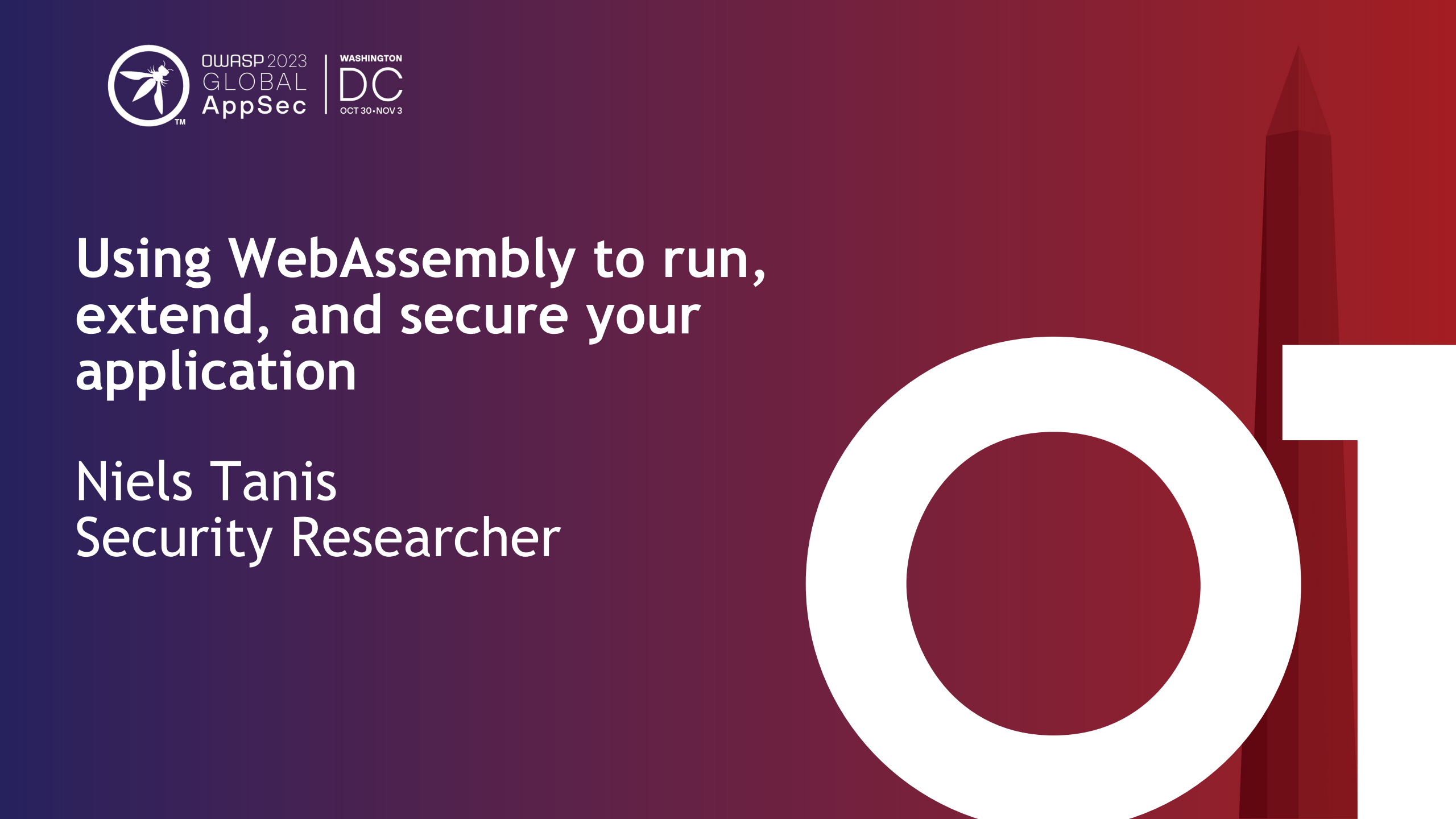

Using WebAssembly to run, extend, and secure your application

Niels Tanis
Security Researcher

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

VERACODE

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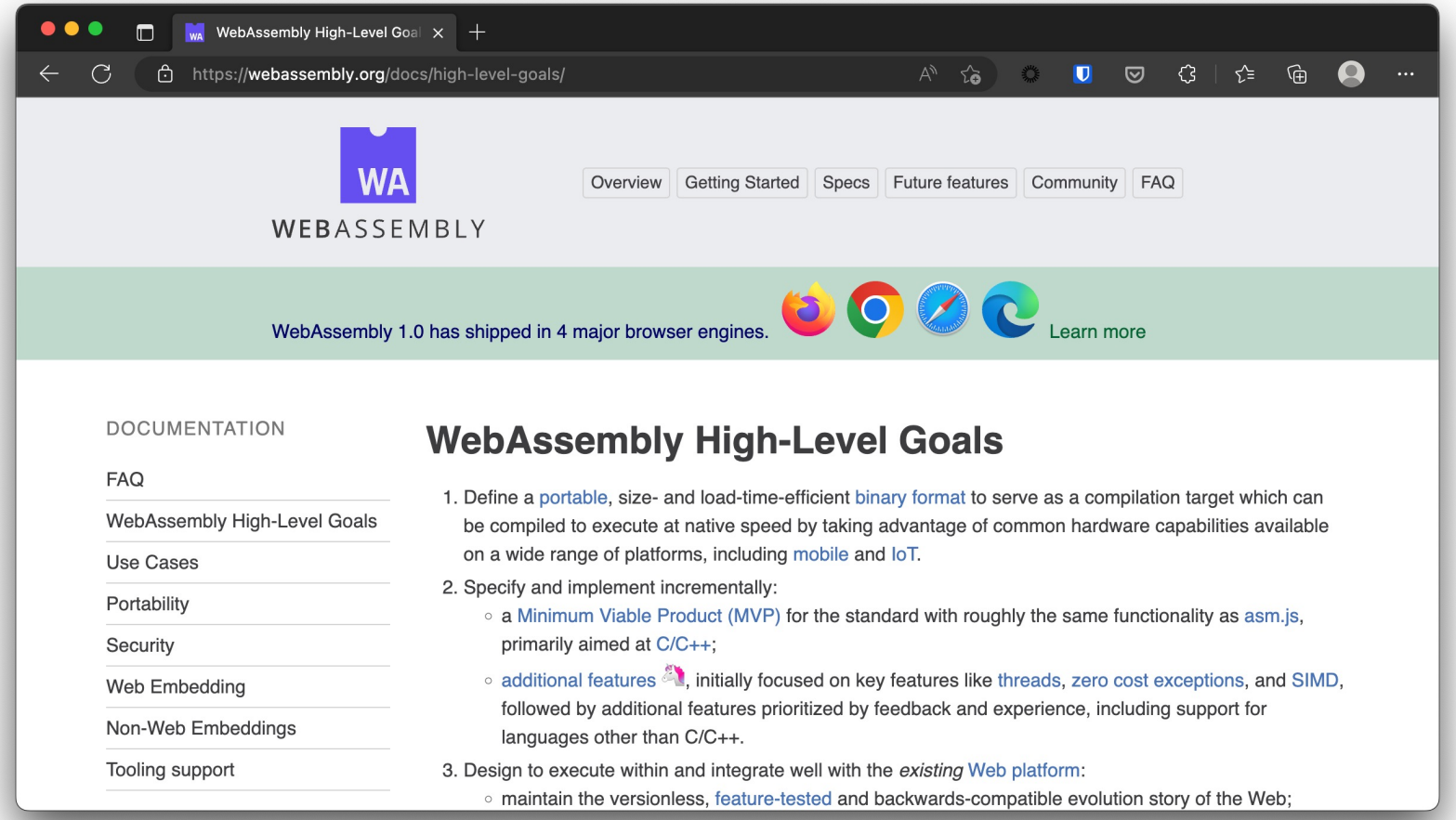
WebAssembly



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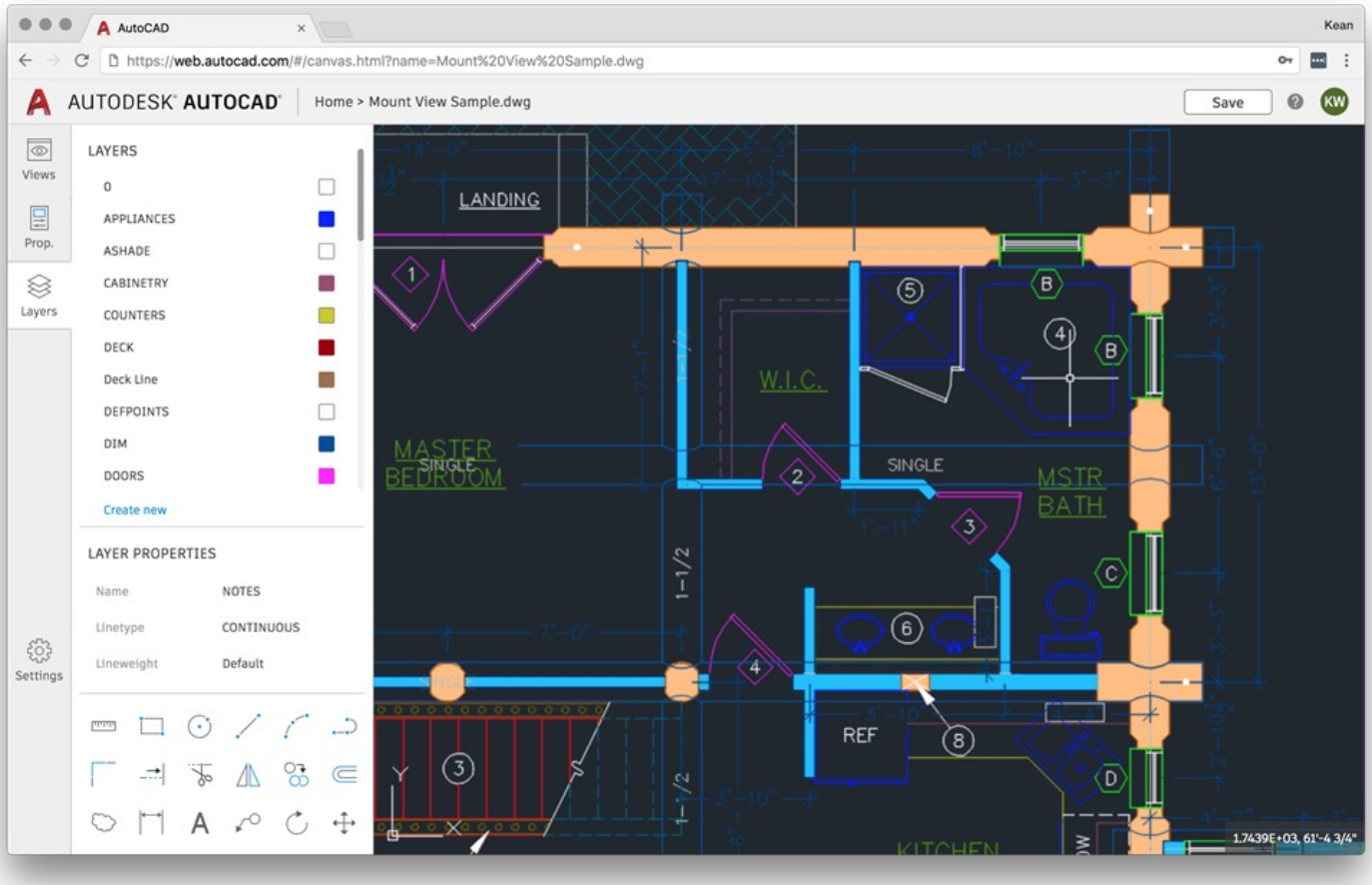
WebAssembly - AutoCAD



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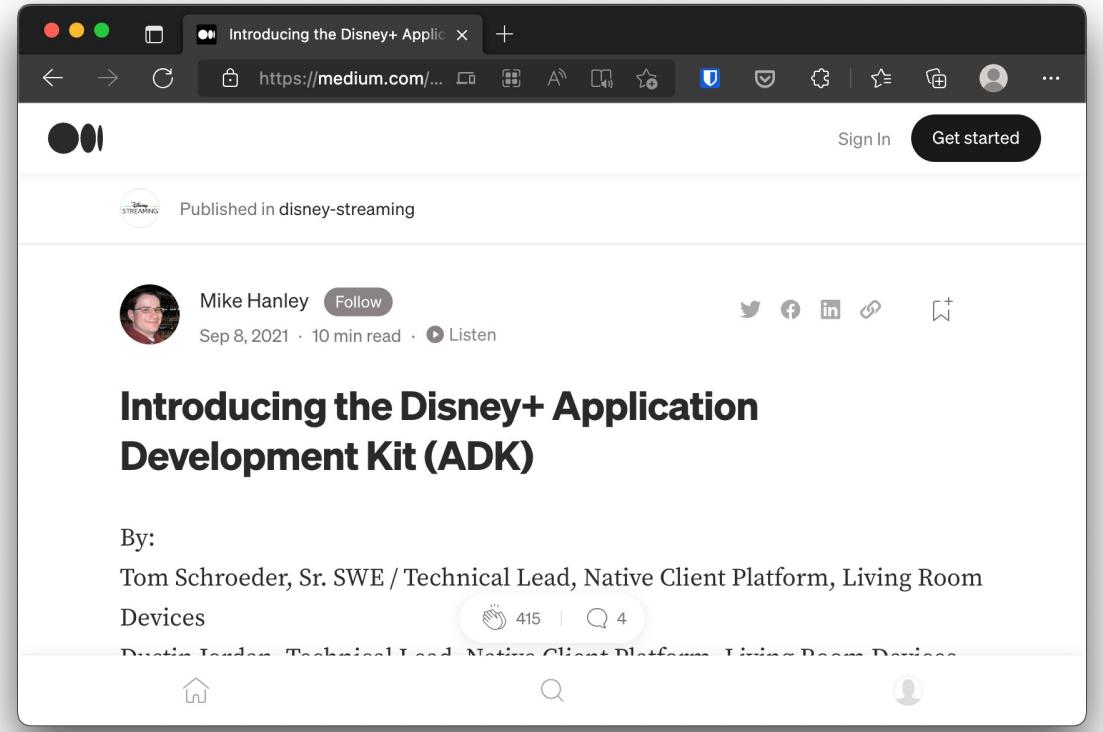
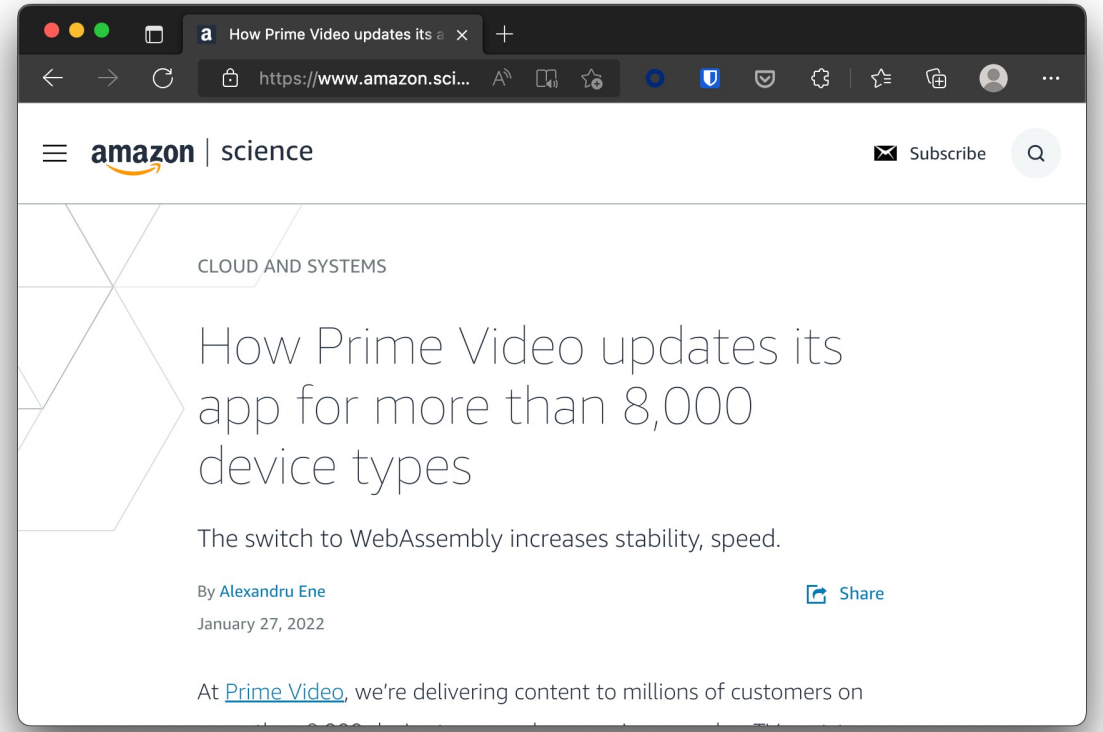
