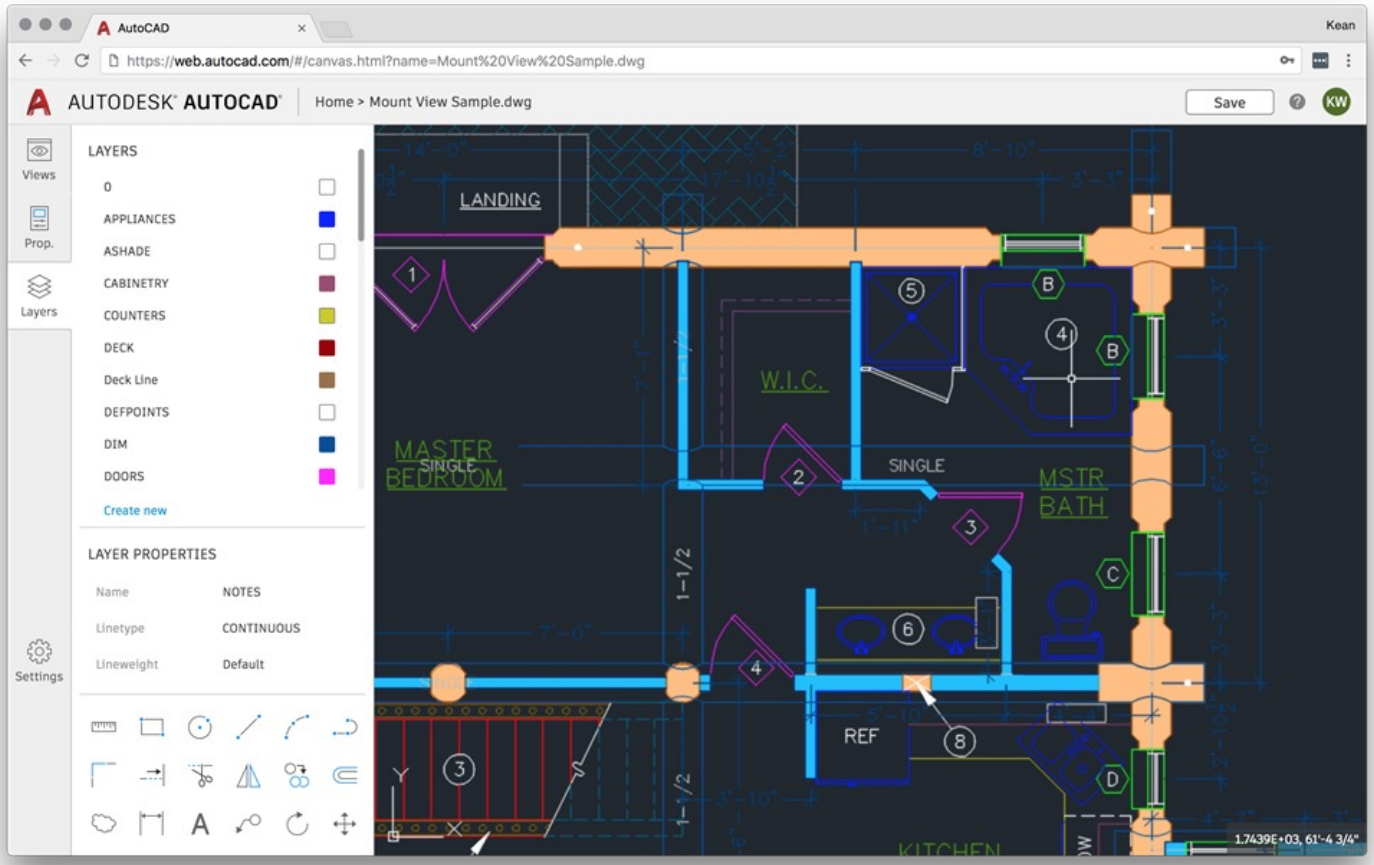
@nielstanis@infosec.exchange

WebAssembly



@nielstanis@infosec.exchange

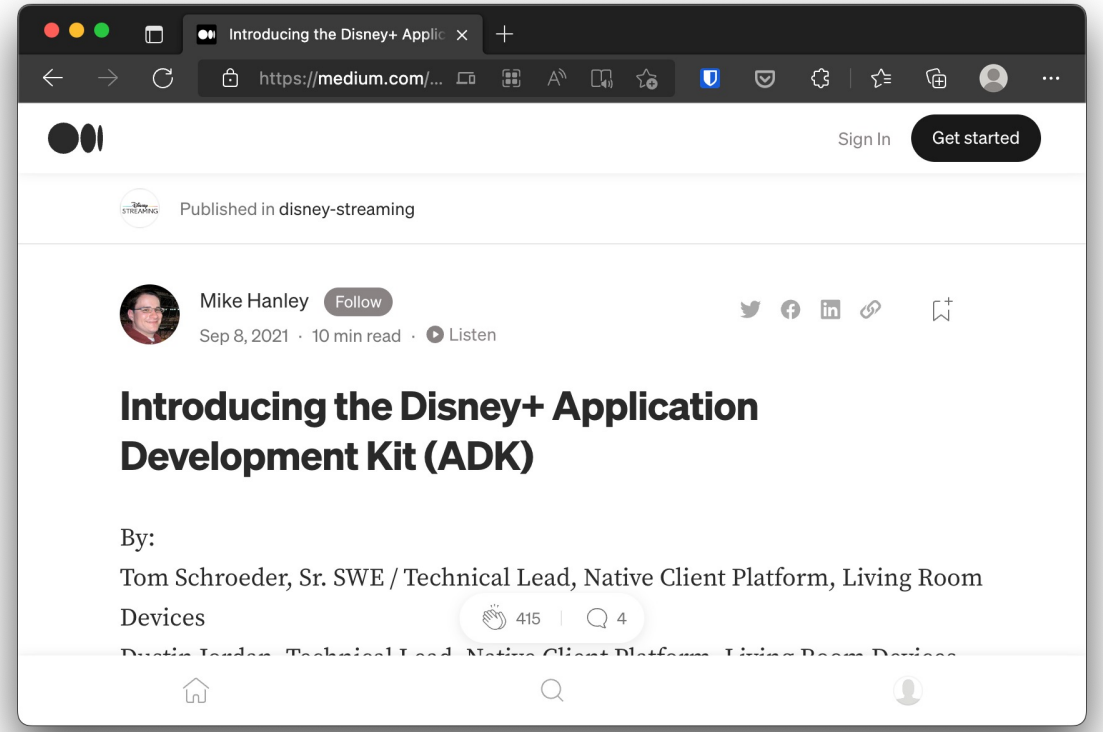
WebAssembly - AutoCAD

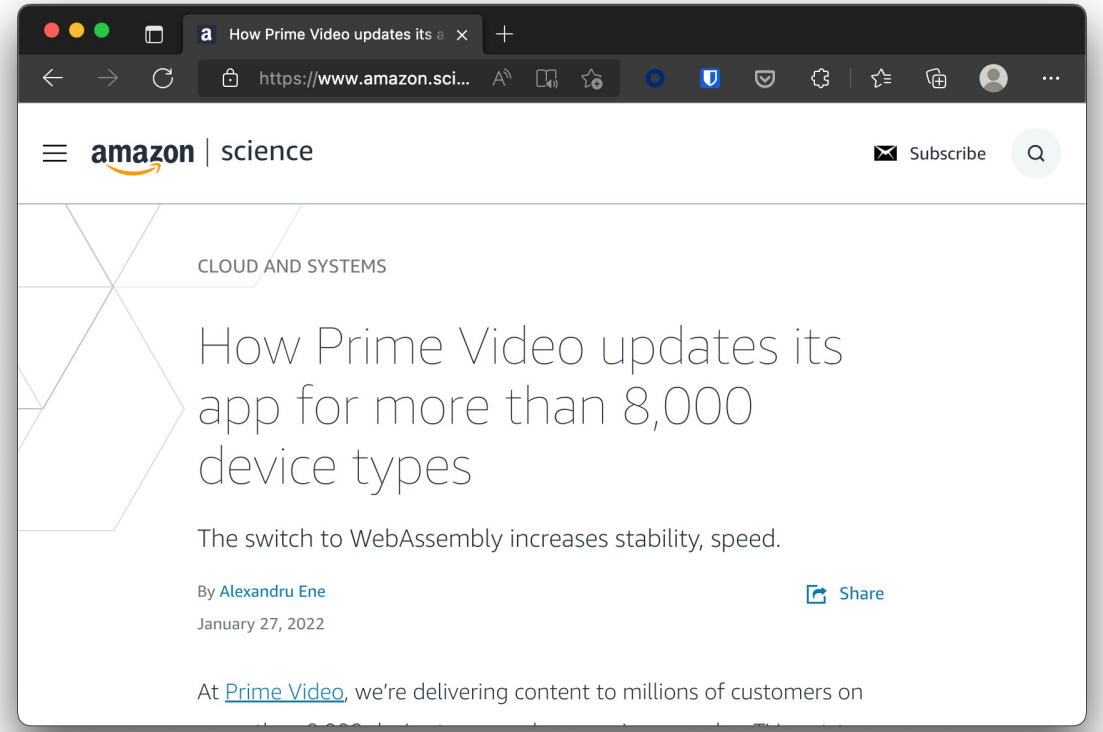


dotnet friday

@nielstanis@infosec.exchange

WebAssembly - SDK's





dotnet friday

@nielstanis@infosec.exchange

Agenda

- Introduction
- WebAssembly 101
- Running .NET on WebAssembly
- Extending .NET with WebAssembly
- Securing .NET with WebAssembly
- Conclusion
- Q&A

WebAssembly Design

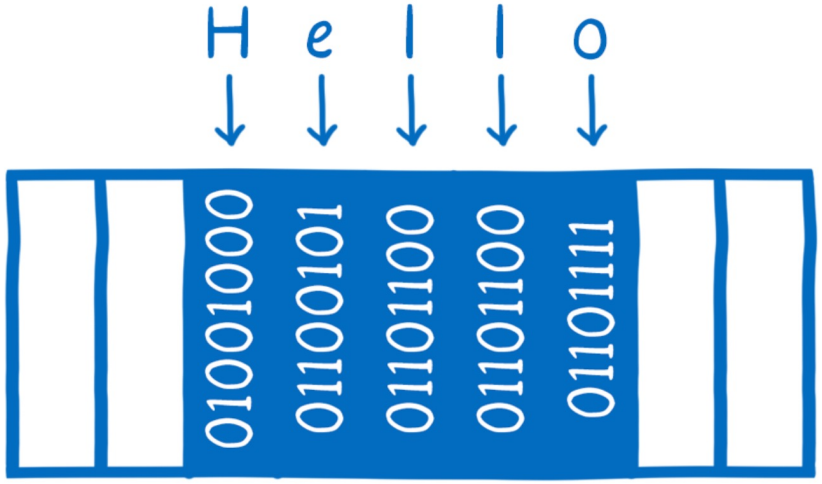
- **Be fast, efficient, and portable**
  - Executed in near-native speed across different platforms
- **Be readable and debuggable**
  - In low-level bytecode but also human readable
- **Keep secure**
  - Run on sandboxed execution environment
- **Don't break the web**
  - Ensure backwards compatibility

WebAssembly

- Binary instruction format for stack-based virtual machine similar to .NET CLR running MSIL or JVM running bytecode
- Designed as a portable compilation target
- The security model of WebAssembly:
  - Protect users from buggy or malicious modules
  - Provide developers with useful primitives and mitigations for developing safe applications

WebAssembly Memory

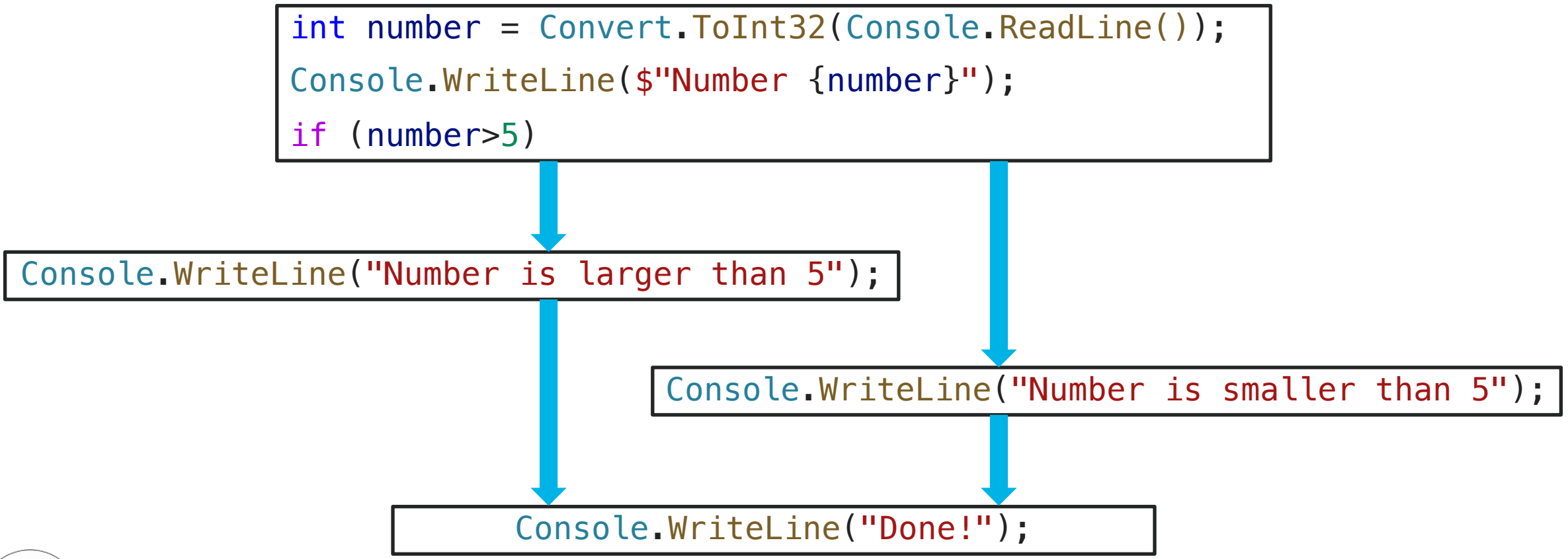
- Isolated per WASM module
- A contiguous, mutable array of uninterpreted bytes