WebAssembly - SDK's





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Agenda

- Introduction
- WebAssembly 101
- Using WebAssembly to …
  - … run your application
  - … extend your application
  - .. secure your application
- Conclusion
- Q&A

WebAssembly Design

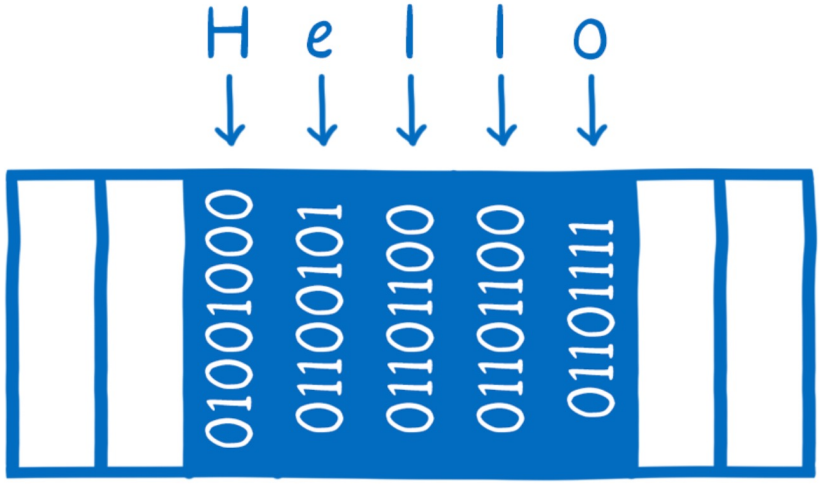
- **Be fast, efficient, and portable**
  - Executed in near-native speed across different platforms
- **Be readable and debuggable**
  - In low-level bytecode but also human readable
- **Keep secure**
  - Run on sandboxed execution environment
- **Don't break the web**
  - Ensure backwards compatibility

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!");
```

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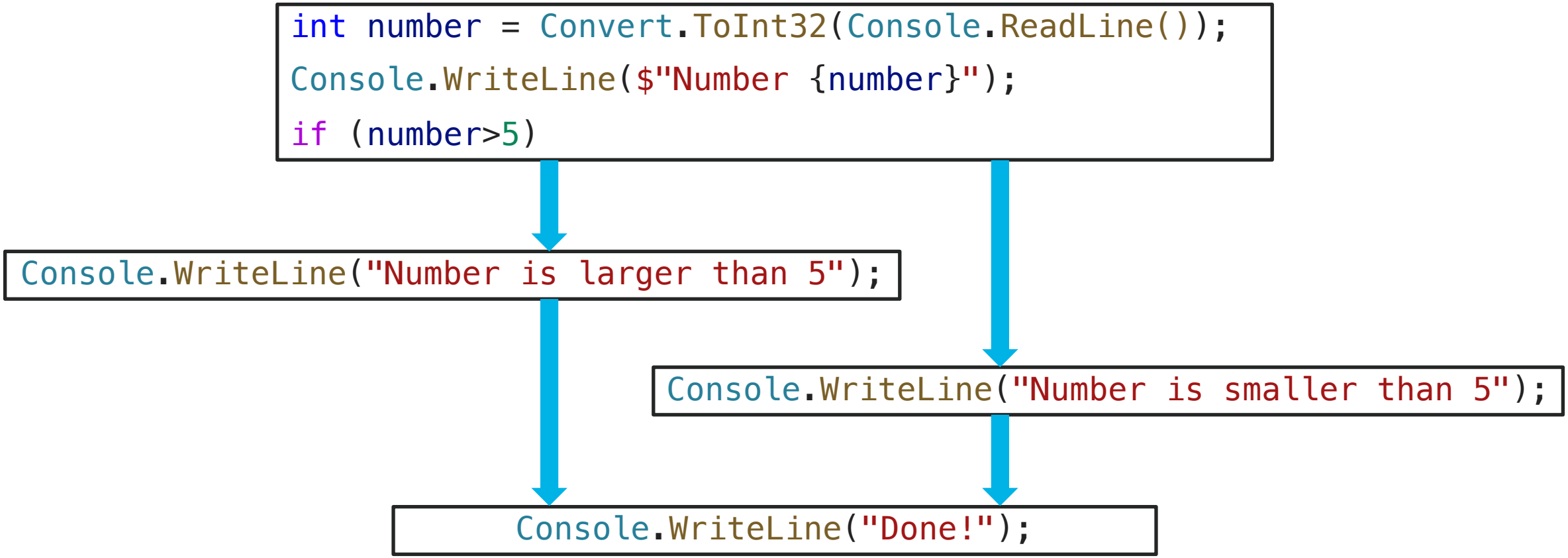
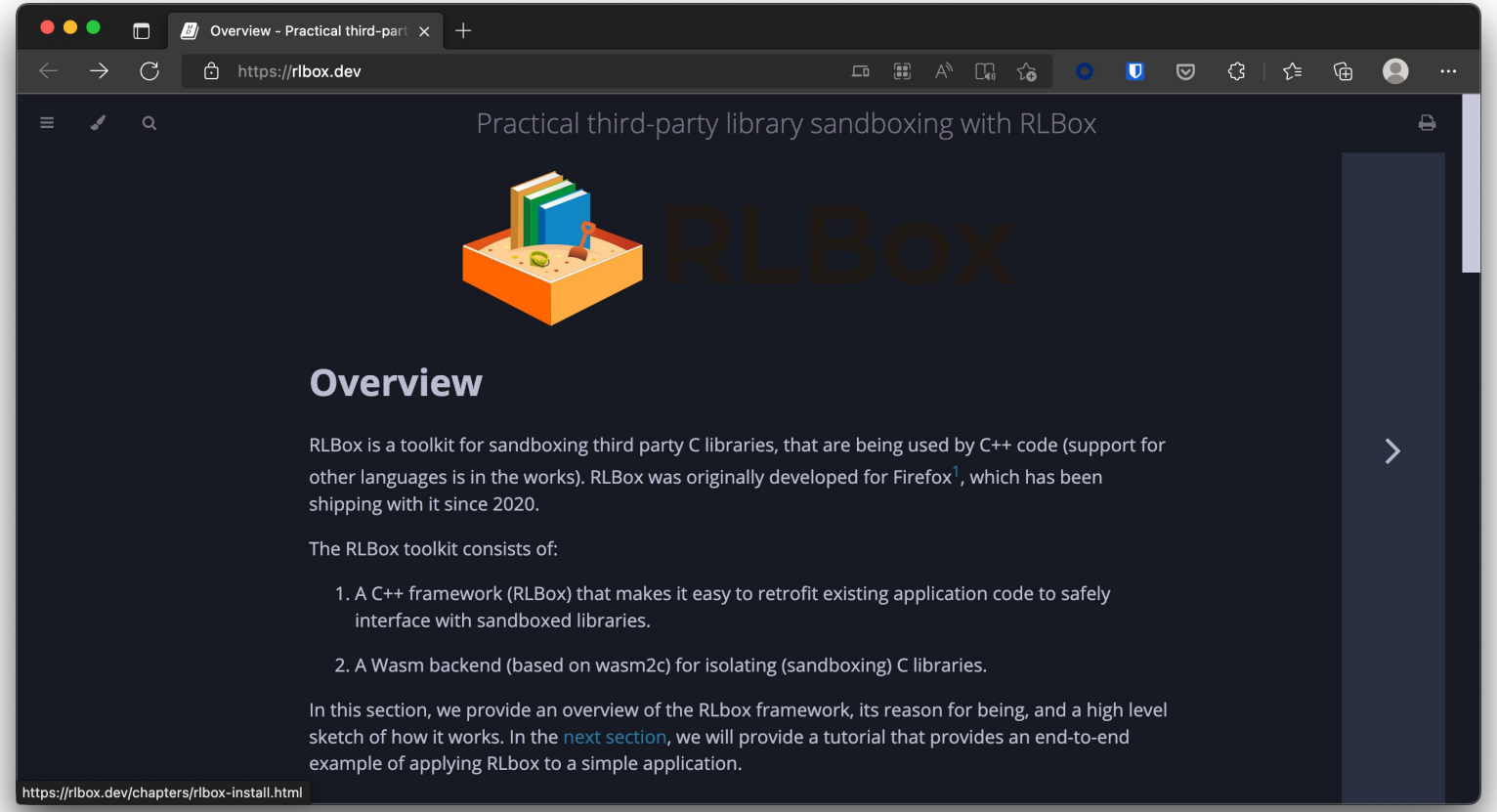
WebAssembly Control-Flow Integrity



FireFox RLBox



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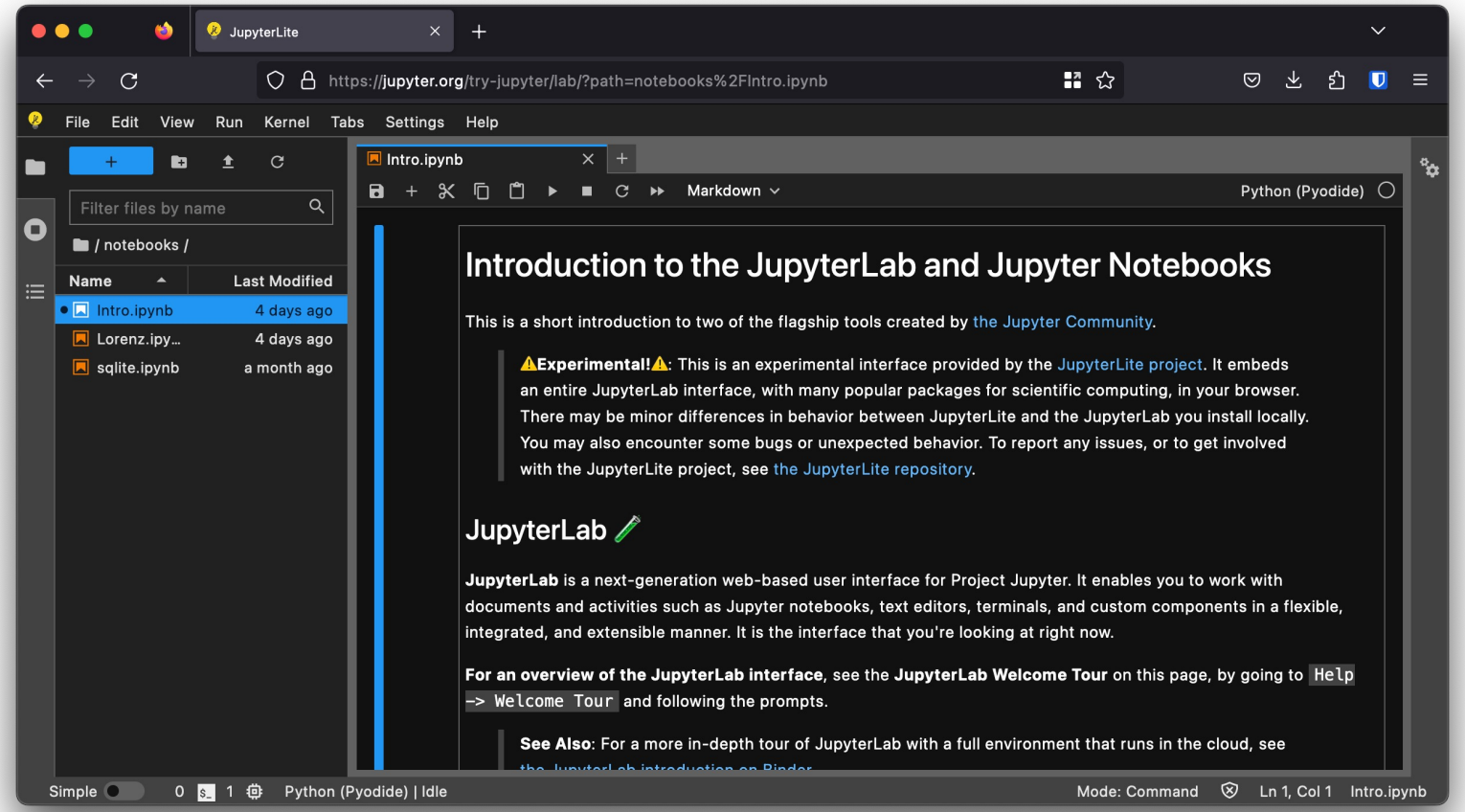
Python on WASM



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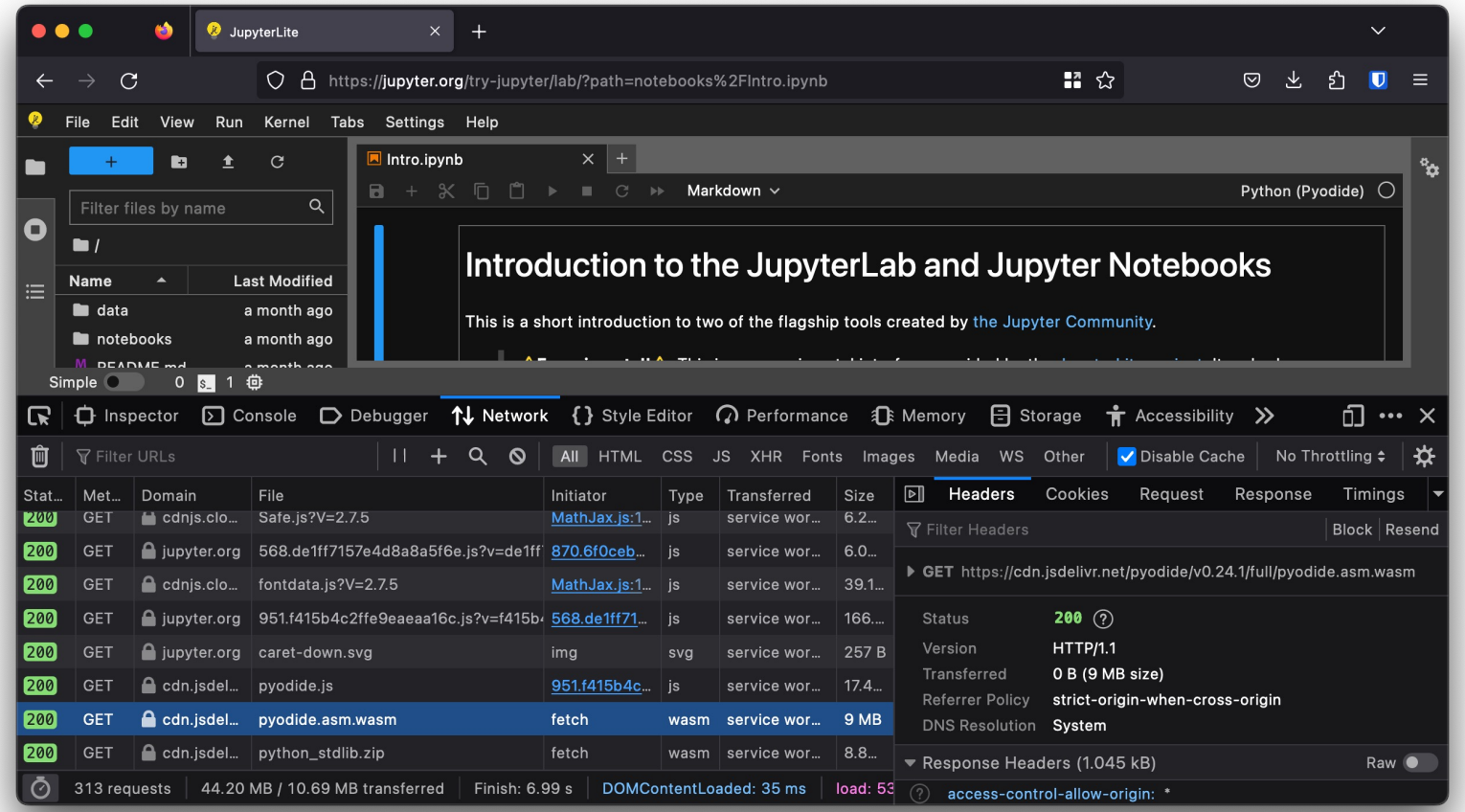
Python on WASM