WebAssembly Control-Flow Integrity

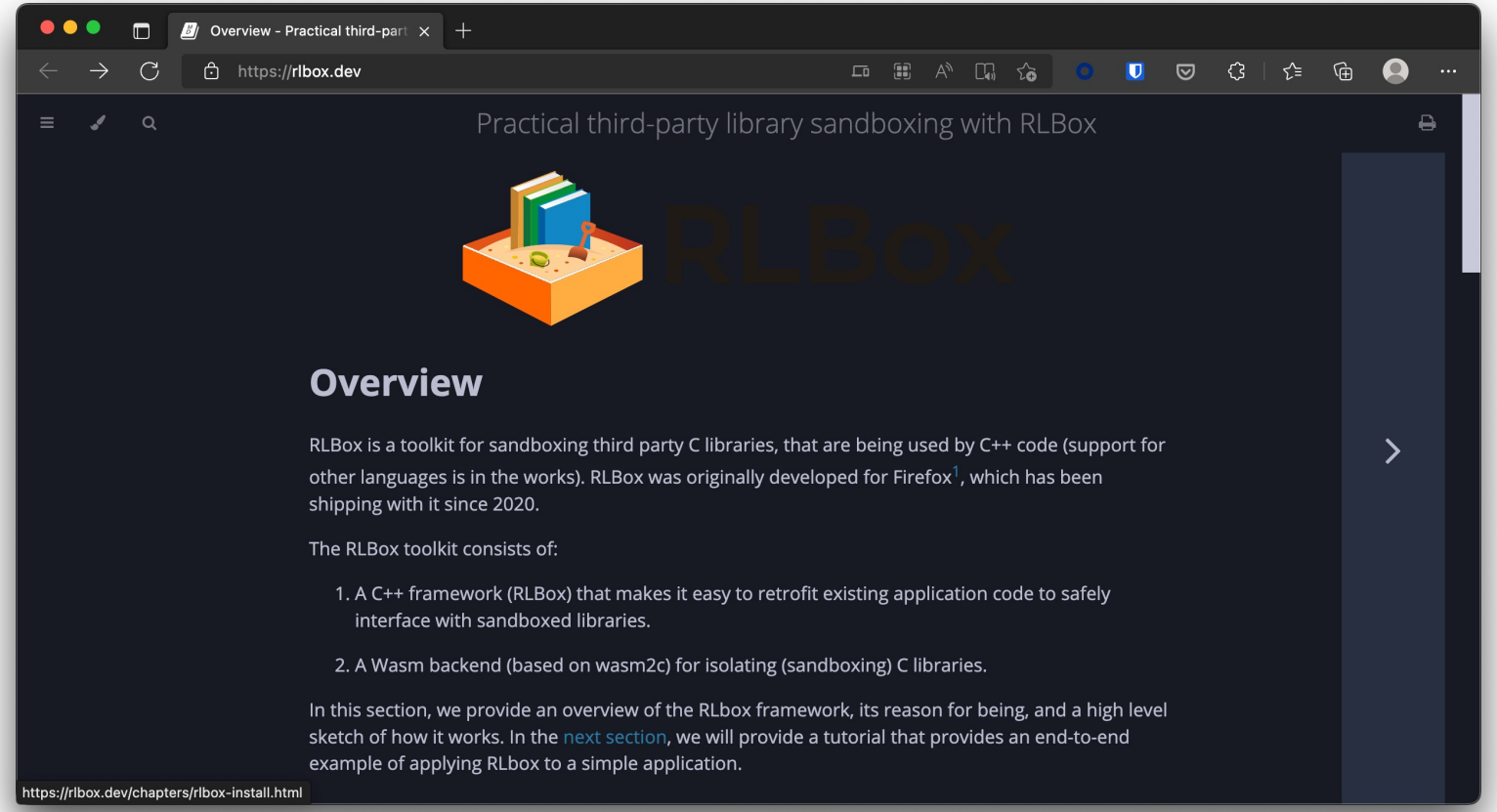
```
int number = Convert.ToInt32(Console.ReadLine());
Console.WriteLine($"Number {number}");
if (number>5)
{
      Console.WriteLine("Number is larger than 5");
}
else
{
      Console.WriteLine("Number is smaller than 5");
}
Console.WriteLine("Done!");
```

WebAssembly Control-Flow Integrity



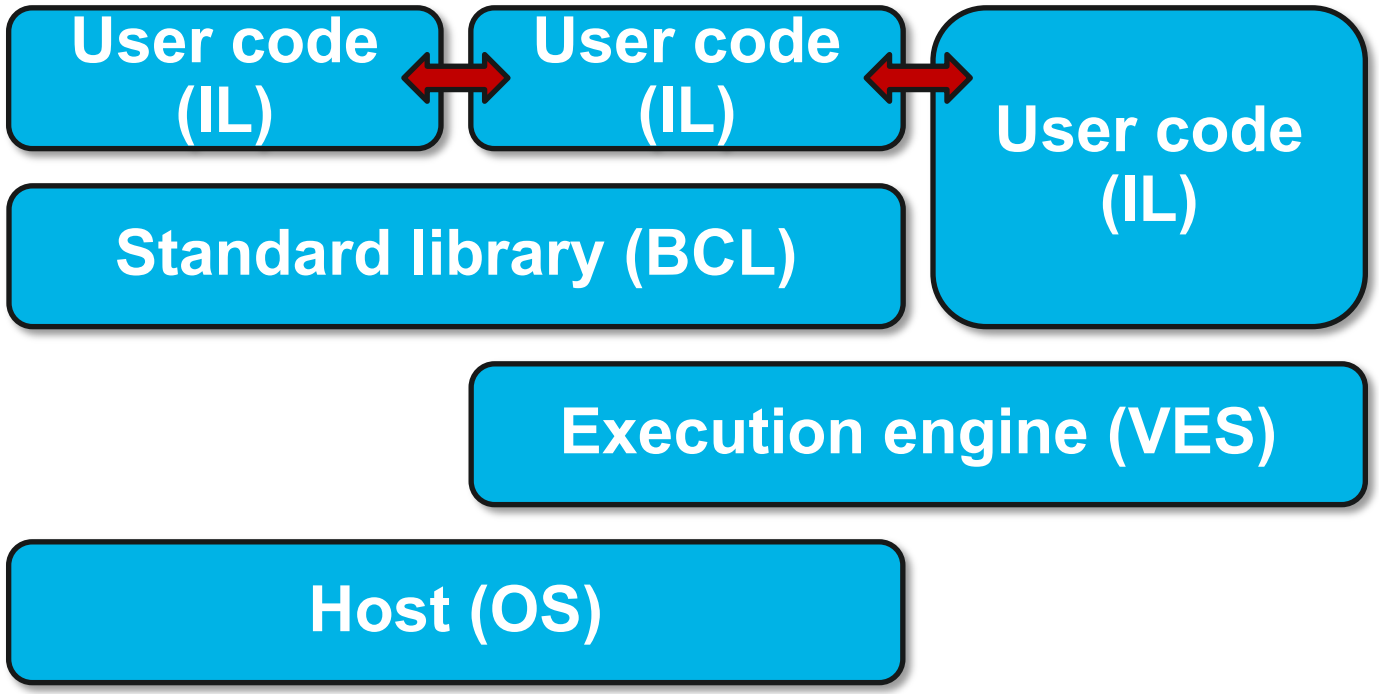
@nielstanis@infosec.exchange

FireFox RLBox

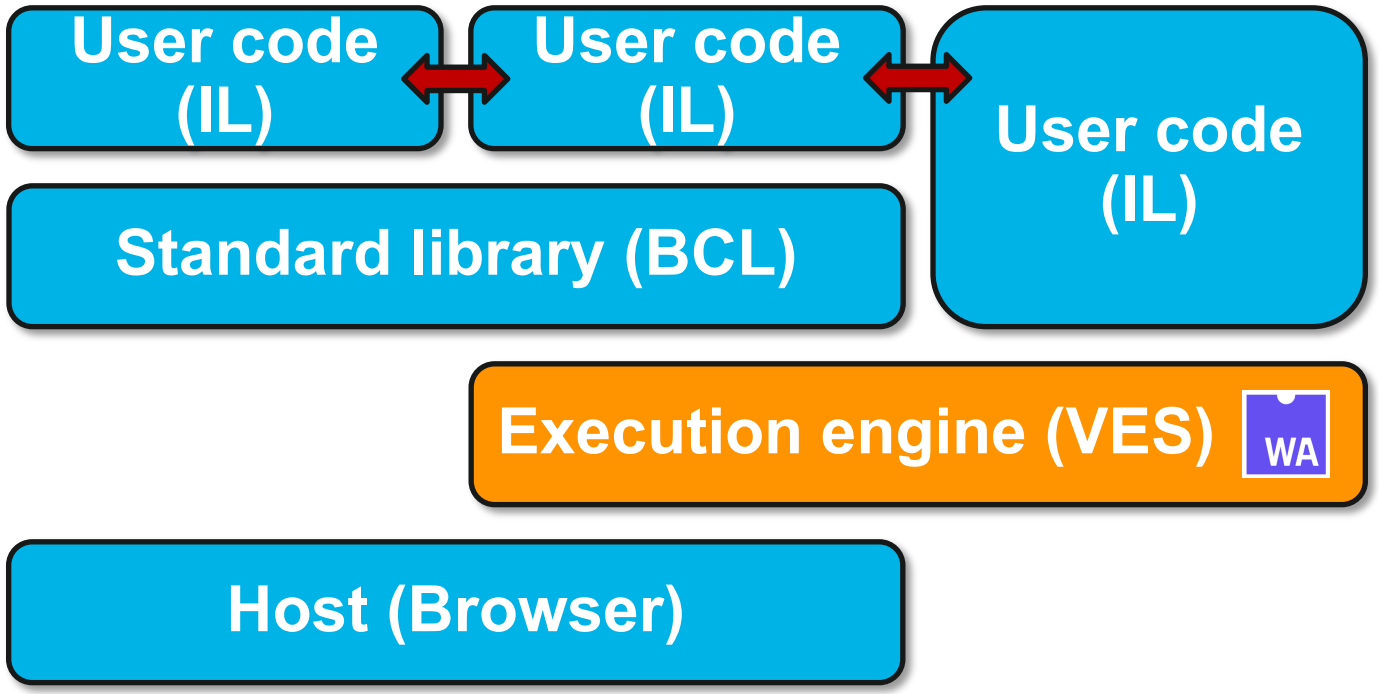


@nielstanis@infosec.exchange

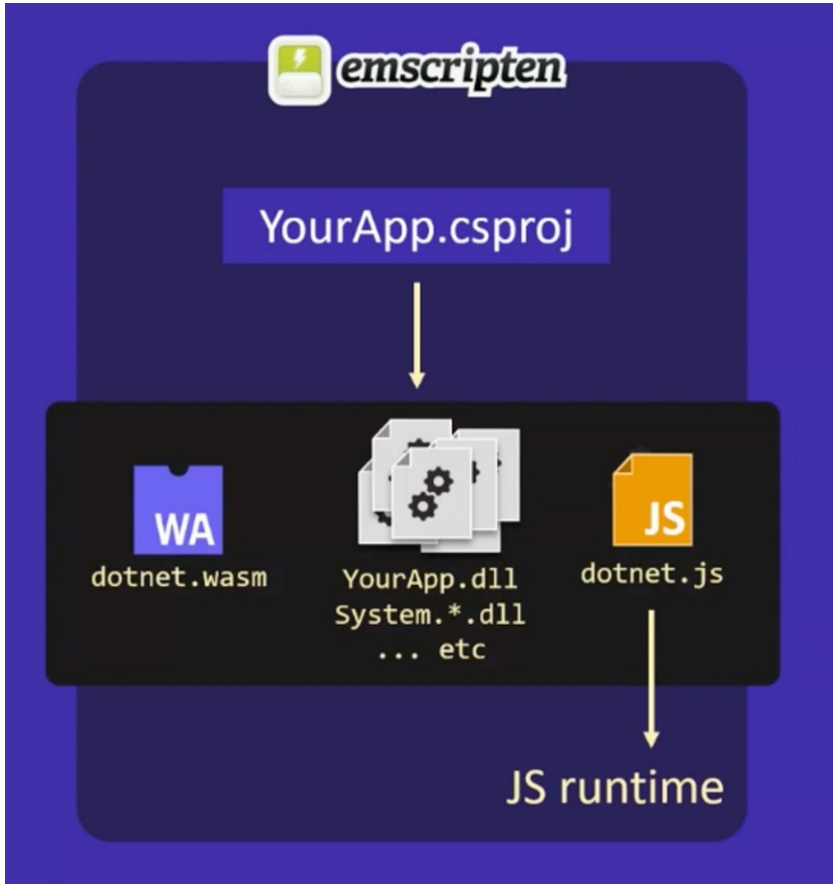
Running .NET on WebAssembly



Running .NET on WebAssembly

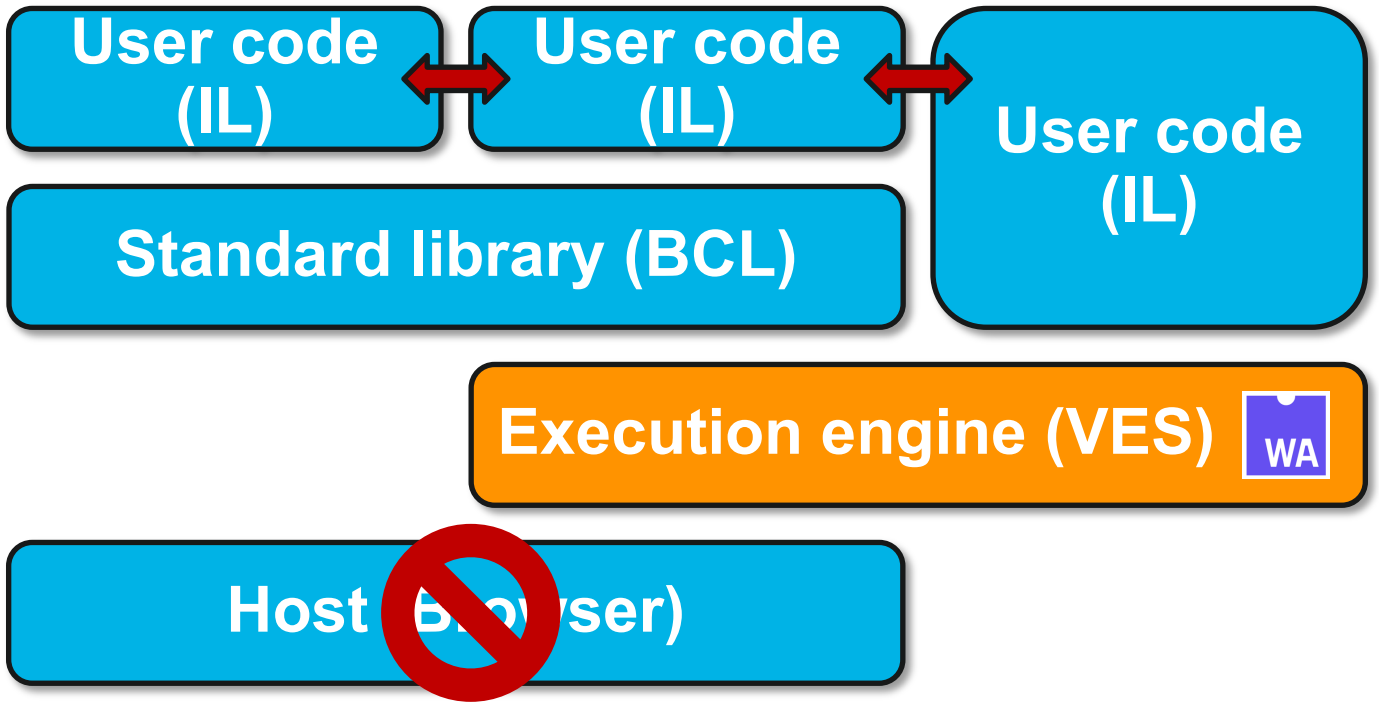


Blazor WebAssembly



@nielstanis@infosec.exchange

Running .NET on WebAssembly



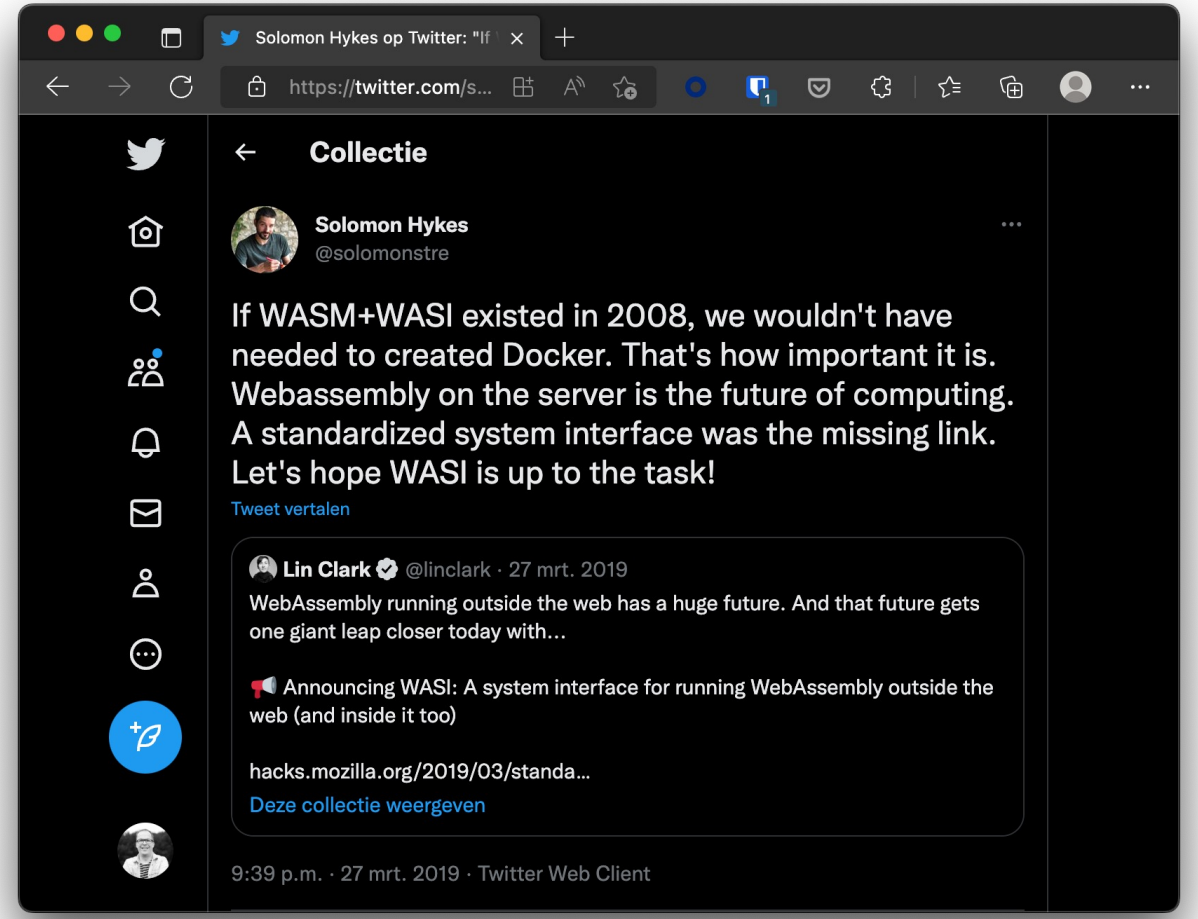
WebAssembly System Interface WASI

- Introduced in March 2019 by Bytecode Alliance
- WasmTime implementation as reference
- POSIX inspired, engine-independent, non-Web system-oriented API for WebAssembly