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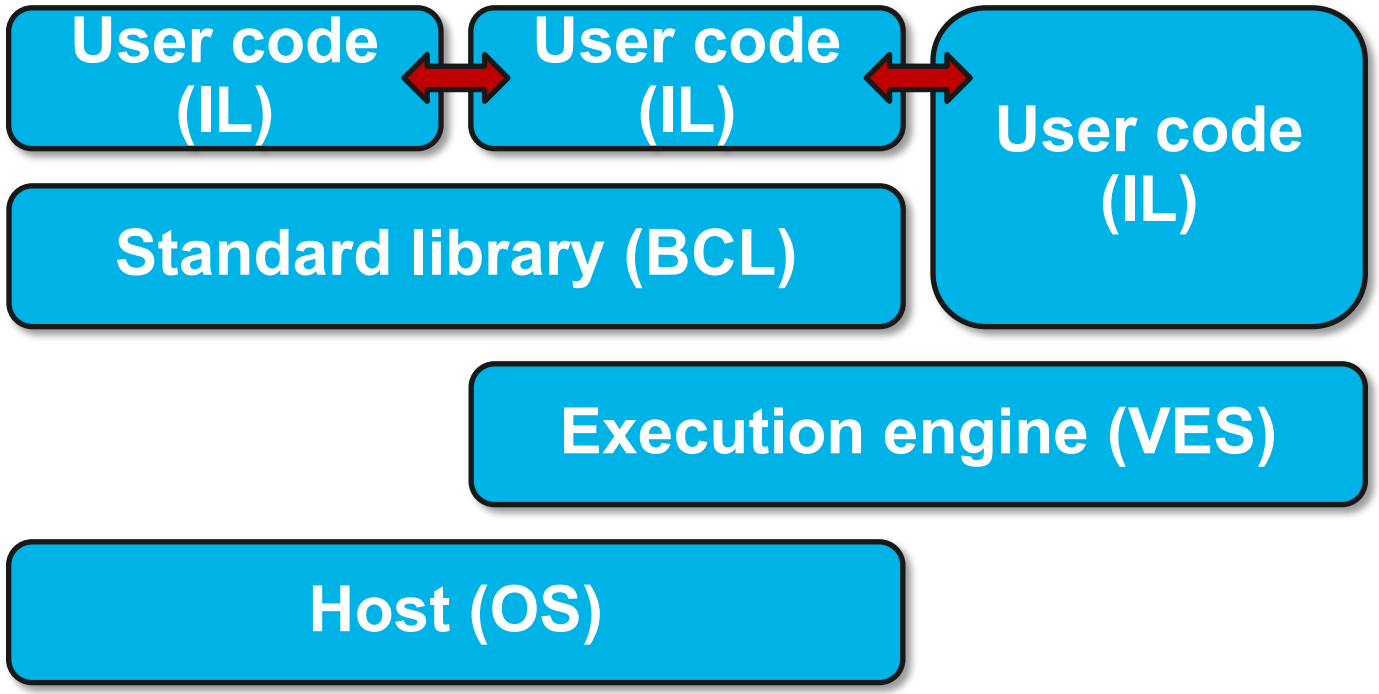
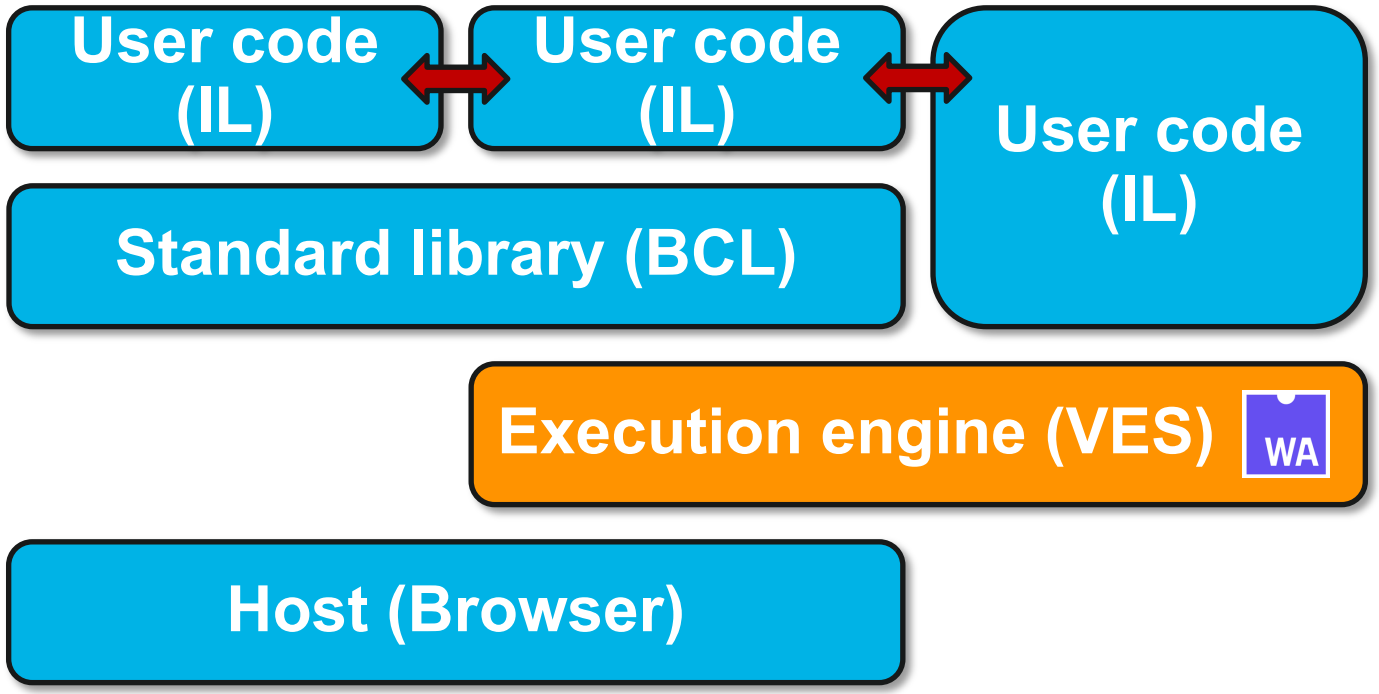
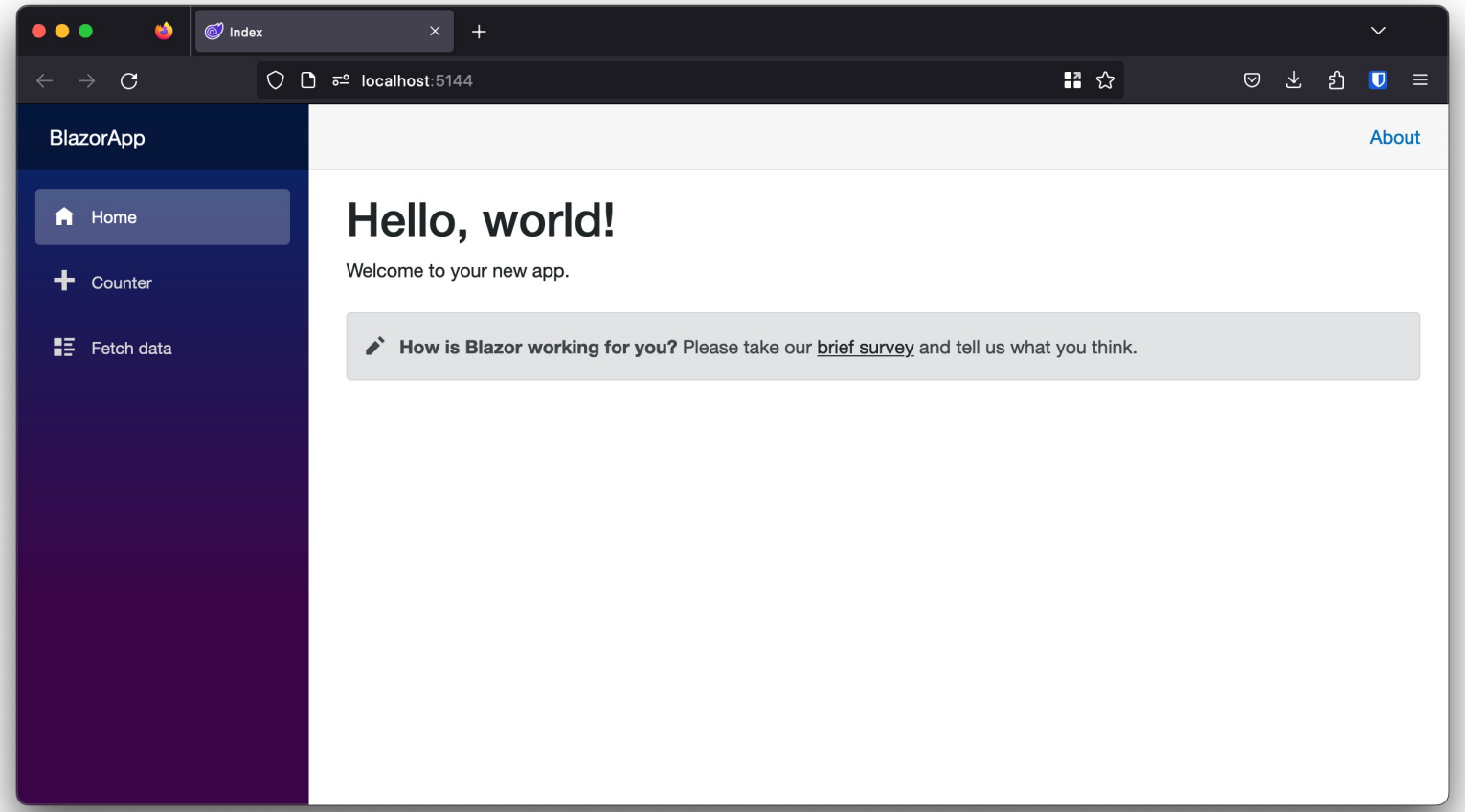
Running .NET on WebAssembly



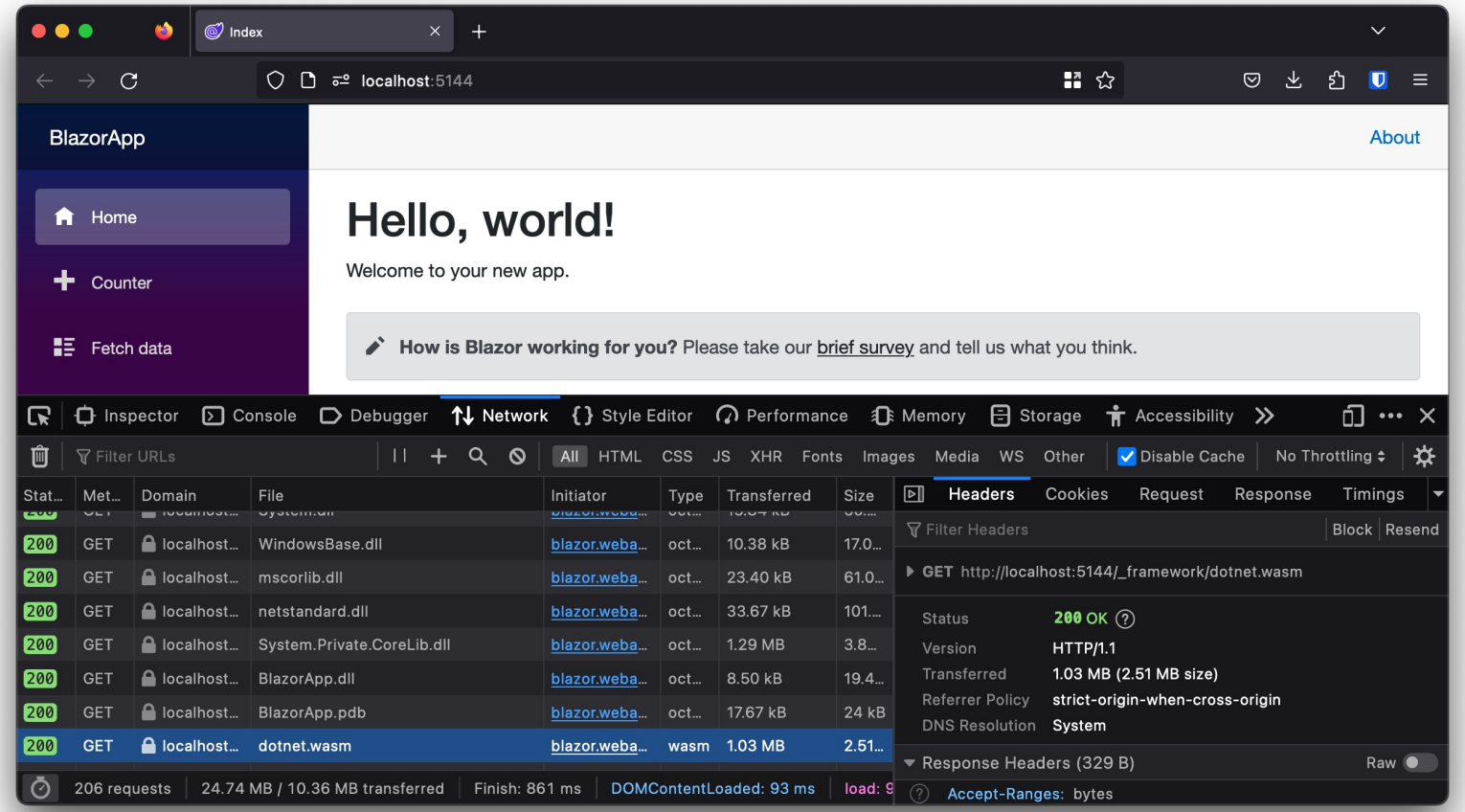
Running .NET on WebAssembly



Blazor WebAssembly



Blazor WebAssembly



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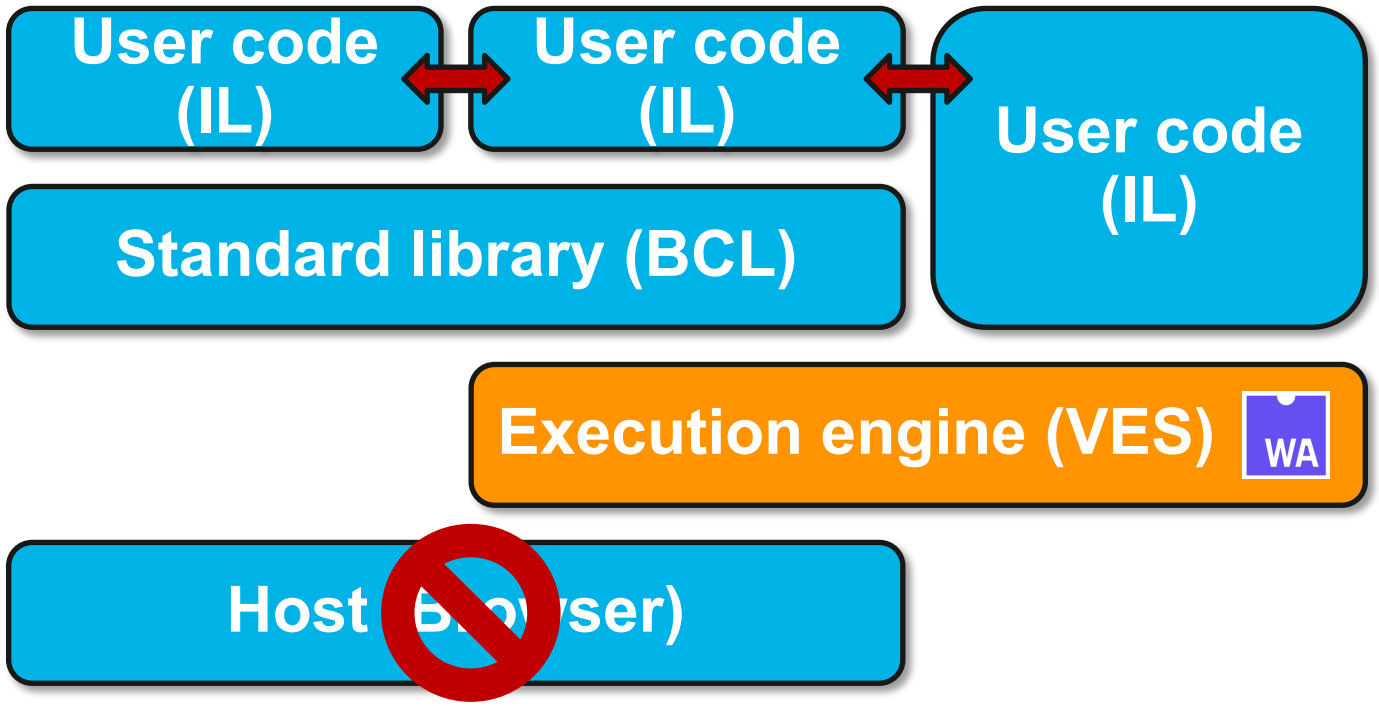
Running .NET on WebAssembly



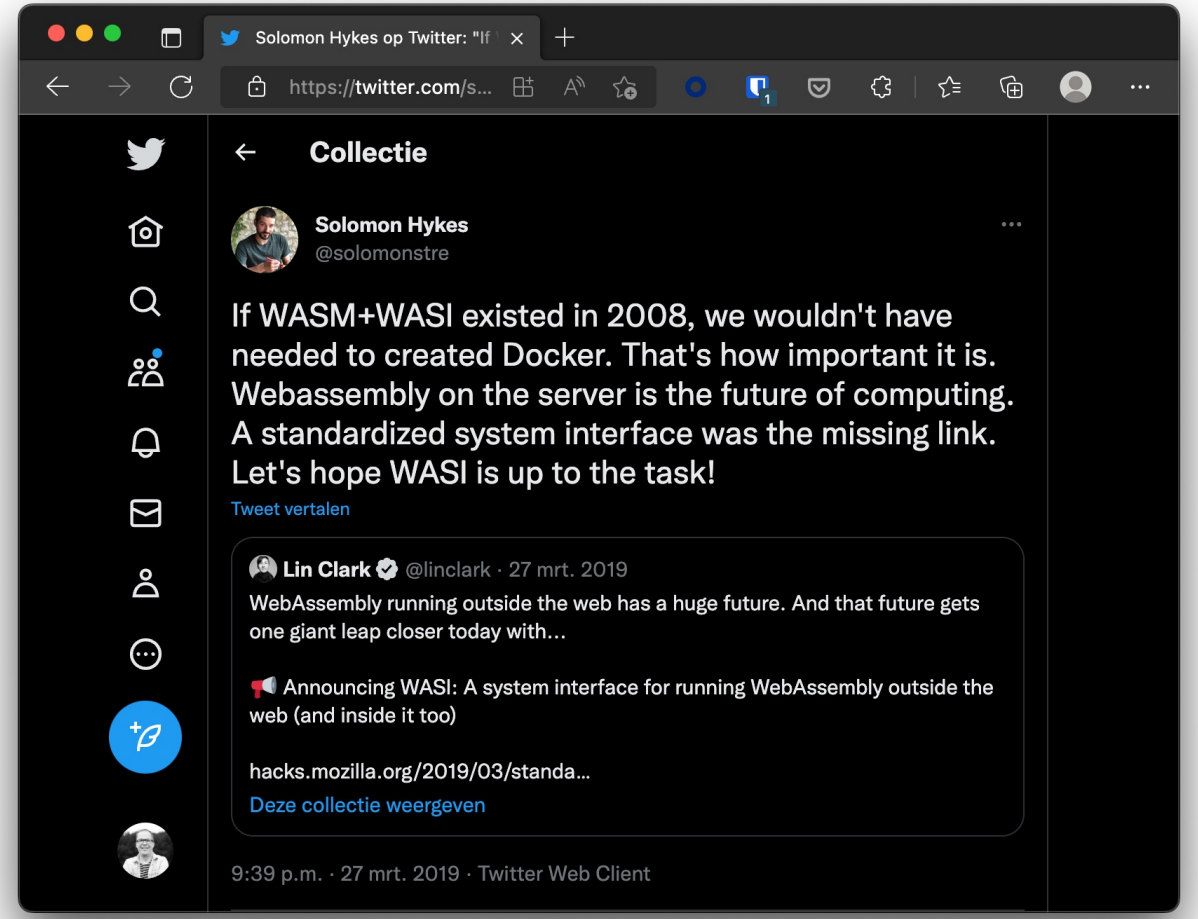
WebAssembly System Interface WASI

- 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

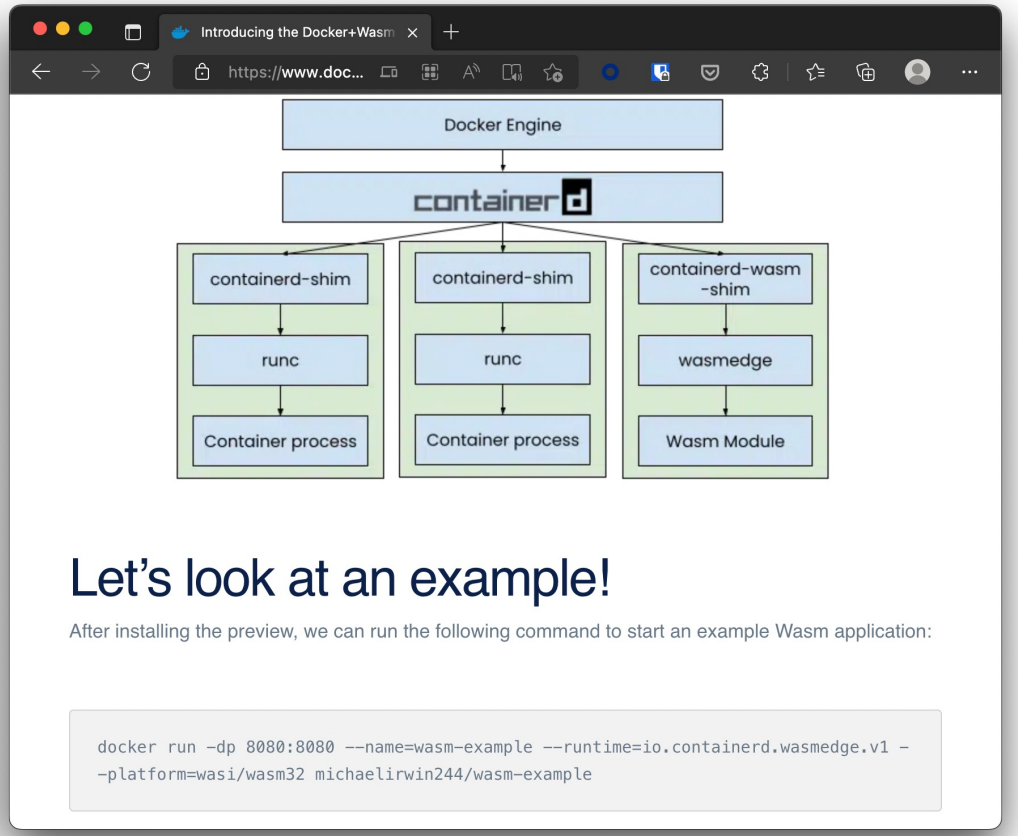