WebAssembly System Interface WASI

- Strong sandbox with Capability Based Security
- Right now, supports e.g. FileSystem actions
- Future support for sockets and other system resources.
- Anyone recall .NET Standard? ☺

Docker vs WASM & WASI

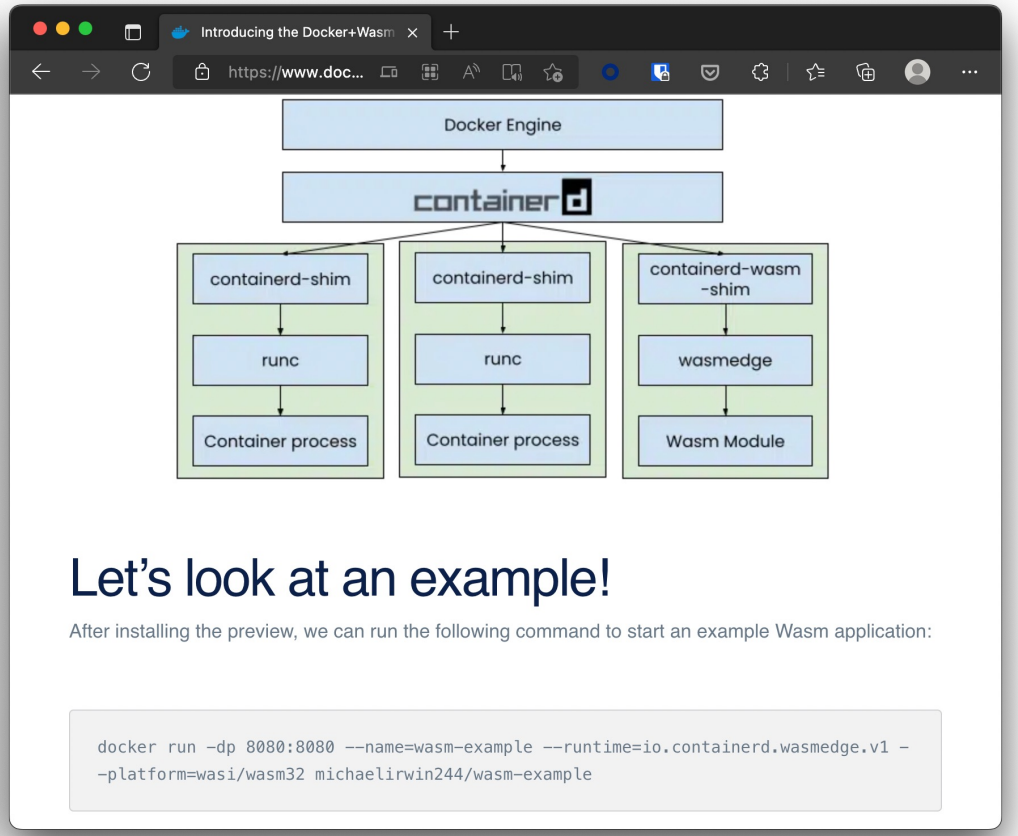


@nielstanis@infosec.exchange

Docker vs WASM & WASI

@nielstanis@infosec.exchange

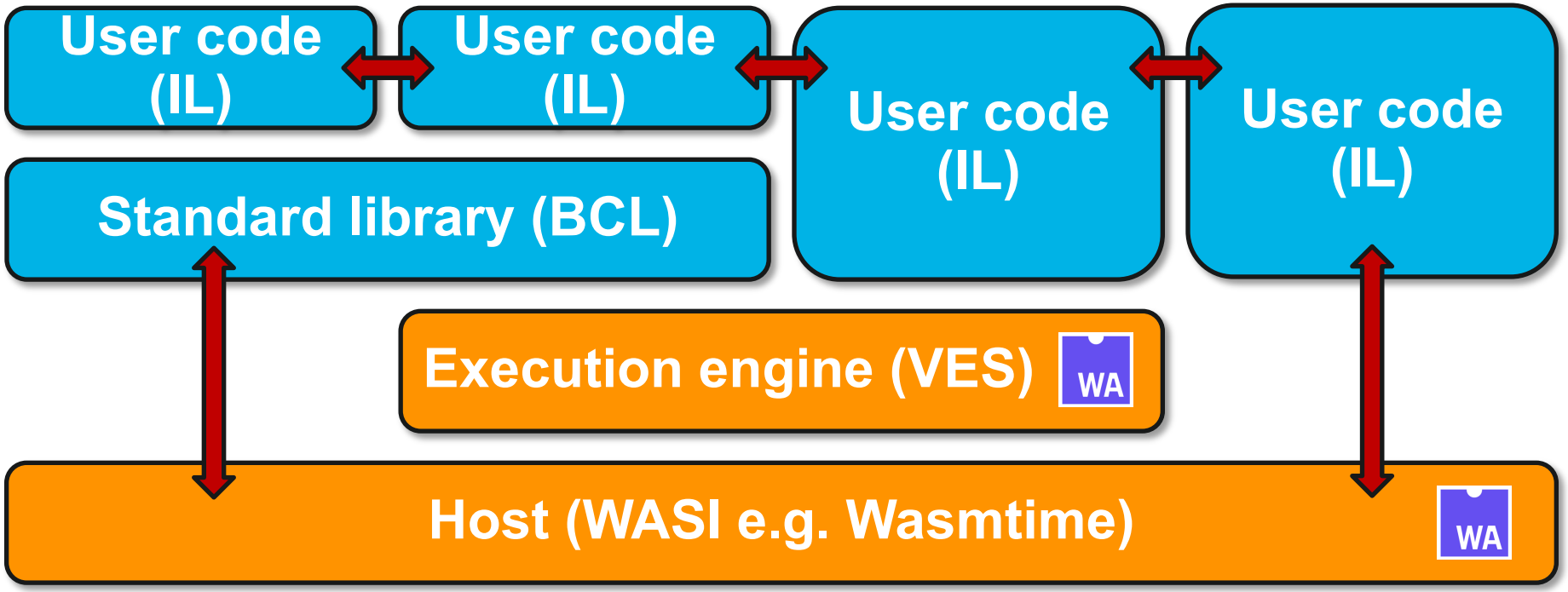
Docker & WASM



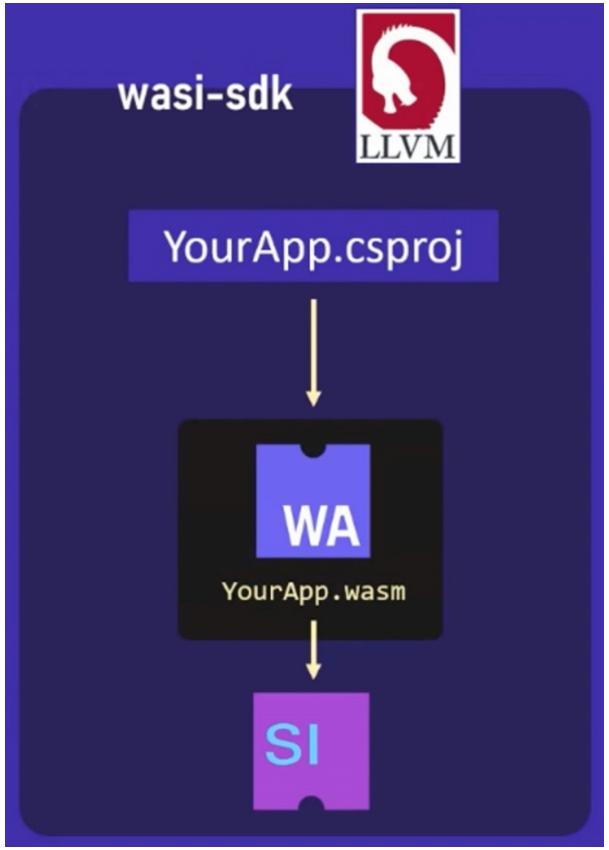
dotnet friday

@nielstanis@infosec.exchange

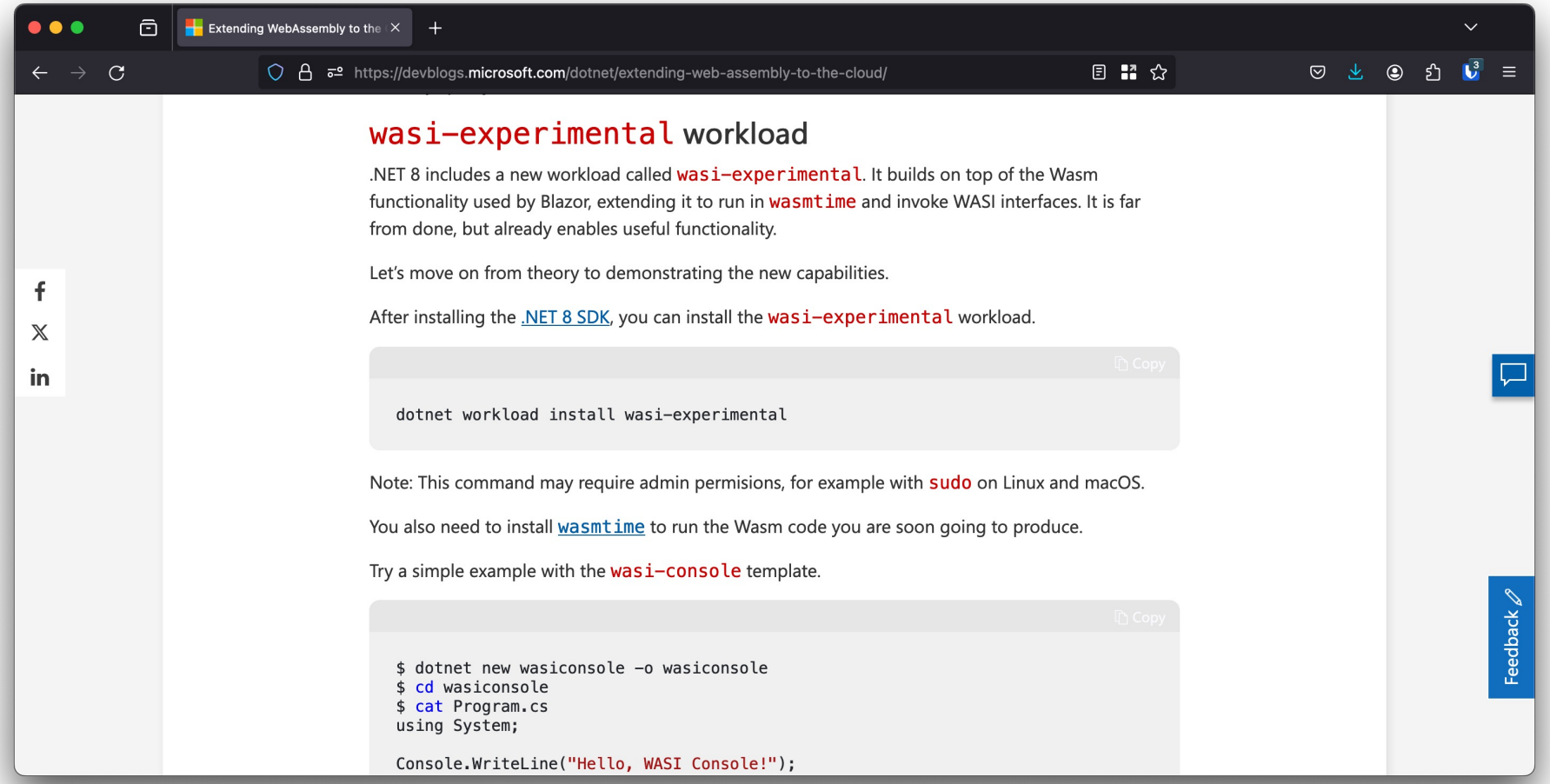
WebAssembly System Interface WASI



Experimental WASI SDK for .NET



.NET 8 WASI-Experimental



@nielstanis@infosec.exchange

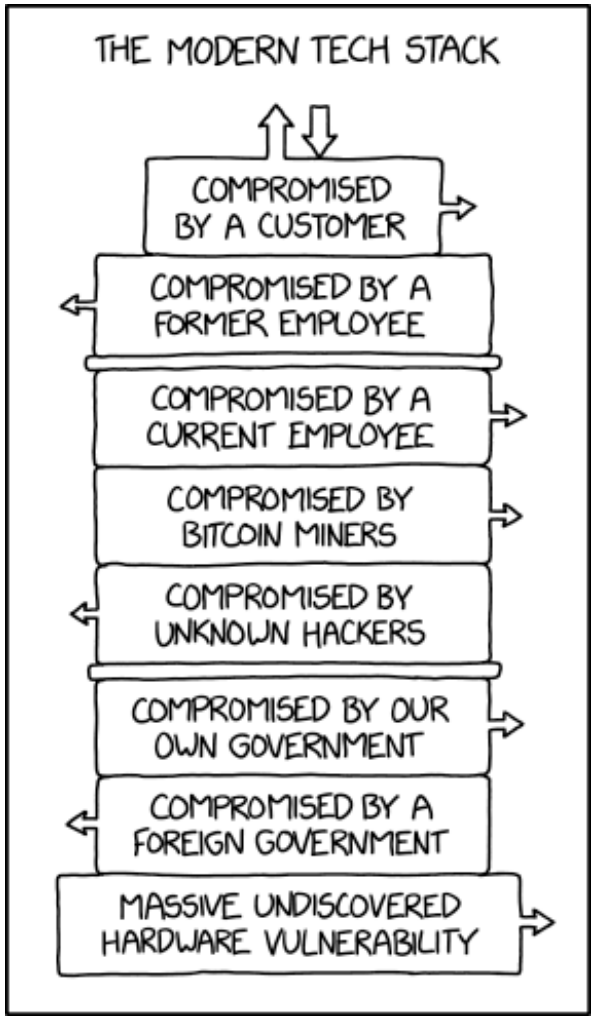
Extending .NET with WASM

- WasmTime.NET NuGet package
- Can run WASM inside of any .NET application
- Extend with Rust based WASM module
- Limit capabilities
- Demo time!