- Strong sandbox with Capability Based Security
- Right now, supports e.g. FileSystem actions
- Future support for sockets and other system resources.
- Anyone familiar with .NET Standard? ☺

Docker vs WASM & WASI



Docker vs WASM & WASI

Docker & WASM



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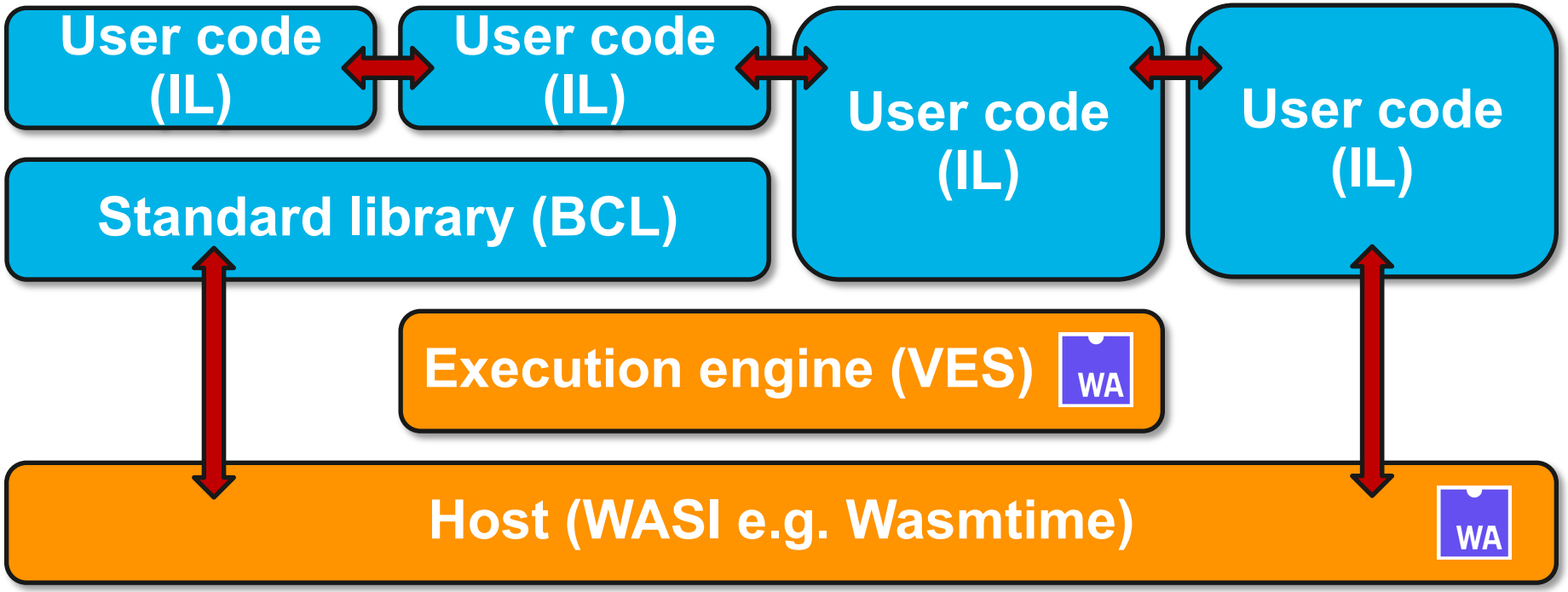
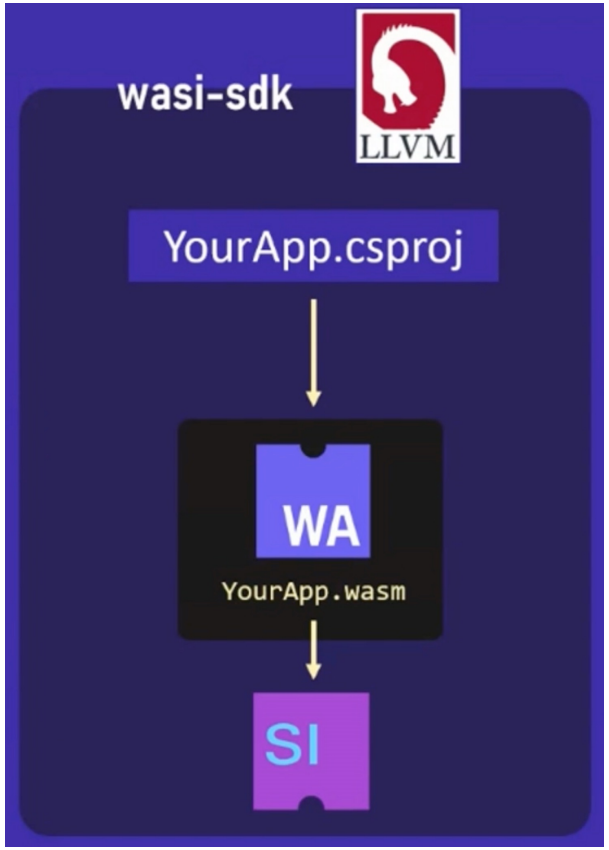
WebAssembly System Interface WASI



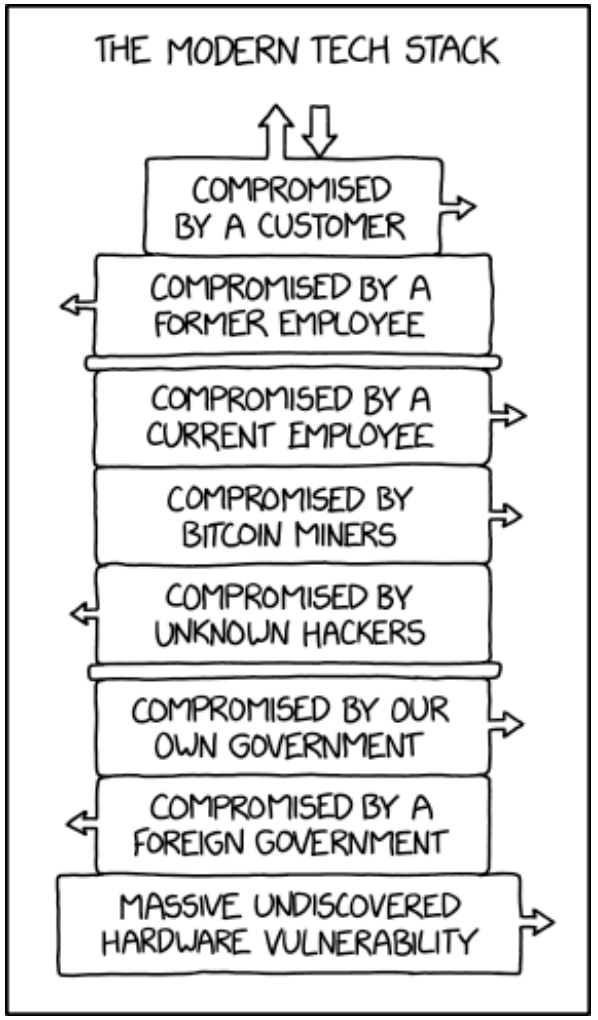
Experimental WASI SDK for .NET



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!