dotnet friday

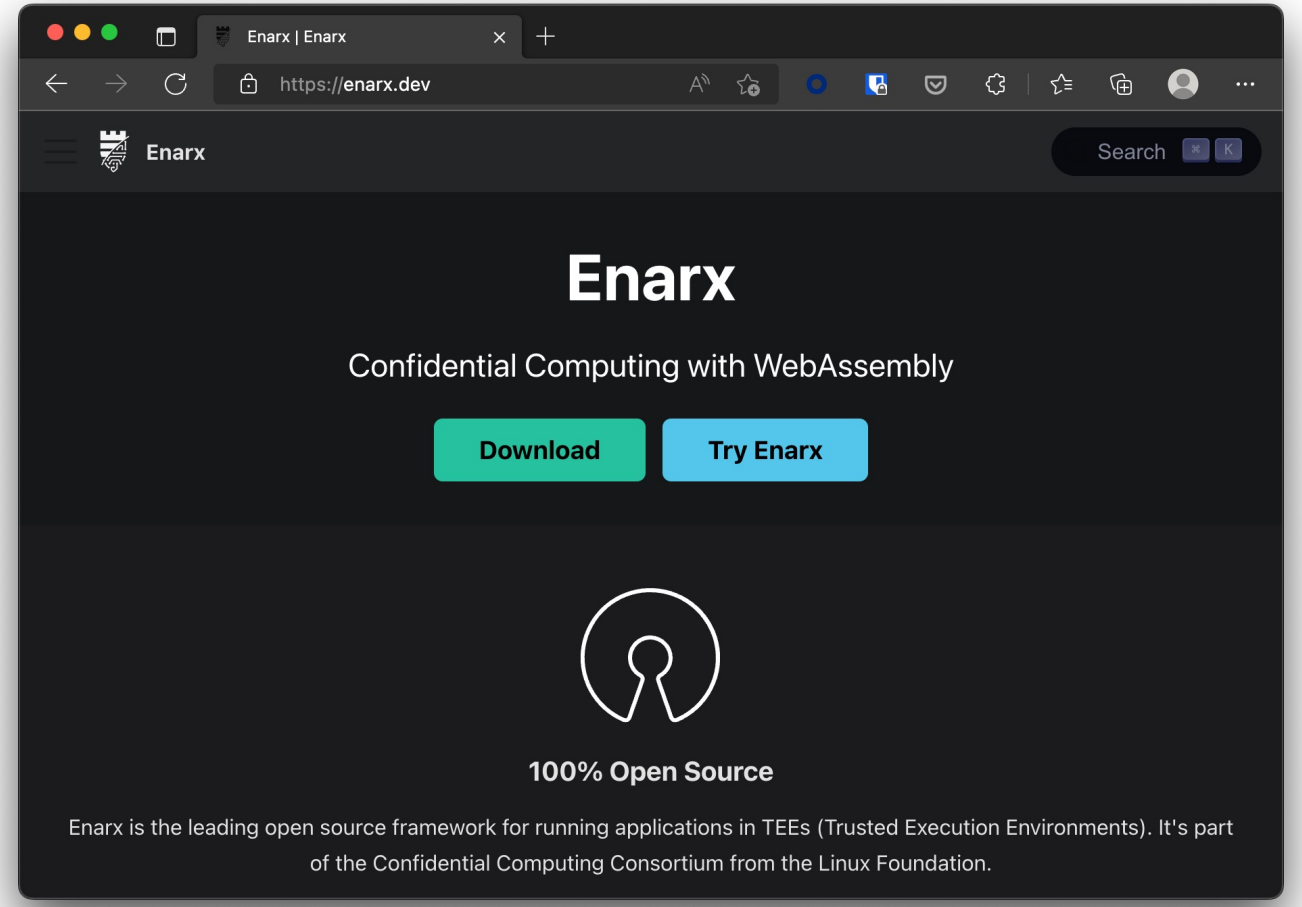
@nielstanis@infosec.exchange

Trusted Computing - XKCD 2166



@nielstanis@infosec.exchange

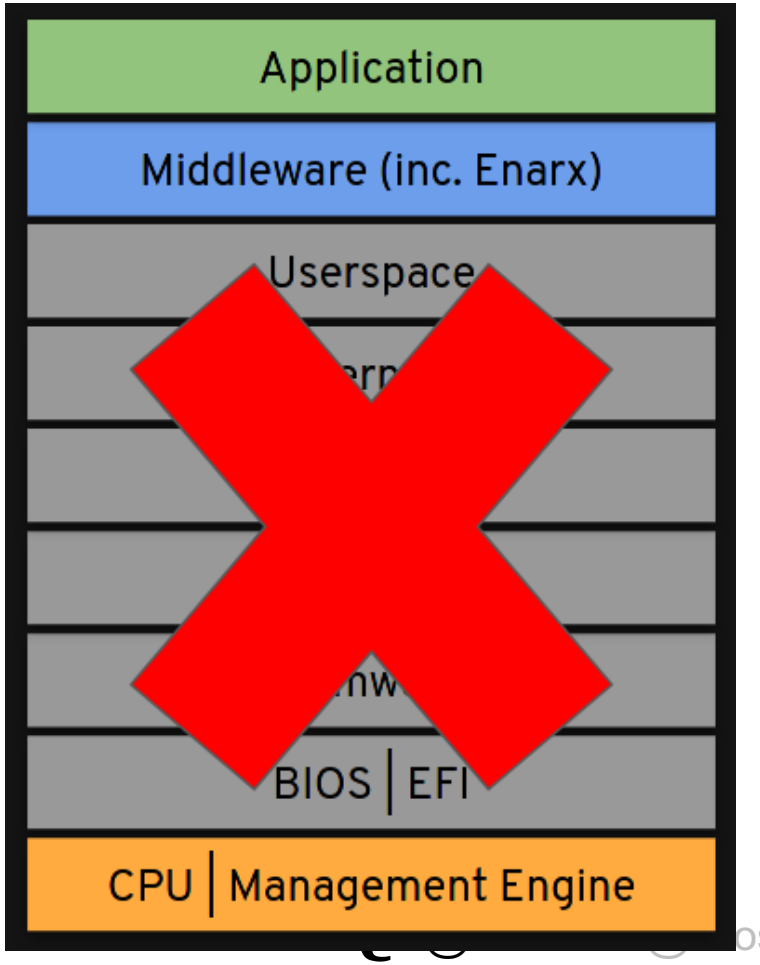
Enarx



@nielstanis@infosec.exchange

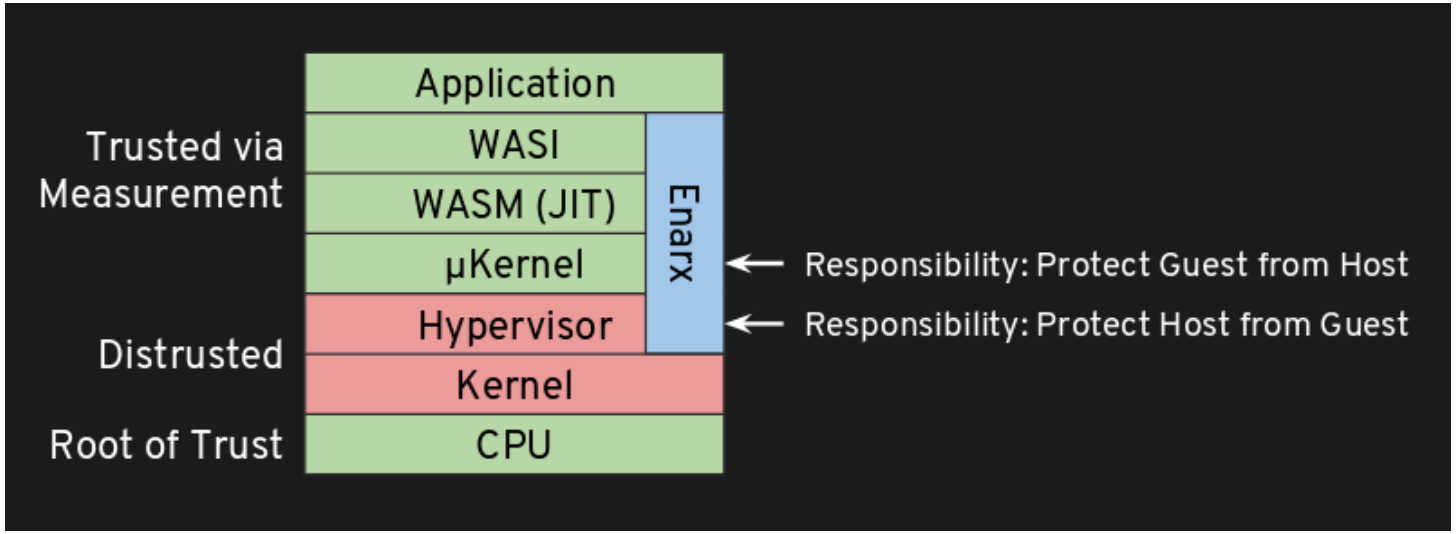
Enarx Threat Model

- Don’t trust the host
- Don’t trust the host owner
- Don’t trust the host operator
- Hardware cryptographically verified
- Software audited and cryptographically verified

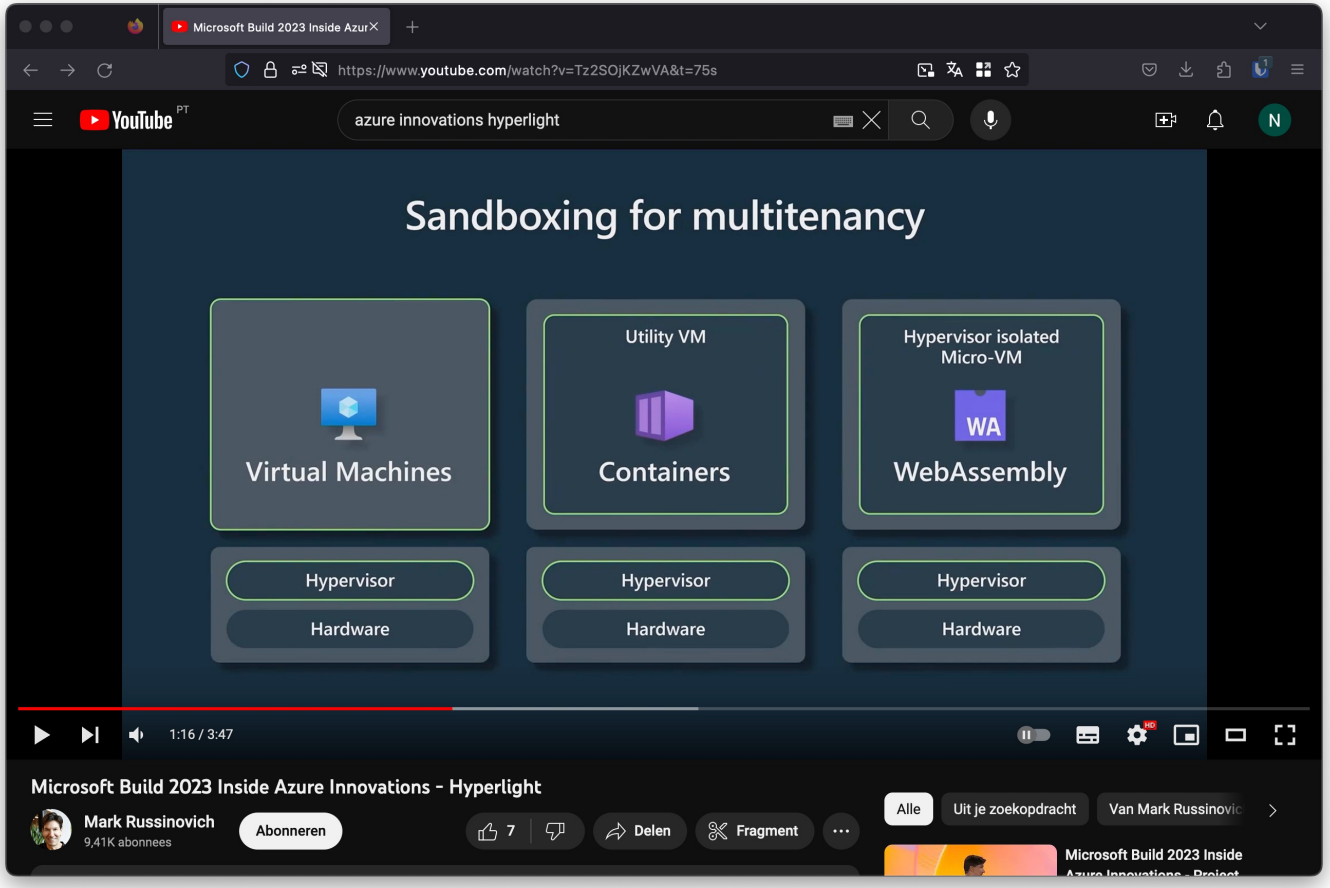


Enarx

- Leverages Trusted Execution Environment (TEE) direct on processor
  - AMD's SEV, Intel's SGX and IBM's PEF
- Attestation of hardware and Enarx runtime



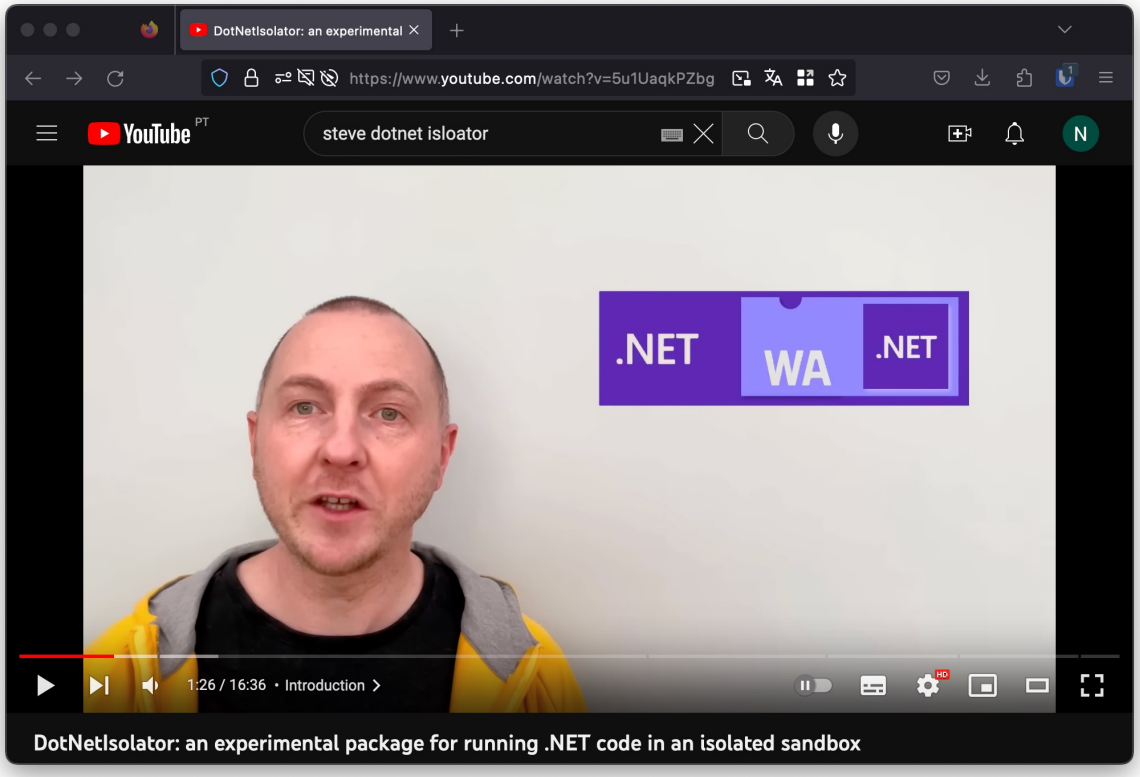
Project Hyperlight



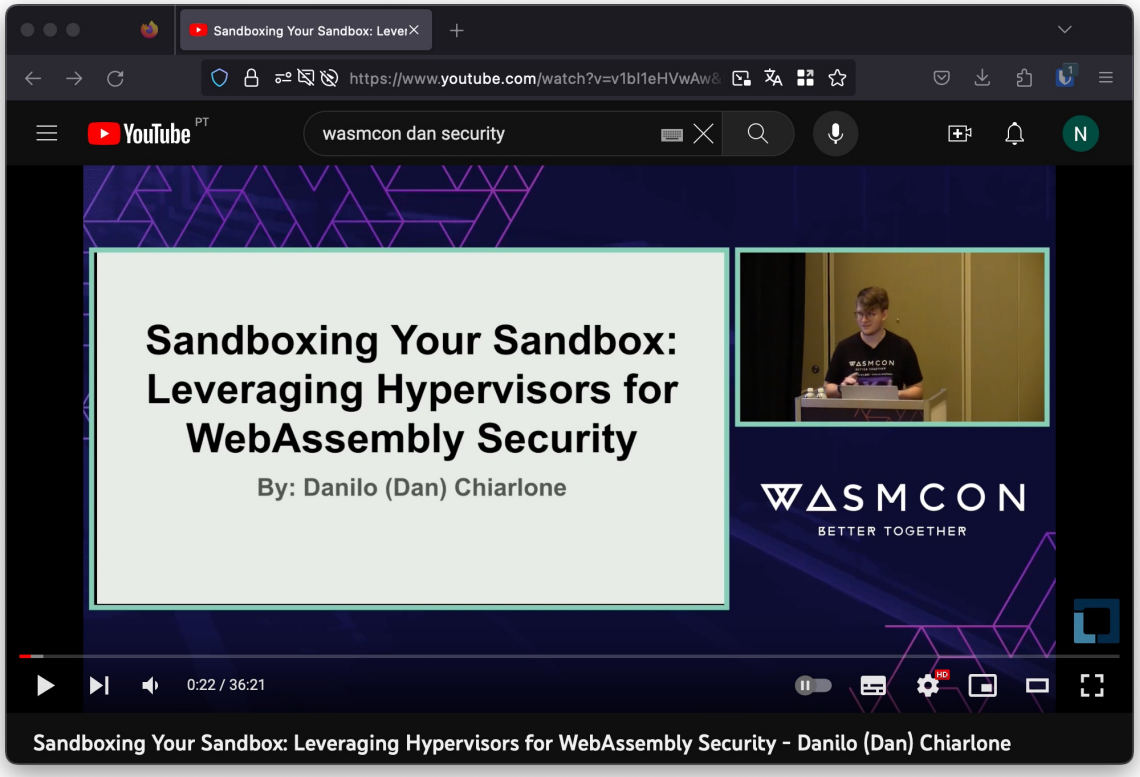
dotnet friday

@nielstanis@infosec.exchange

DotNetIsolator & Project Hyperlight



DotNetIsolator: an experimental package for running .NET code in an isolated sandbox

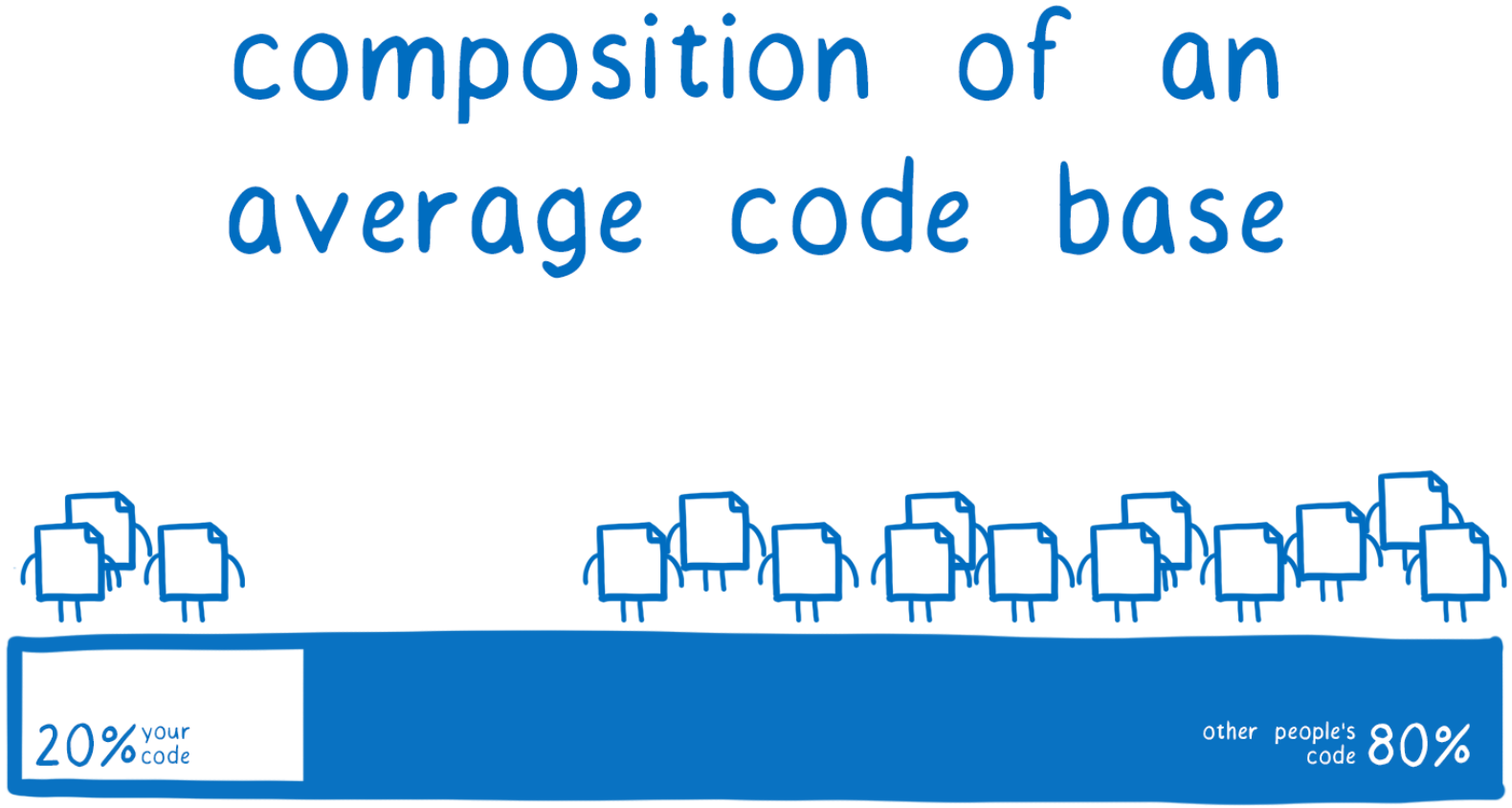


Sandboxing Your Sandbox: Leveraging Hypervisors for WebAssembly Security - Danilo (Dan) Chiarlone

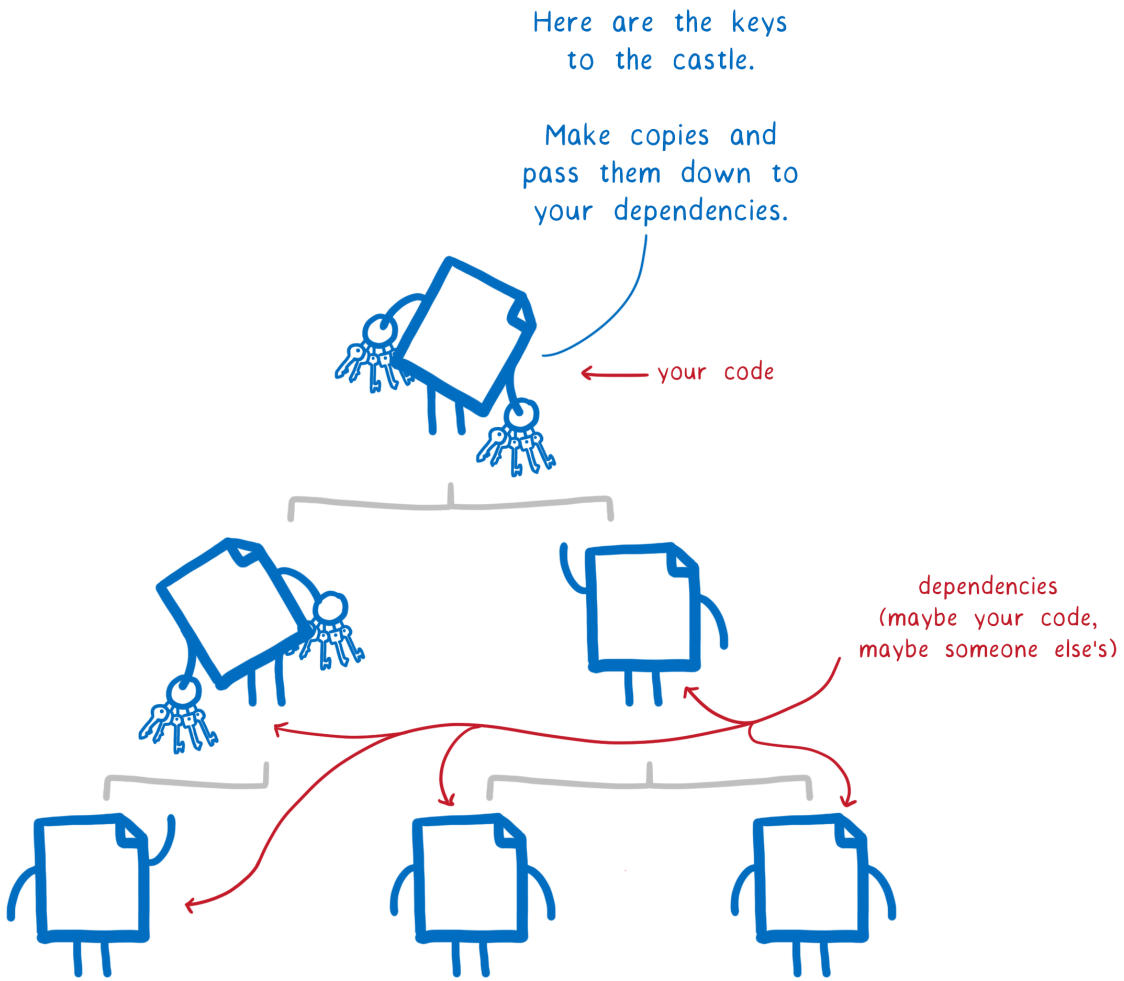
dotnet friday

@nielstanis@infosec.exchange

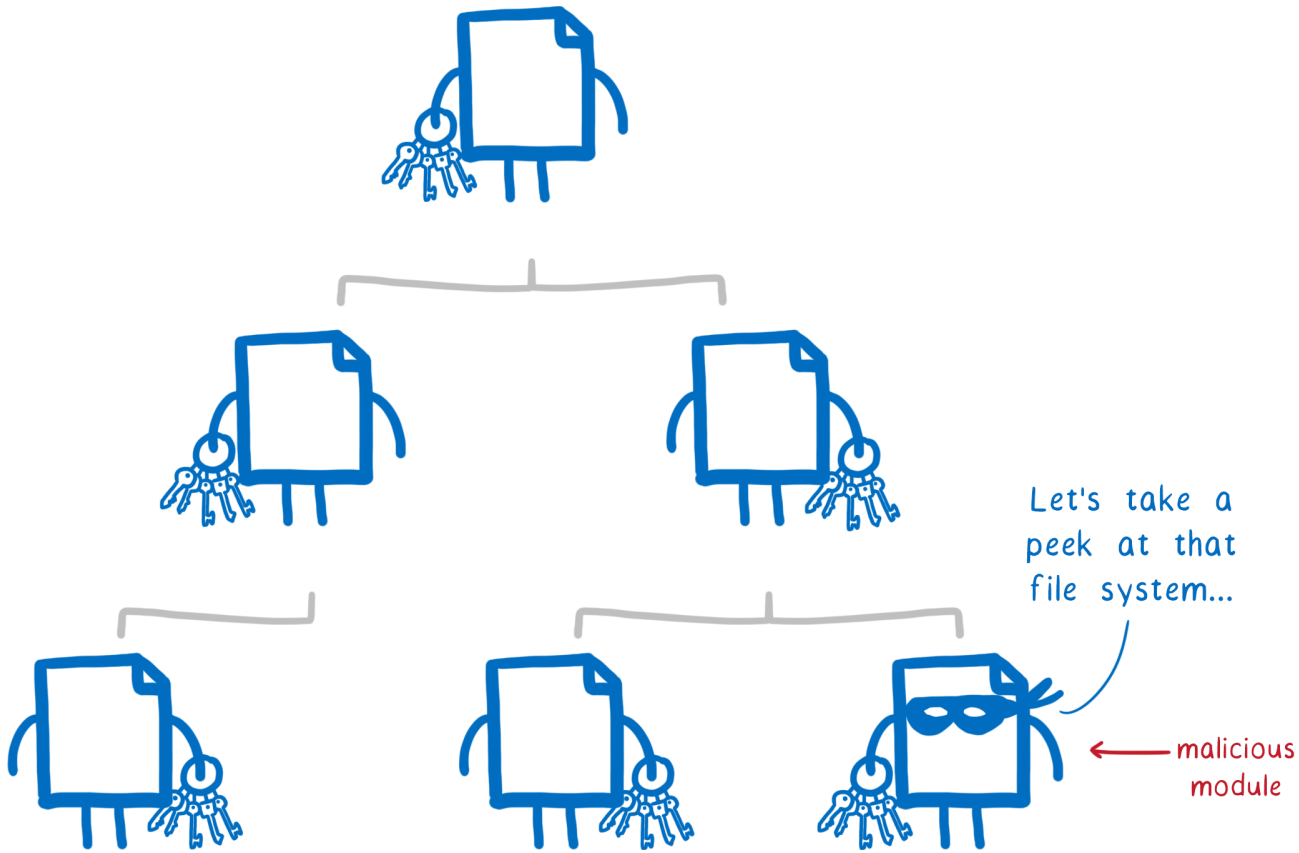
WASM – What's next?