Trusted Computing – XKCD 2166



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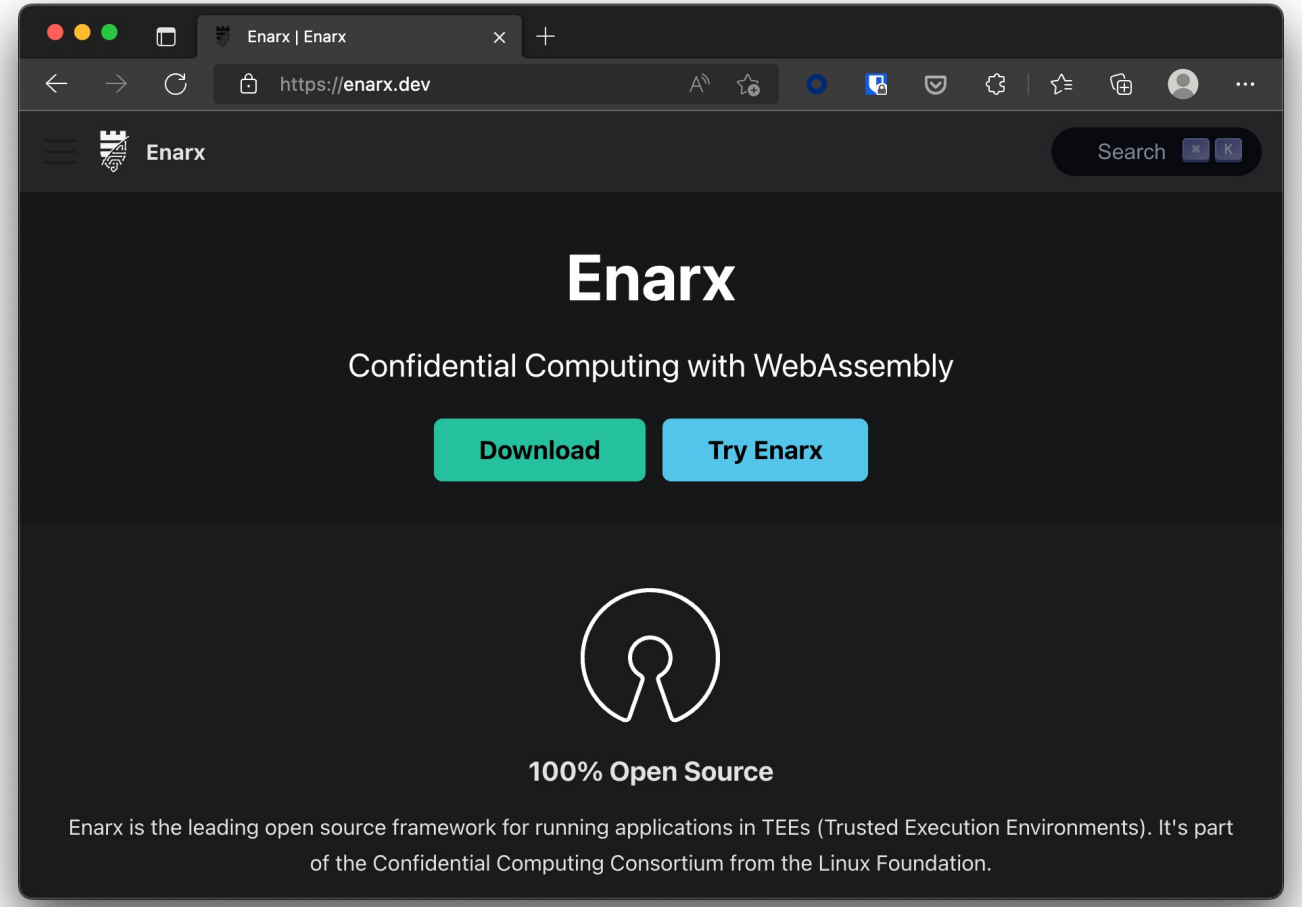
Enarx



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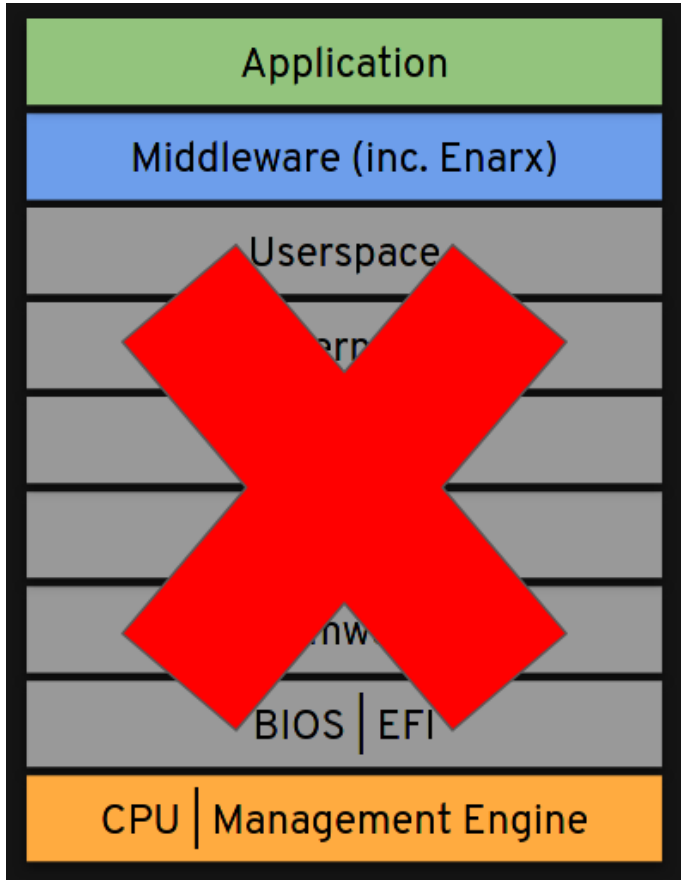
Enarx Threat Model

- 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



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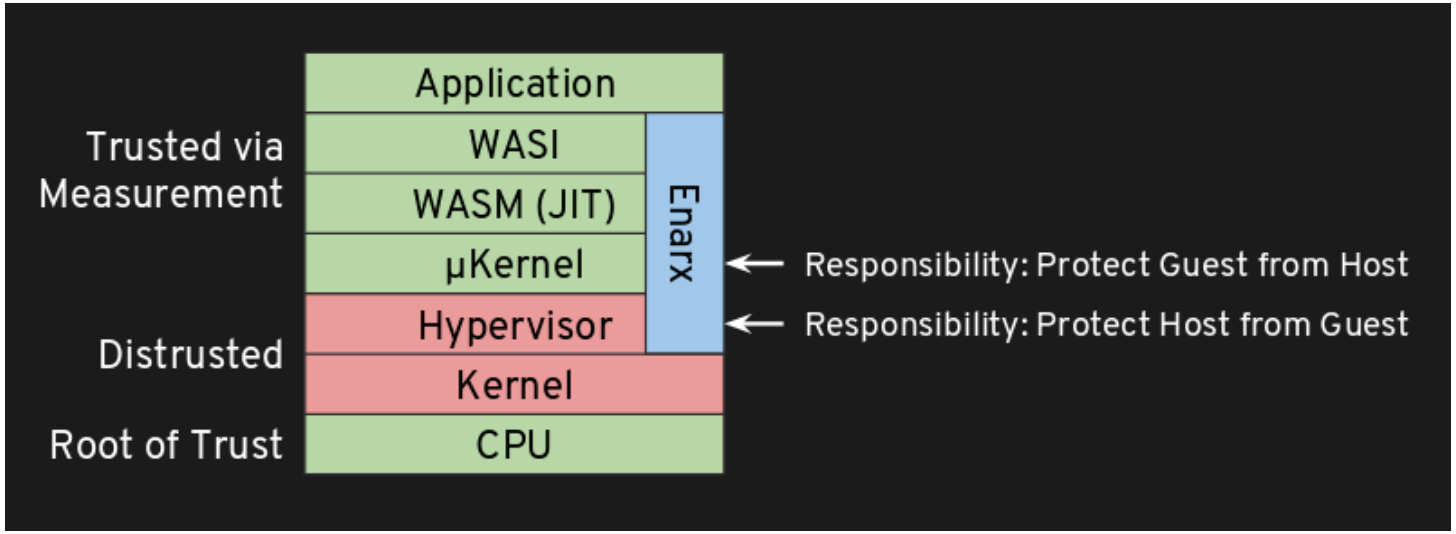