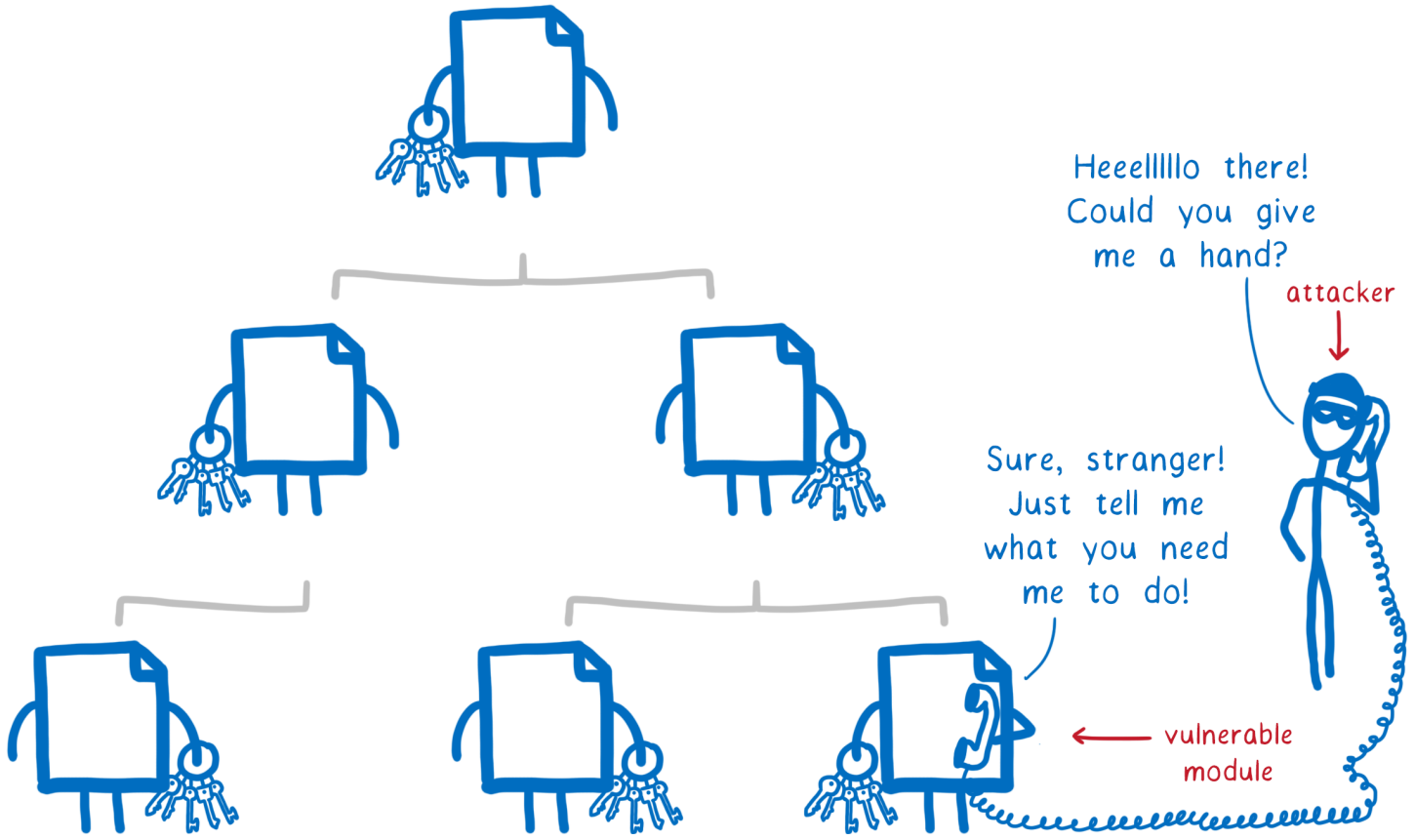
Dependencies



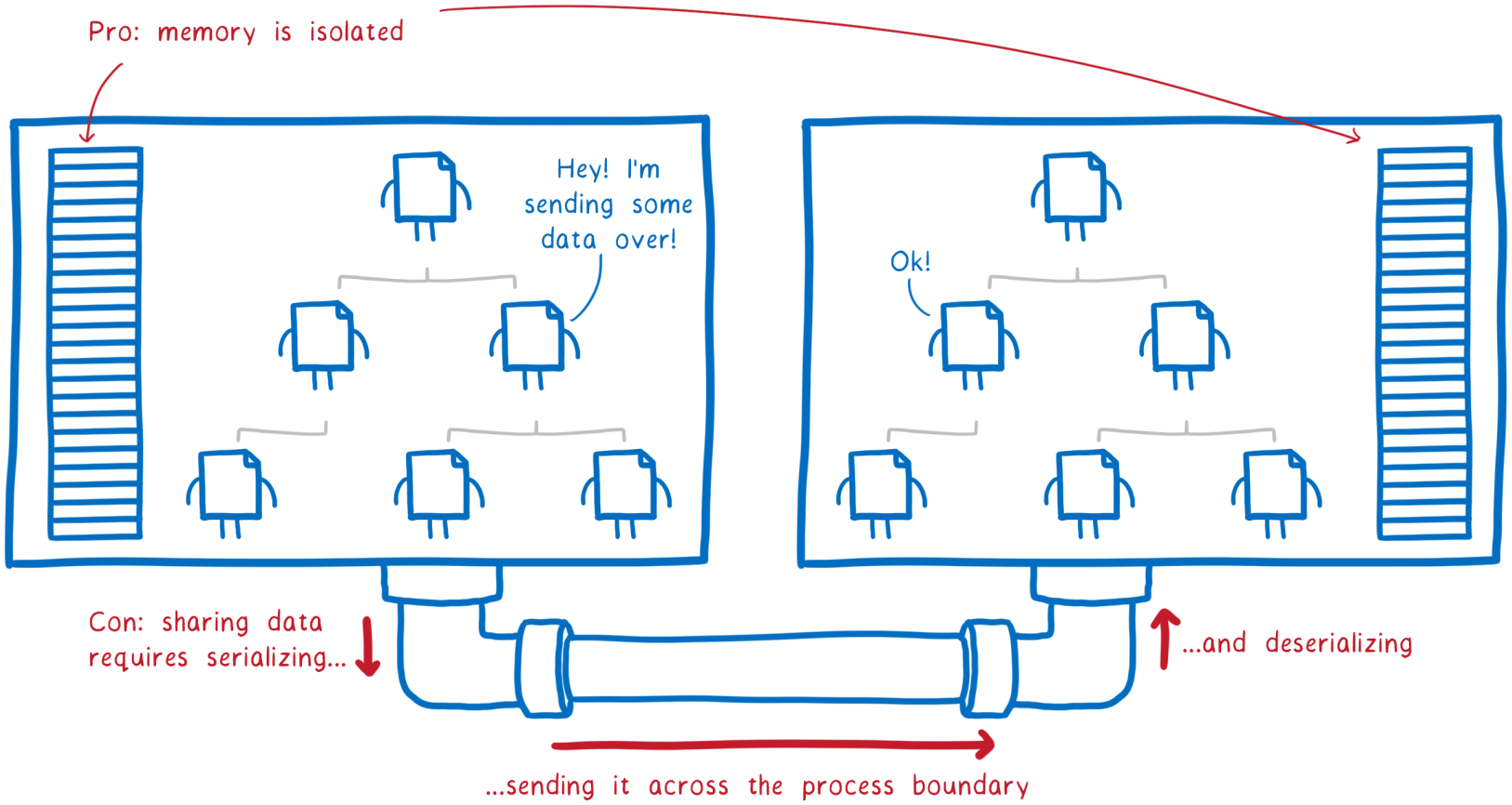
Malicious module



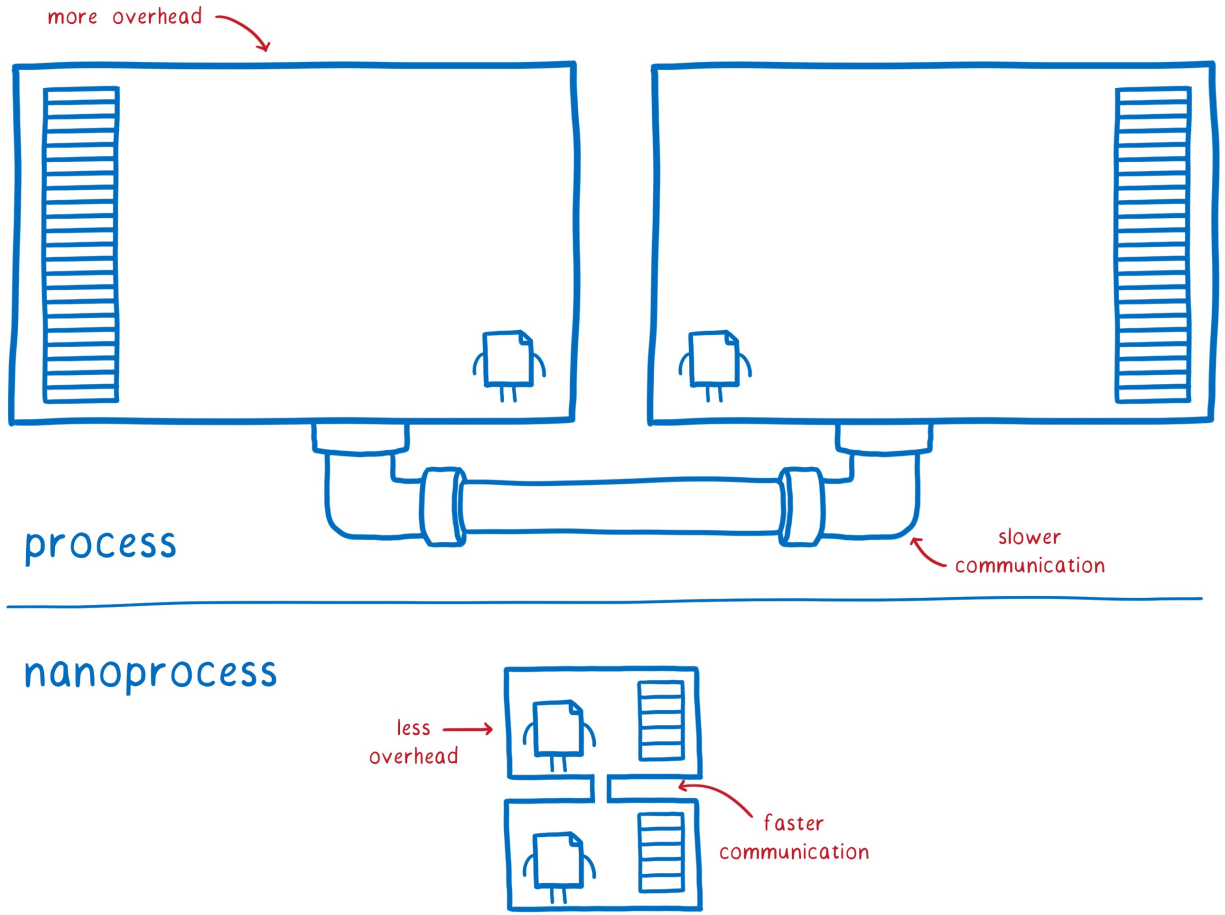
Vulnerable module



Process Isolation

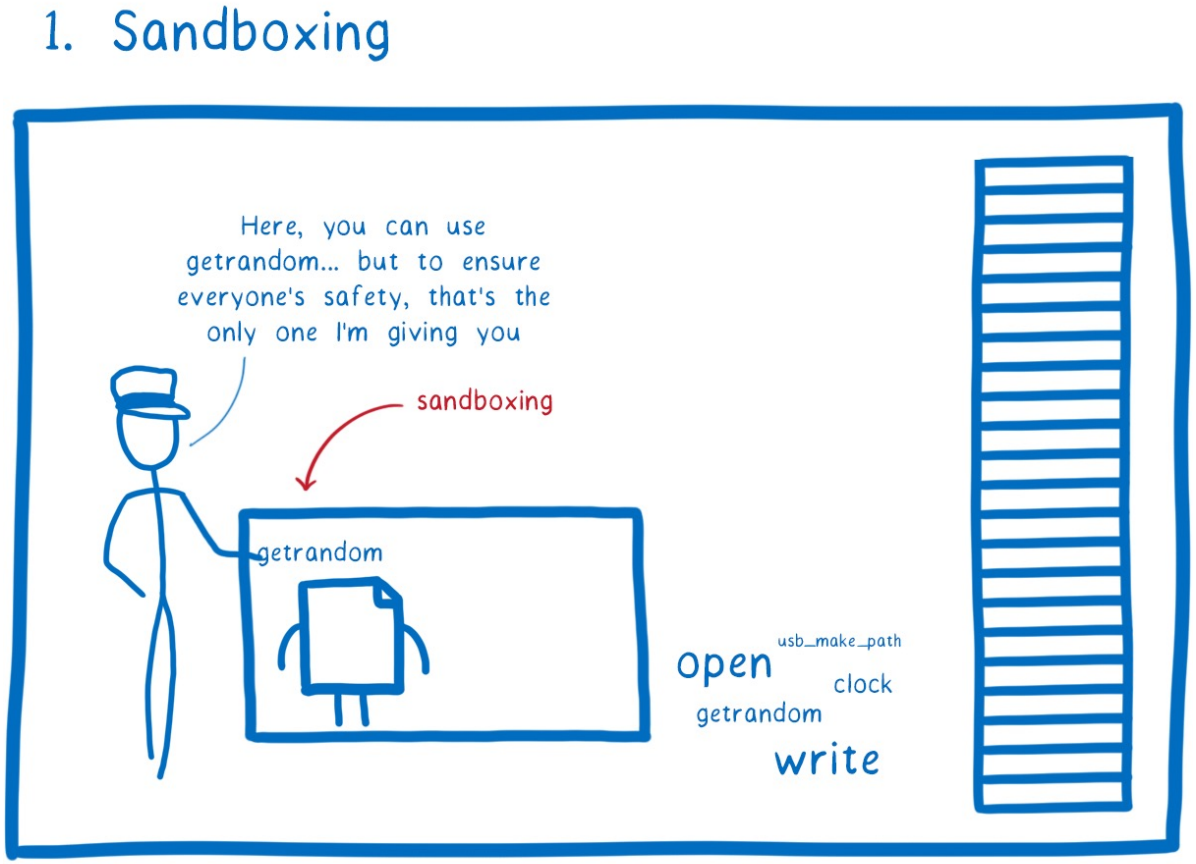


WebAssembly Nano-Process

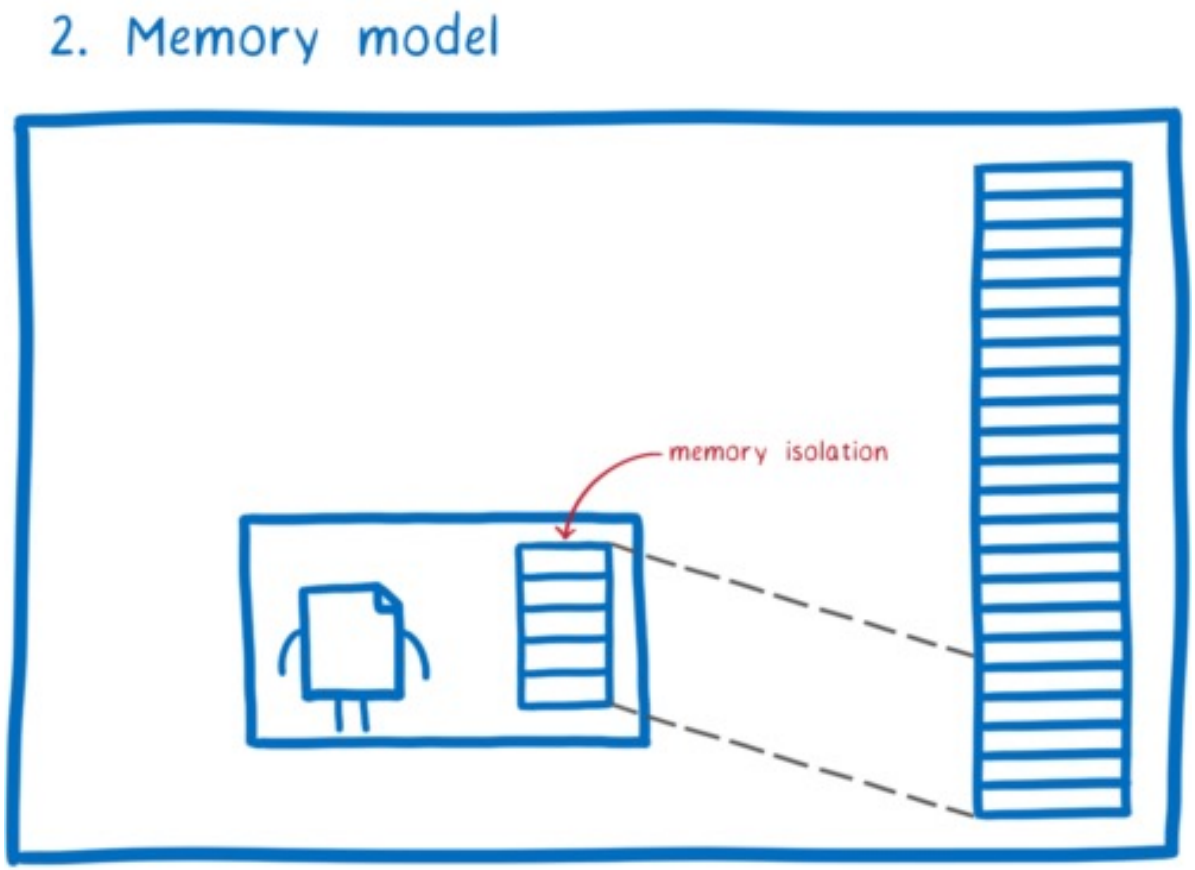


@nielstanis@infosec.exchange

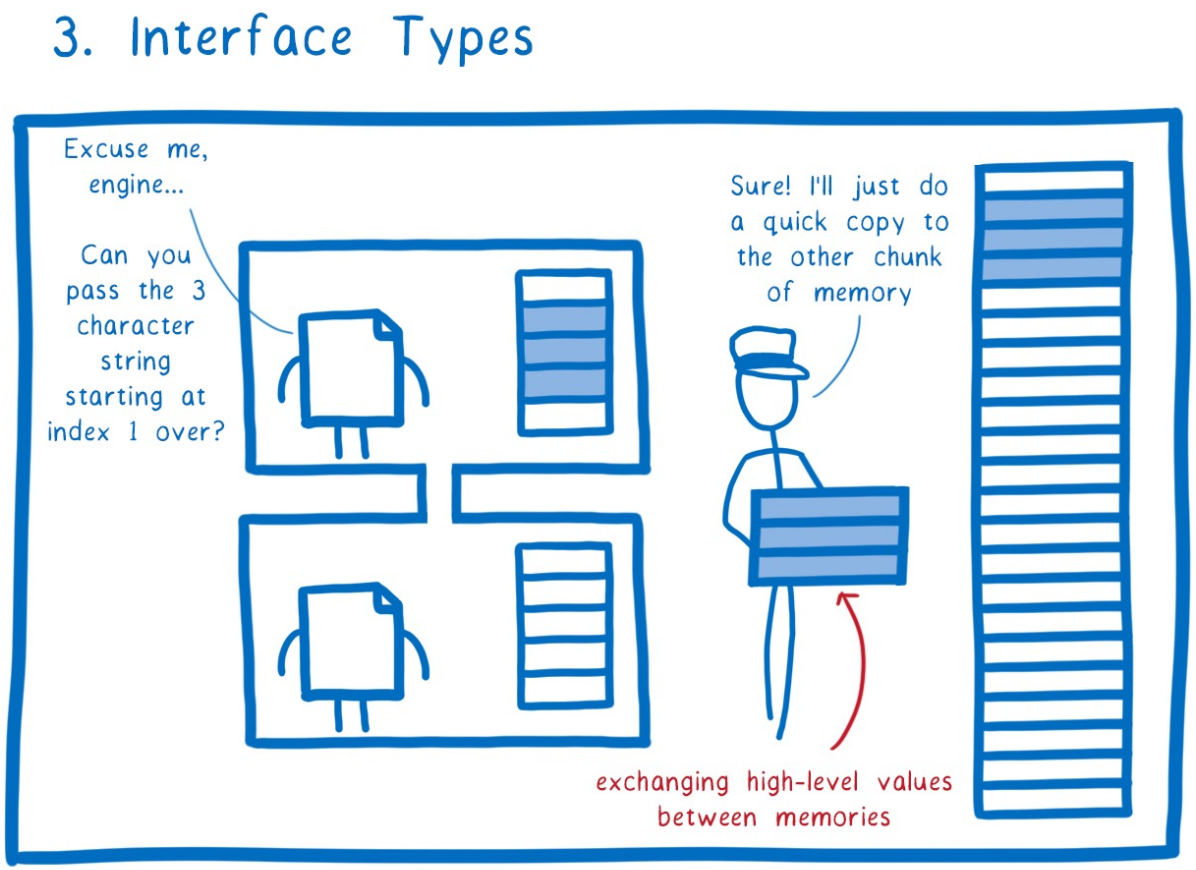
WebAssembly Nano-Process



WebAssembly Nano-Process



WebAssembly Nano-Process

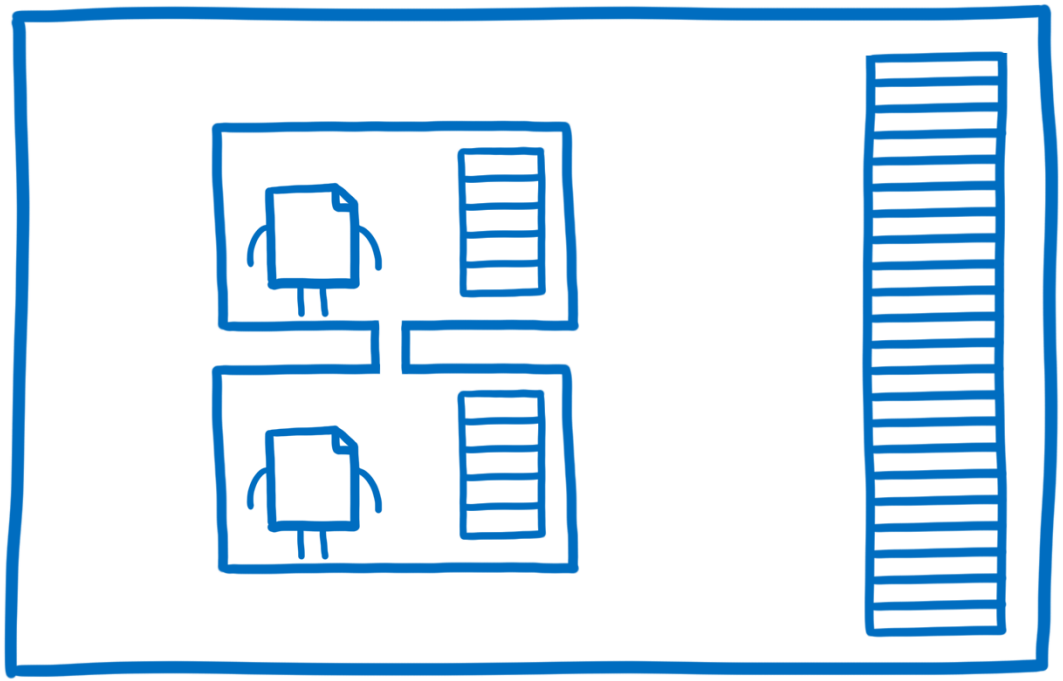


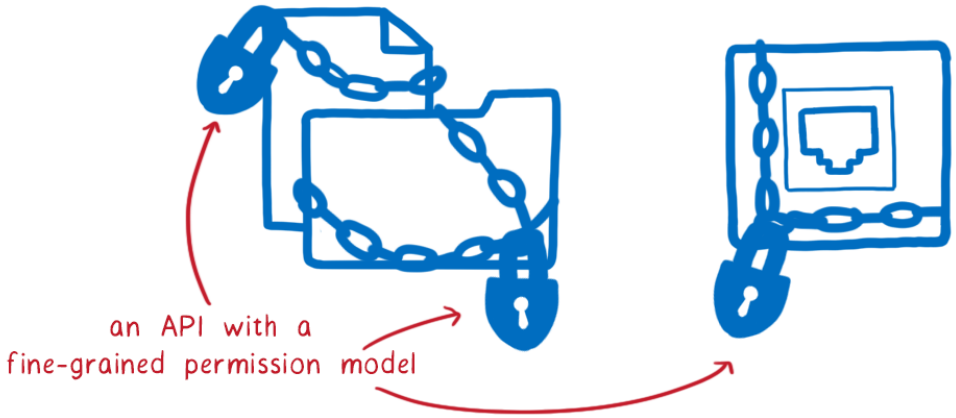
dotnet friday

@nielstanis@infosec.exchange

WebAssembly Nano-Process

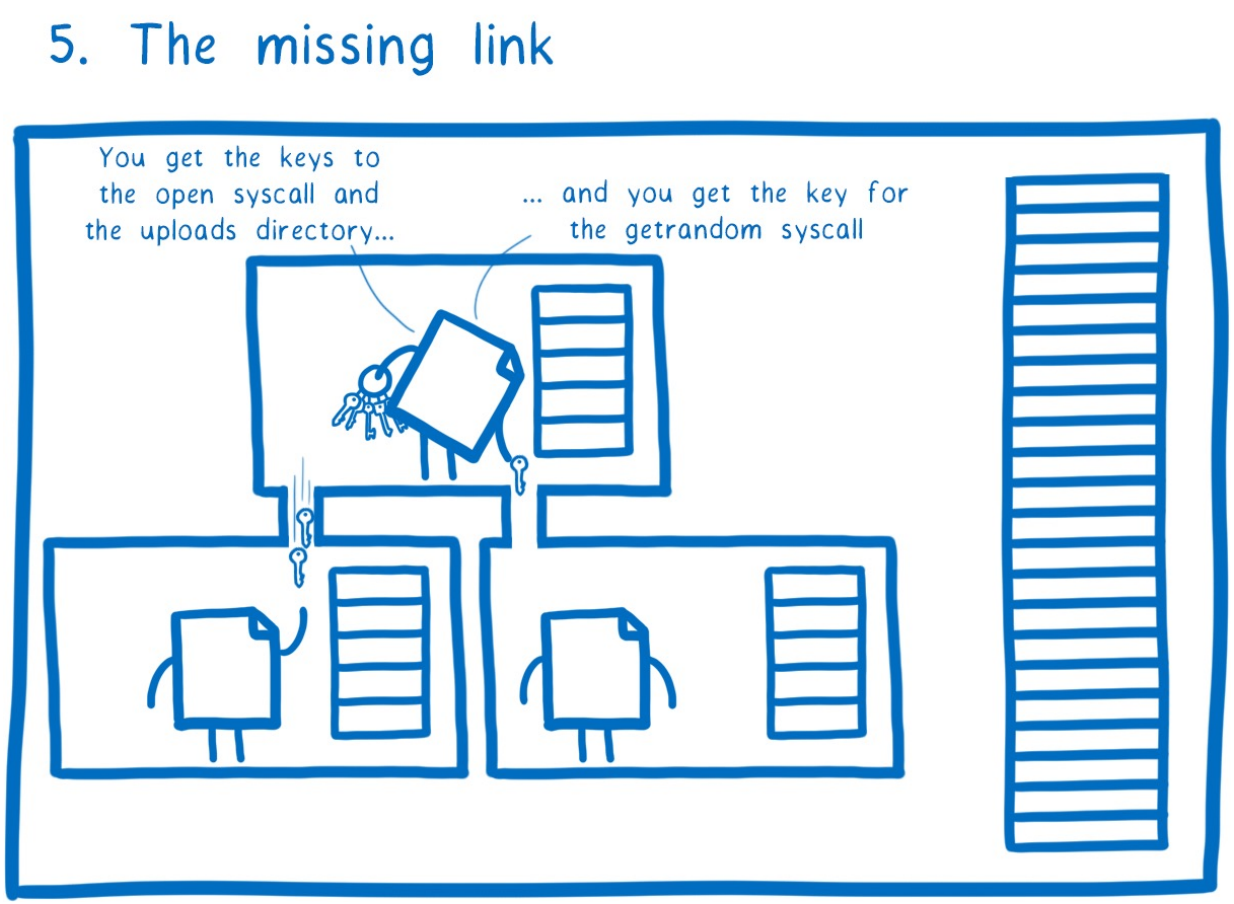
4. WebAssembly System Interface





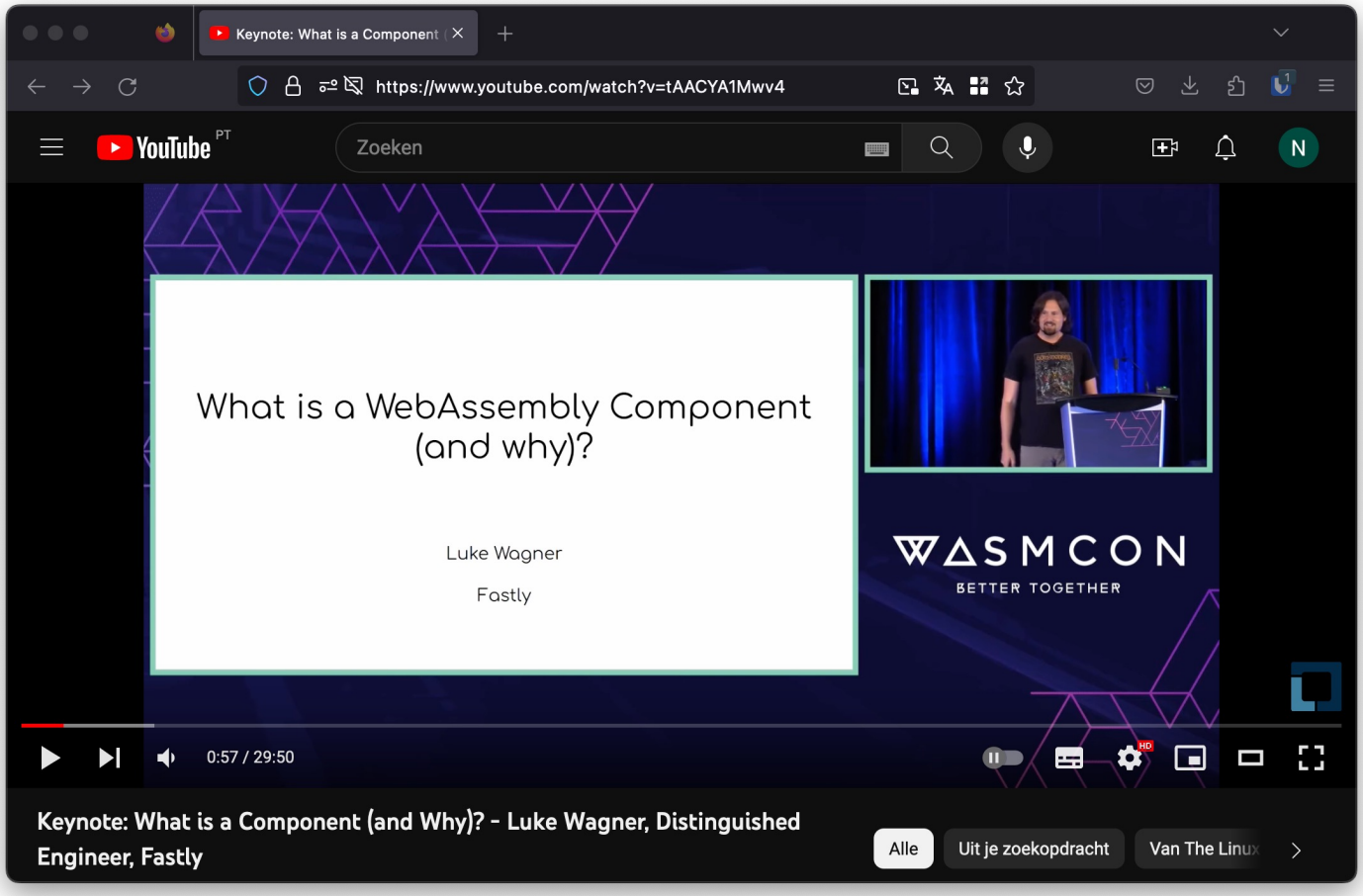