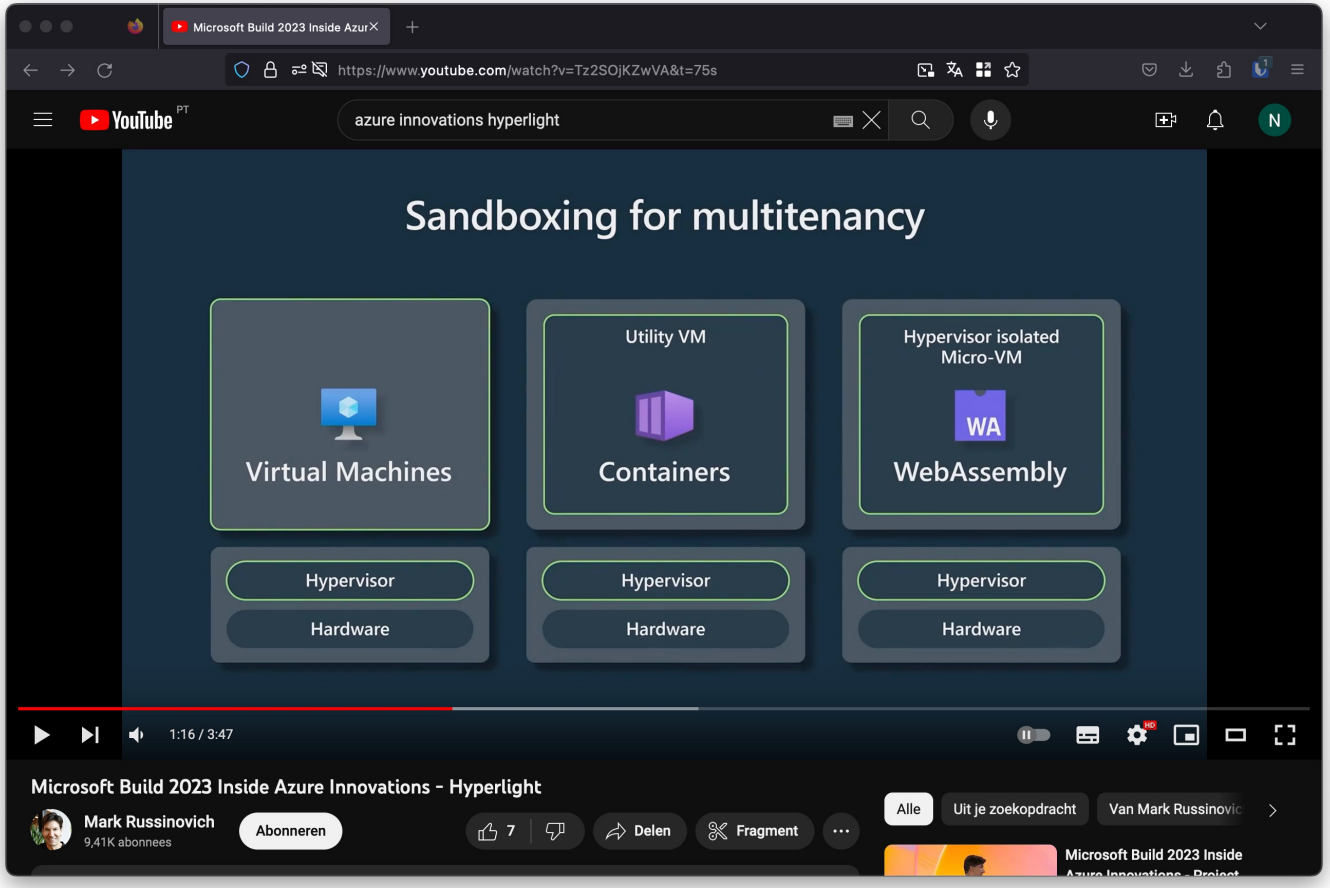
Enarx

- 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



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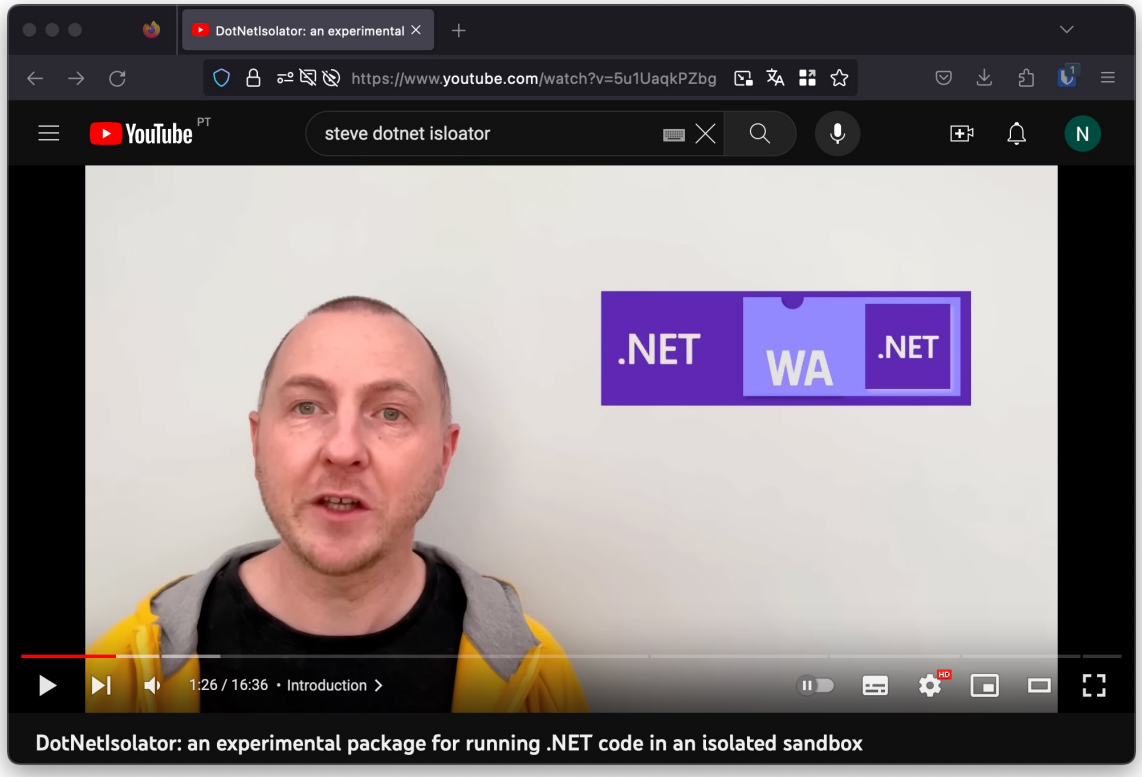
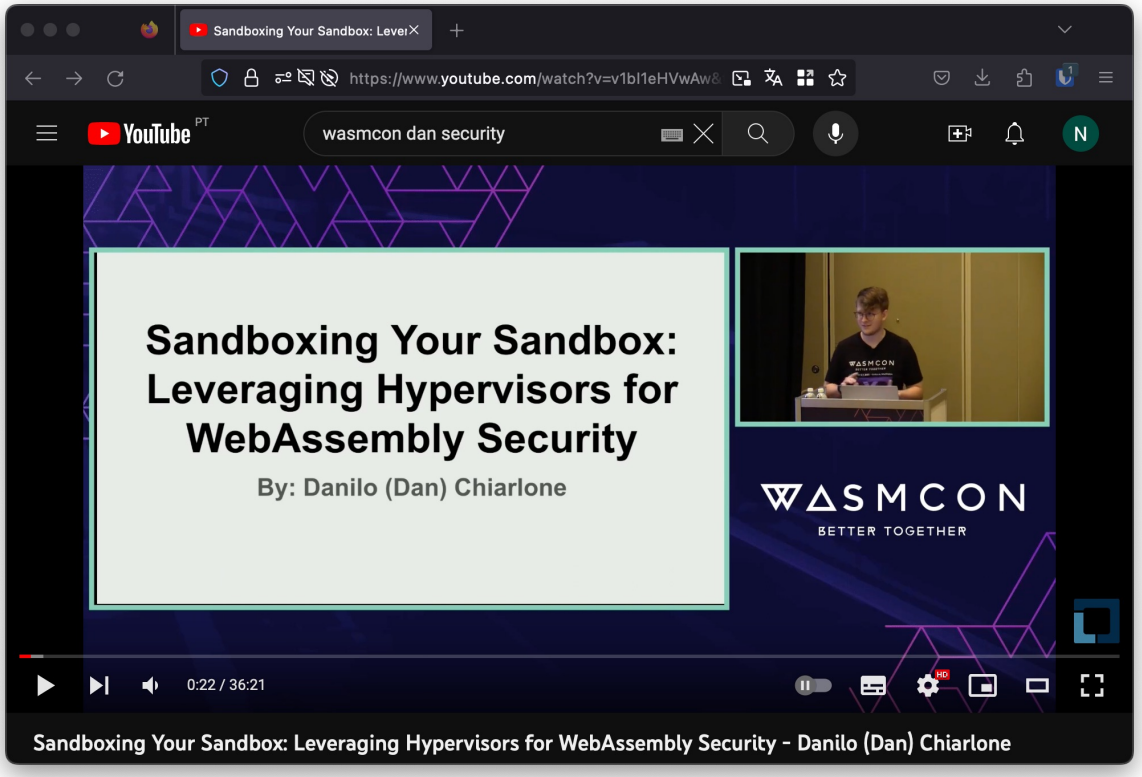
DotNetIsolator & Project Hyperlight





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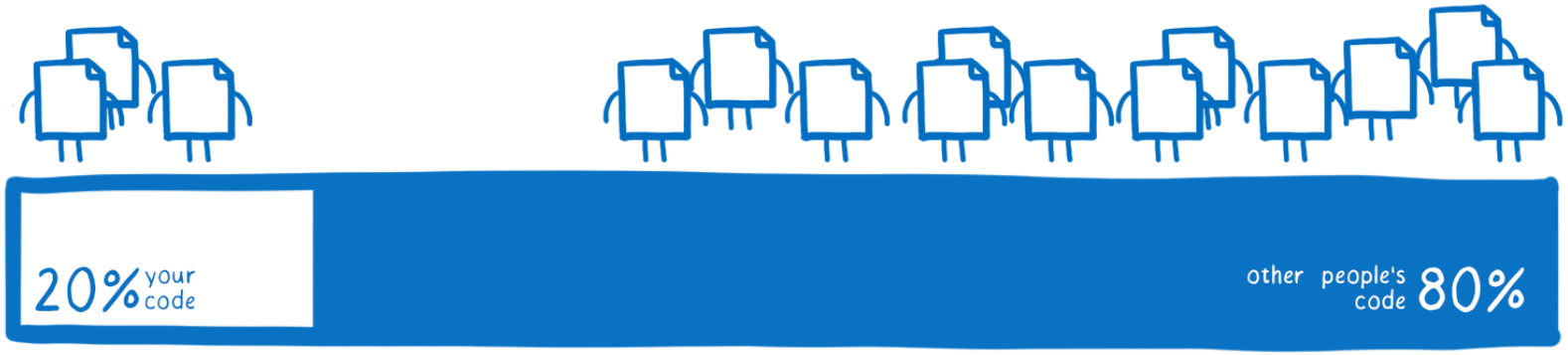
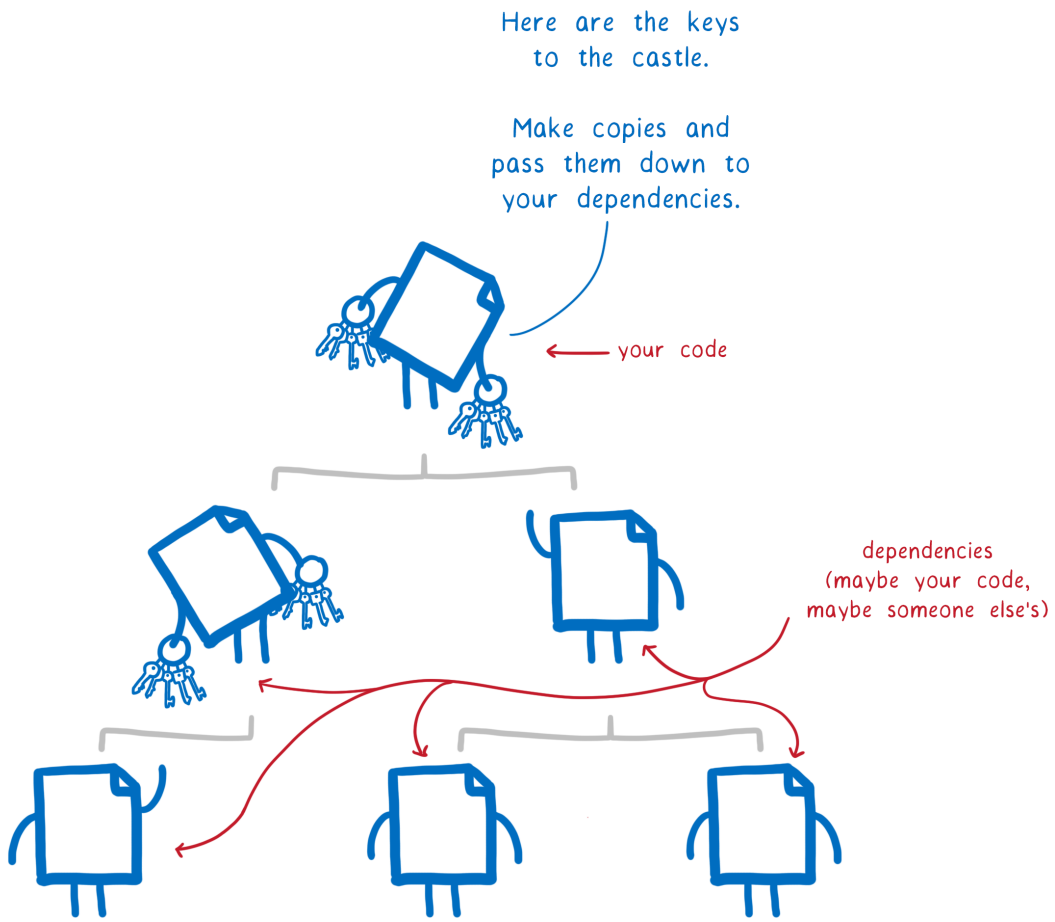
WASM – What's next?