@nielstanis@infosec.exchange

WebAssembly Nano-Process



@nielstanis@infosec.exchange

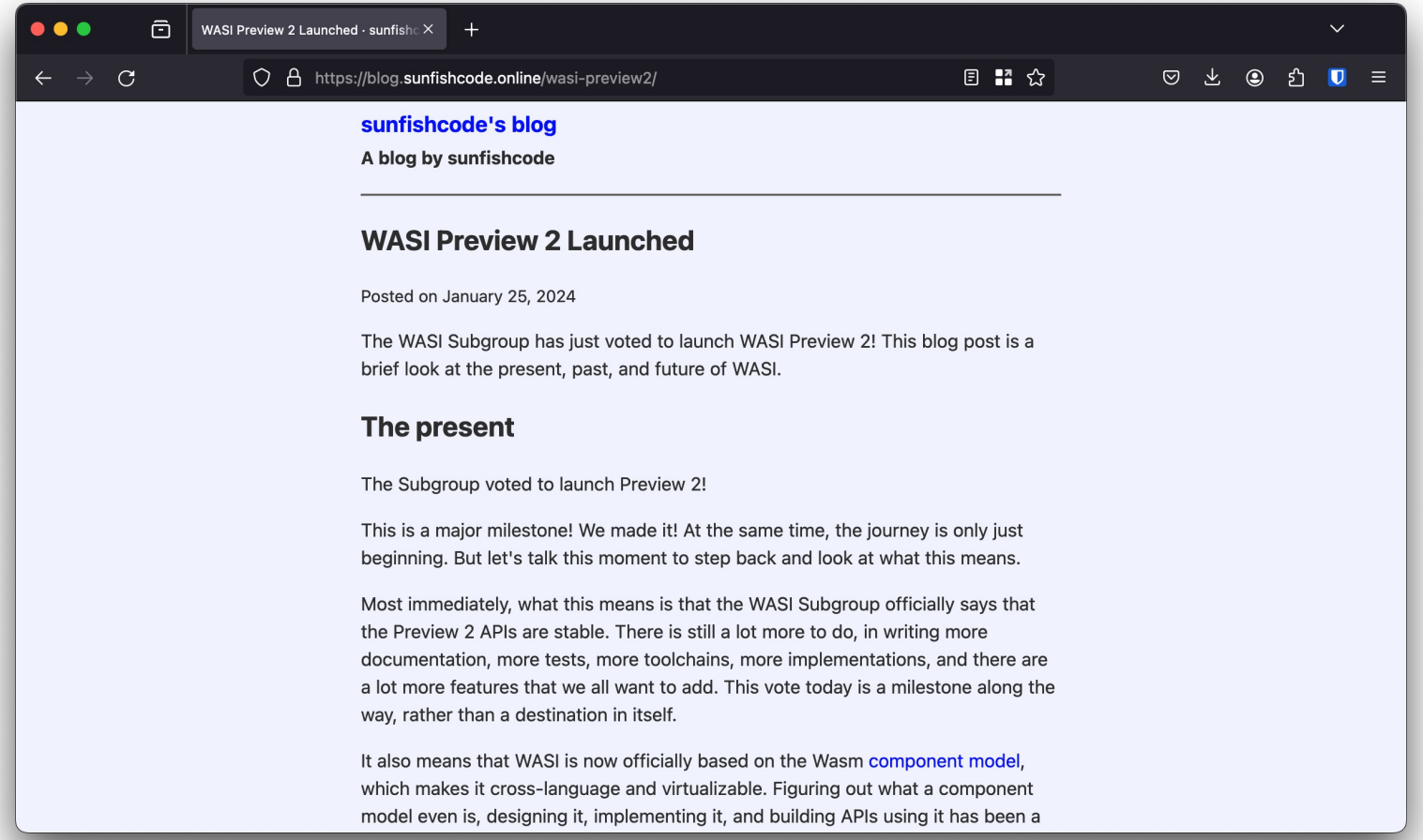
WebAssembly Component Model



dotnet friday

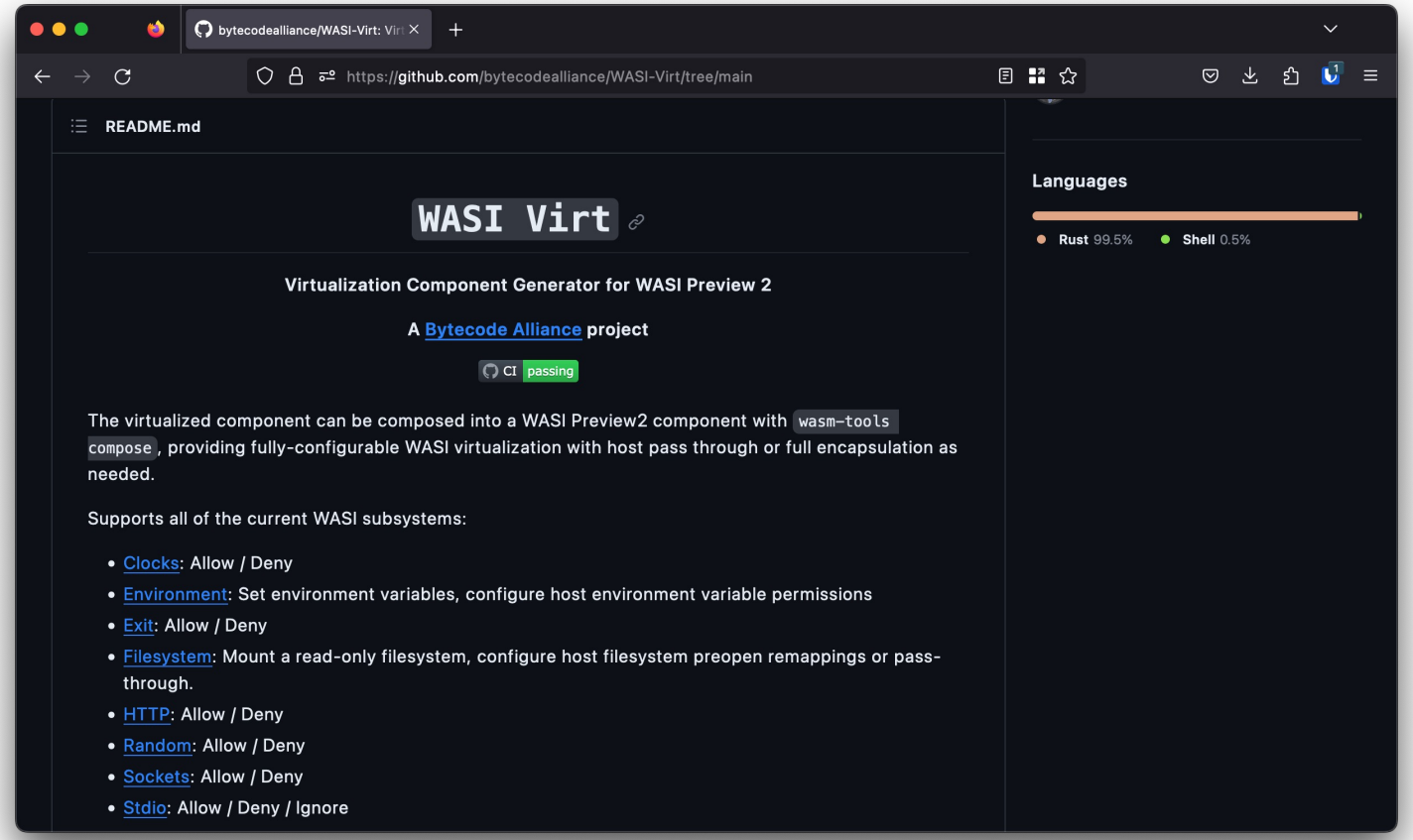
@nielstanis@infosec.exchange

WASI Preview 2



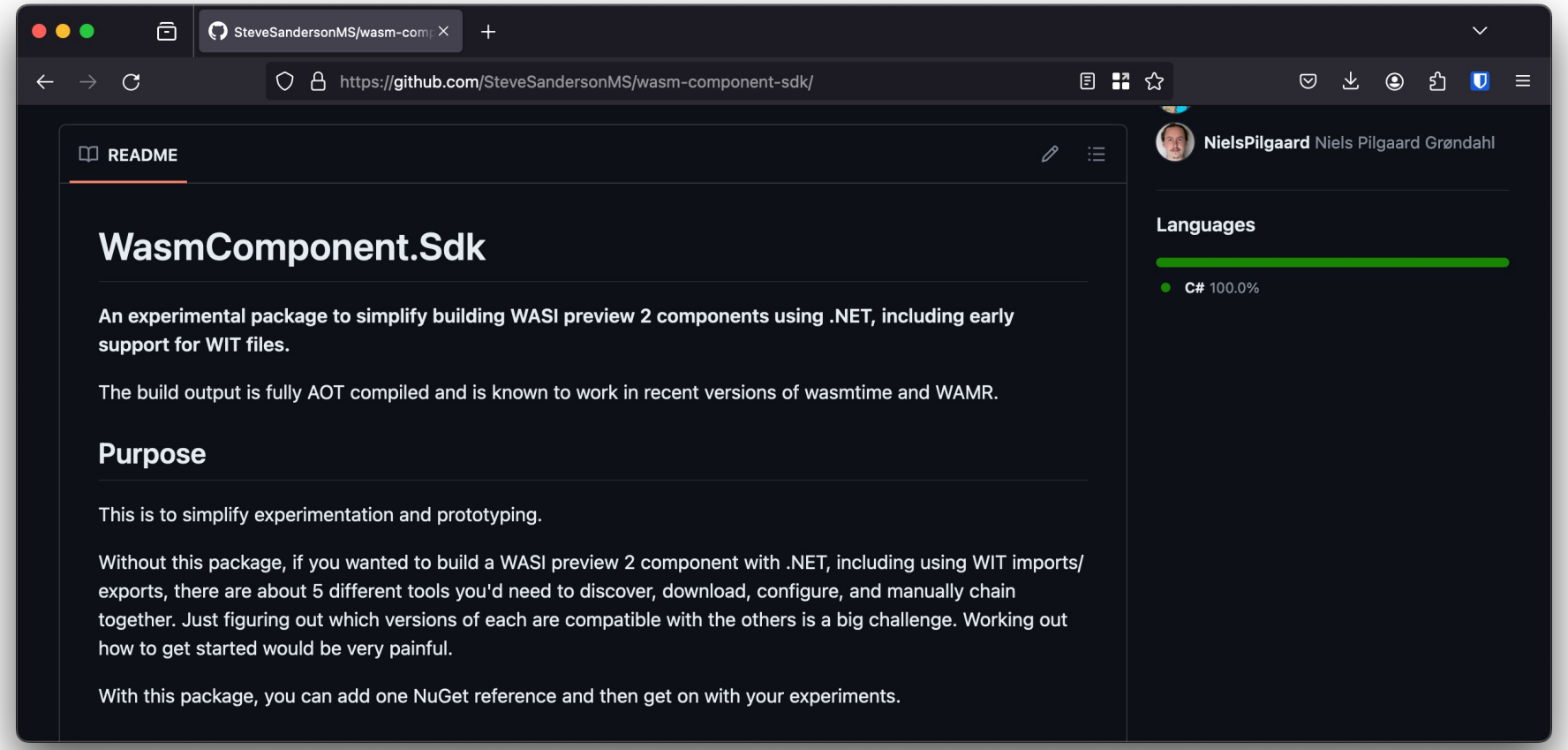
@nielstanis@infosec.exchange

WASI Virt



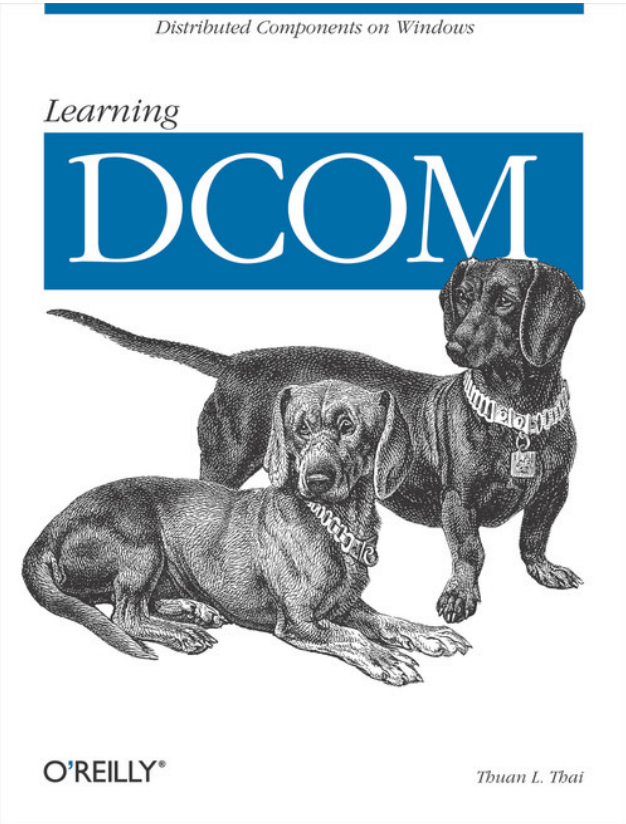
@nielstanis@infosec.exchange

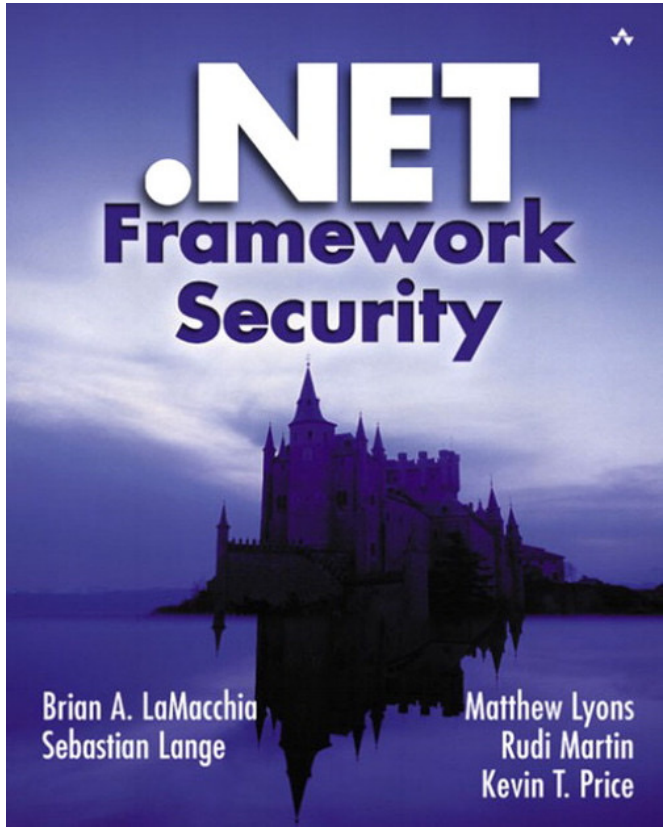
WasmComponent.SDK



@nielstanis@infosec.exchange

Have we seen this before?



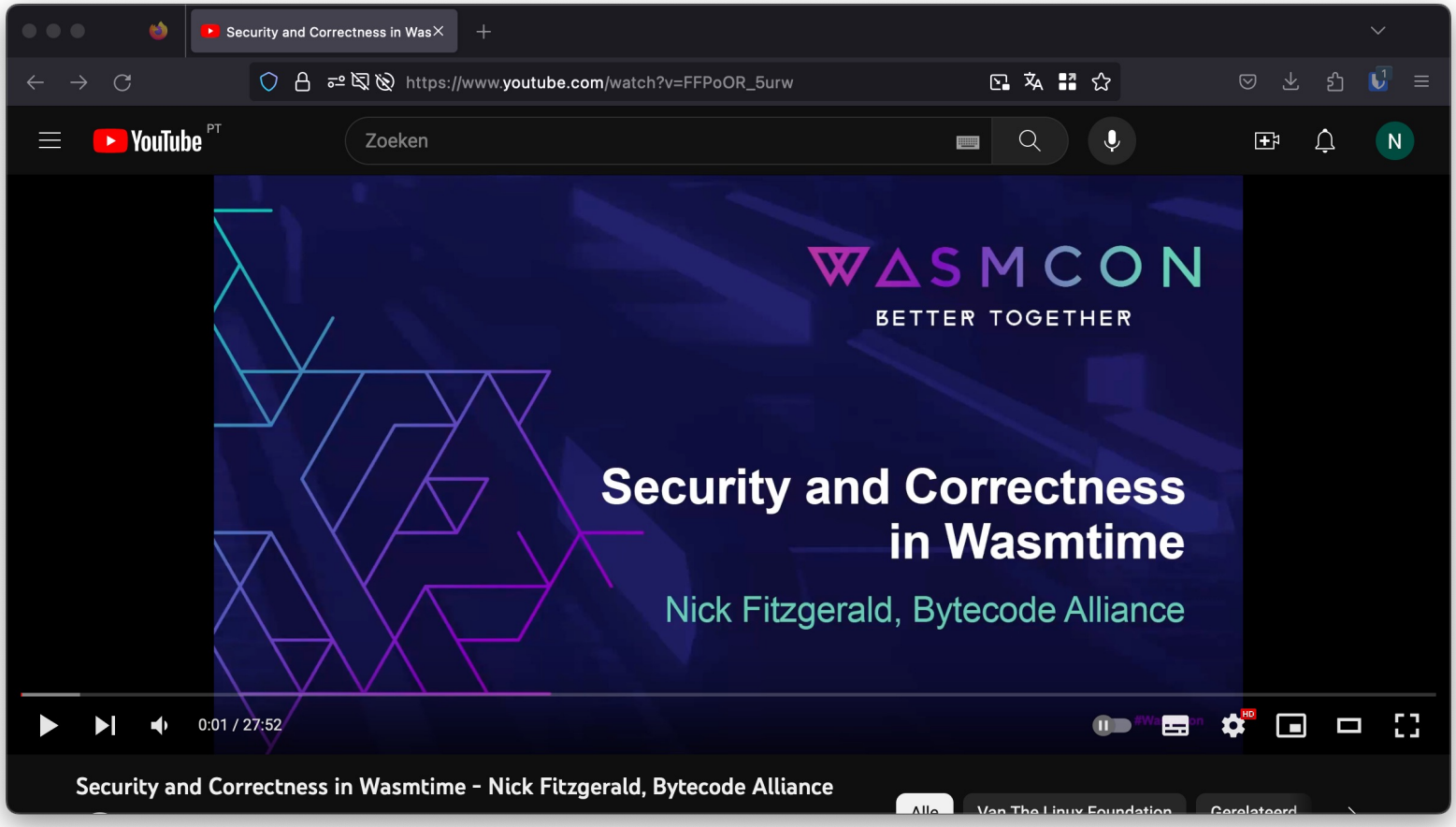


Runtimes and Security

- Most security research published focusses on correctness of WASM runtimes/VM's

- Bytecode Alliance Blogpost September 2022:
  - "Security and Correctness in Wasmtime"
  - Written in Rust → Using all it's LangSec features
  - Continues Fuzzing & formal verification
  - Security process & vulnerability disclosure

Runtimes and Security



dotnet friday

@nielstanis@infosec.exchange

Conclusion

- Cloud Native ❤️ WebAssembly
- WebAssembly has a lot of potential to be used to run, extend, and secure your applications!
- Its as secure as the WebAssembly runtime implementation!
- WASI Preview 2 big milestone; now tooling can be implemented!

Questions?

- https://github.com/nielstanis/dotnetfriday2024
- ntanis at Veracode.com
- @nielstanis@infosec.exchange
- https://blog.fennec.dev
- Dank je wel! Thank you!