composition of an average code base



Dependencies



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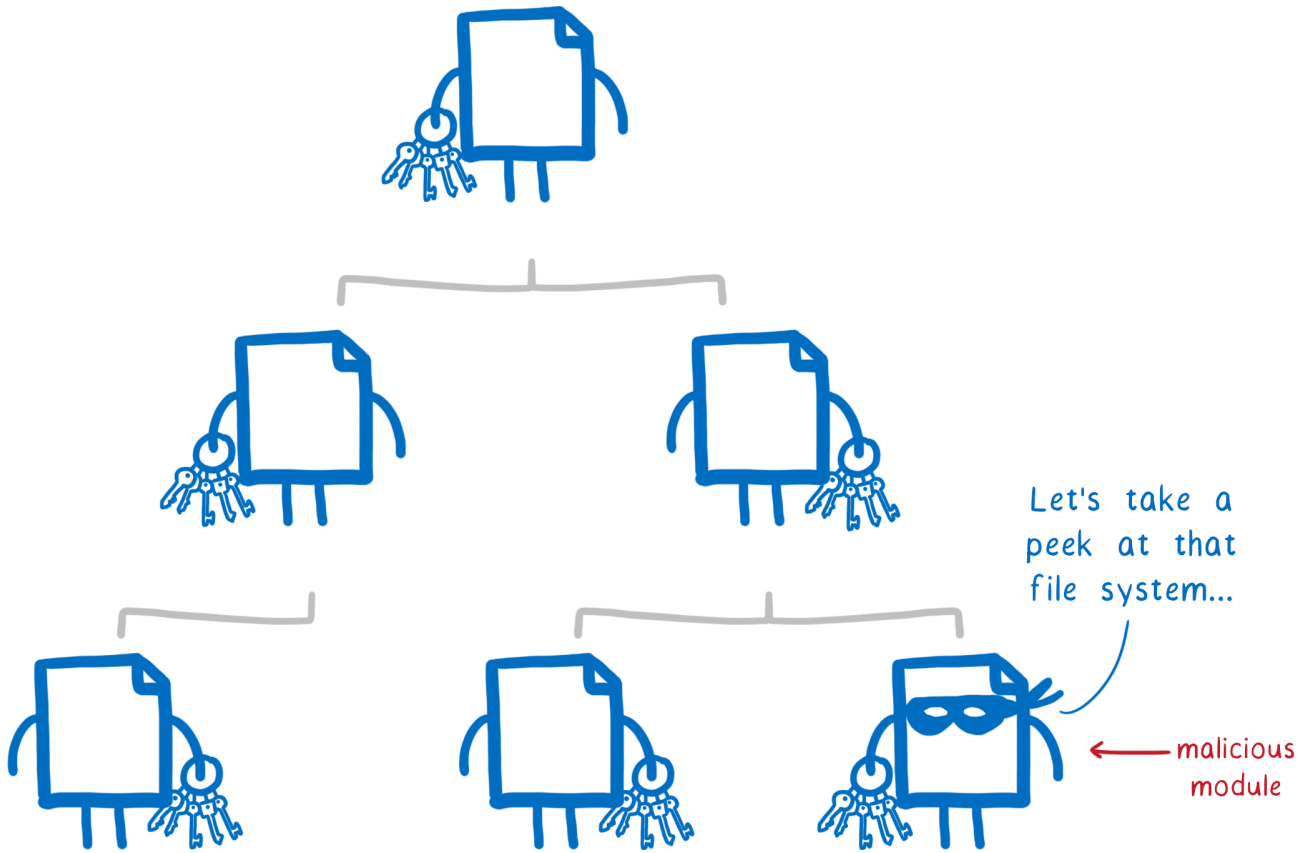
Malicious module



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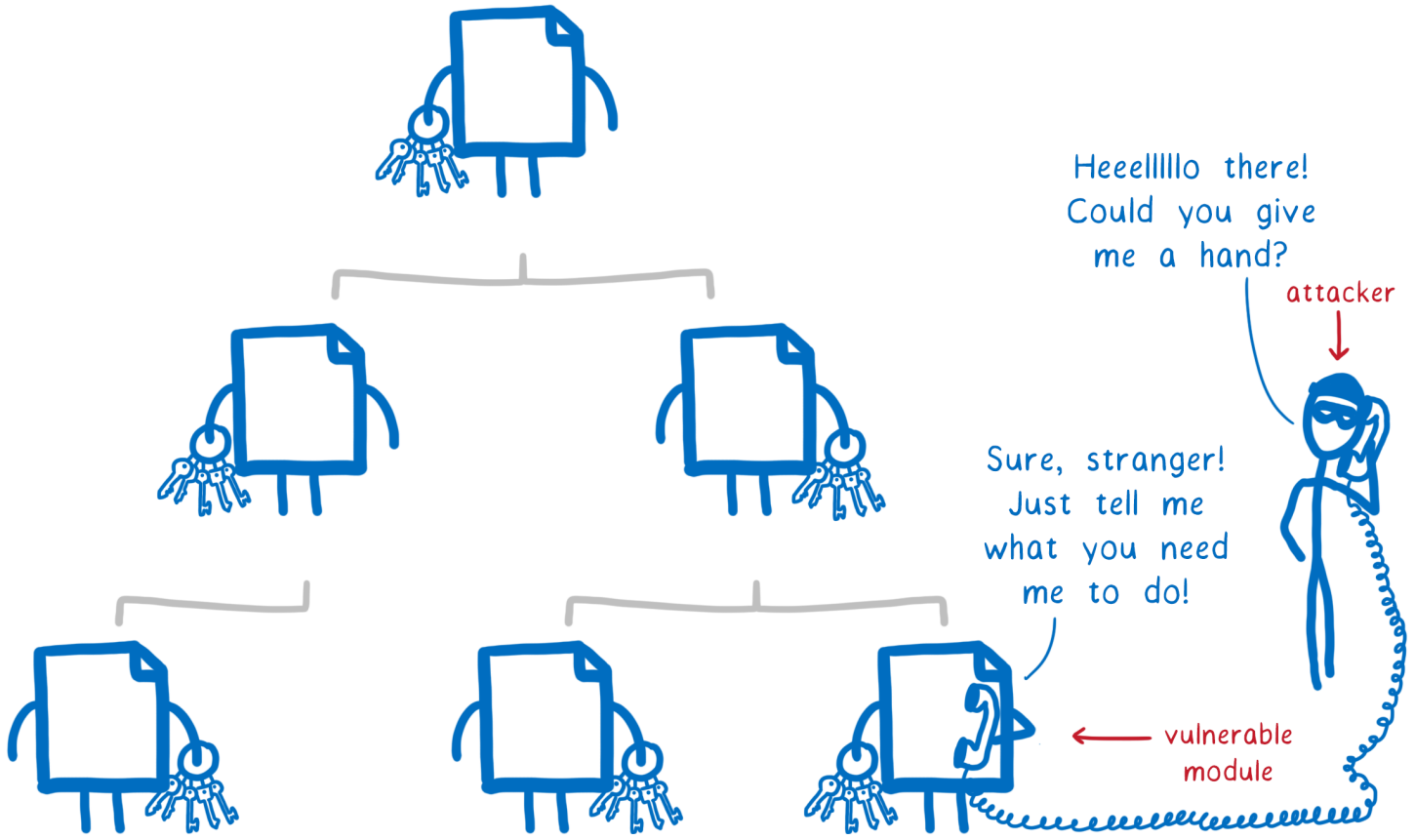
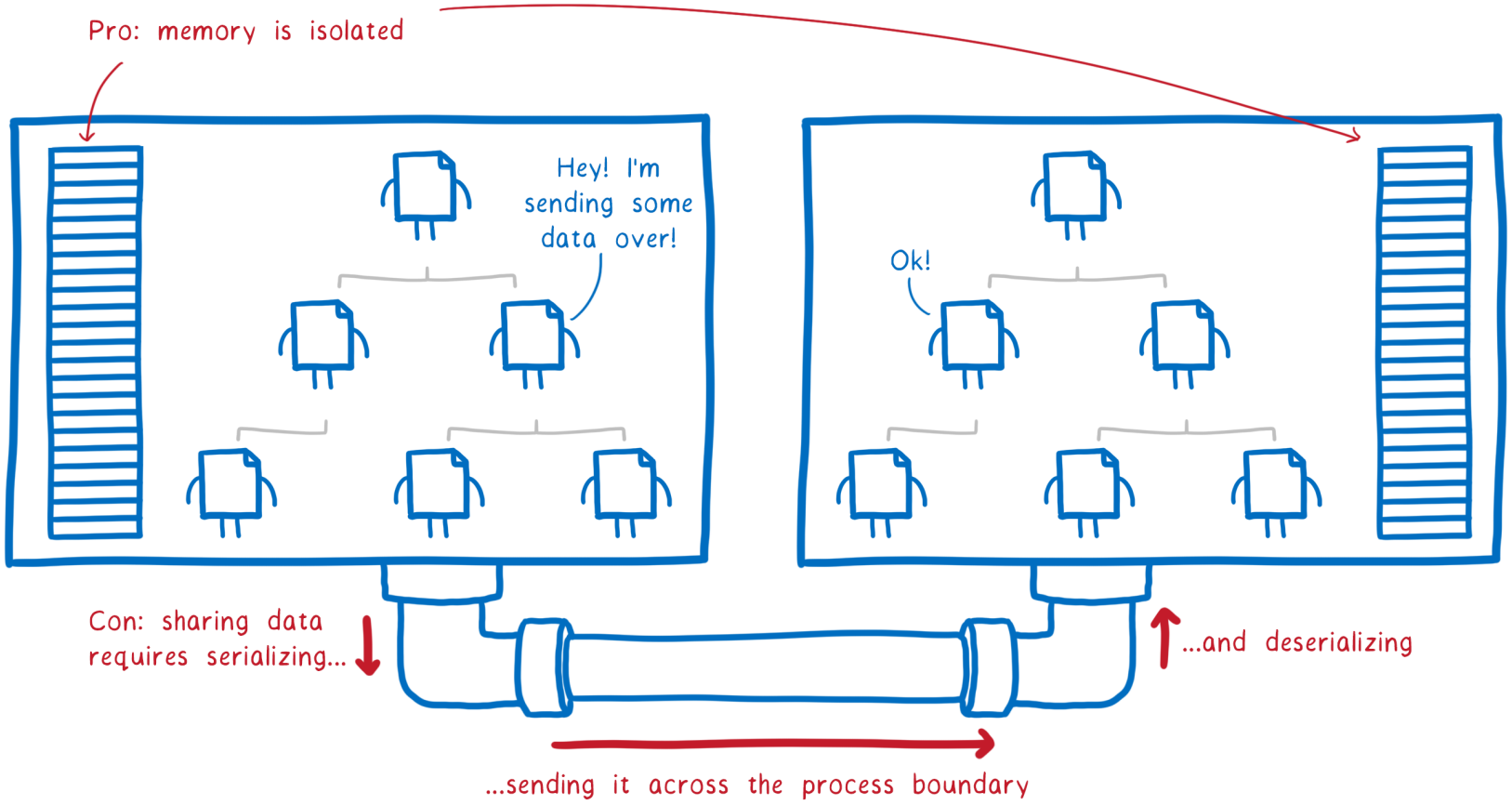
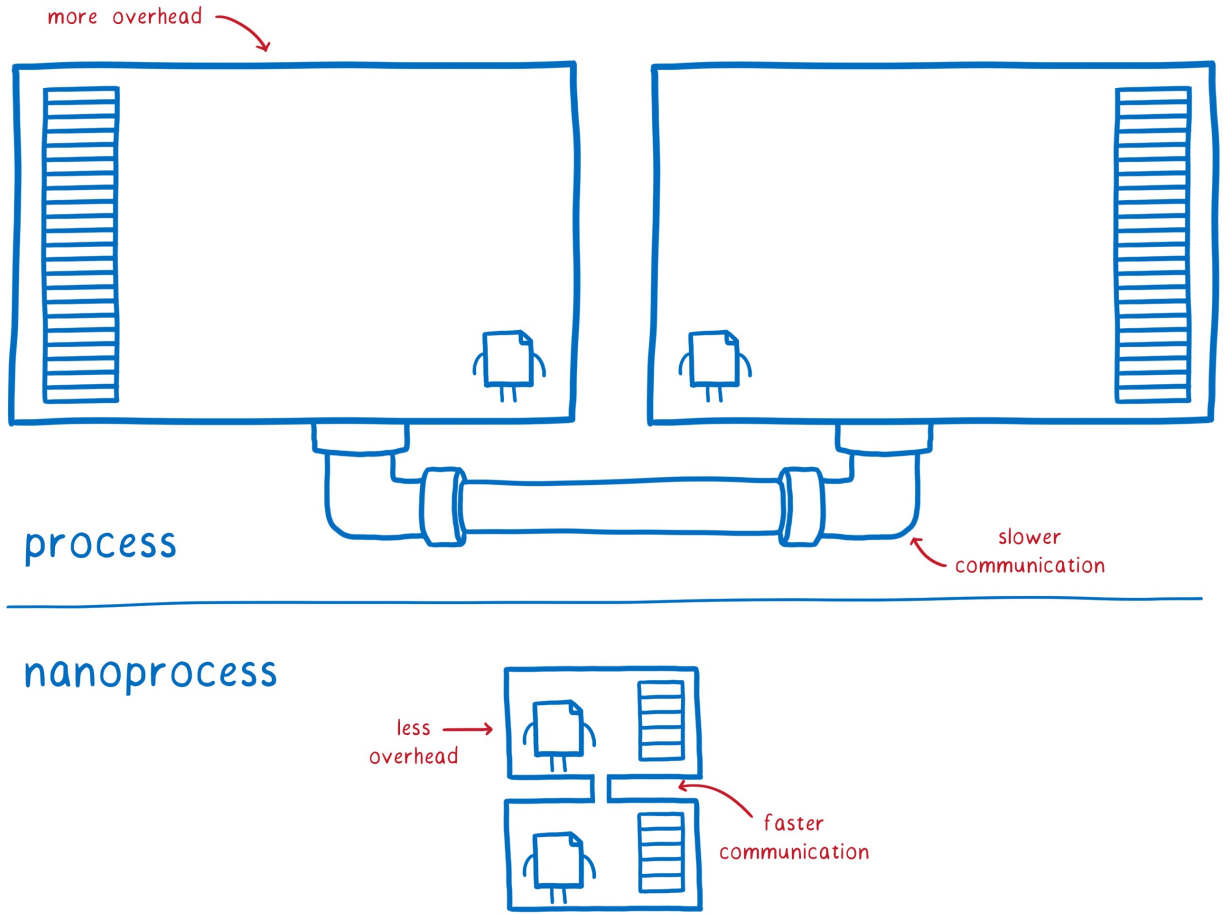
Vulnerable module



Process Isolation



WebAssembly Nano-Process



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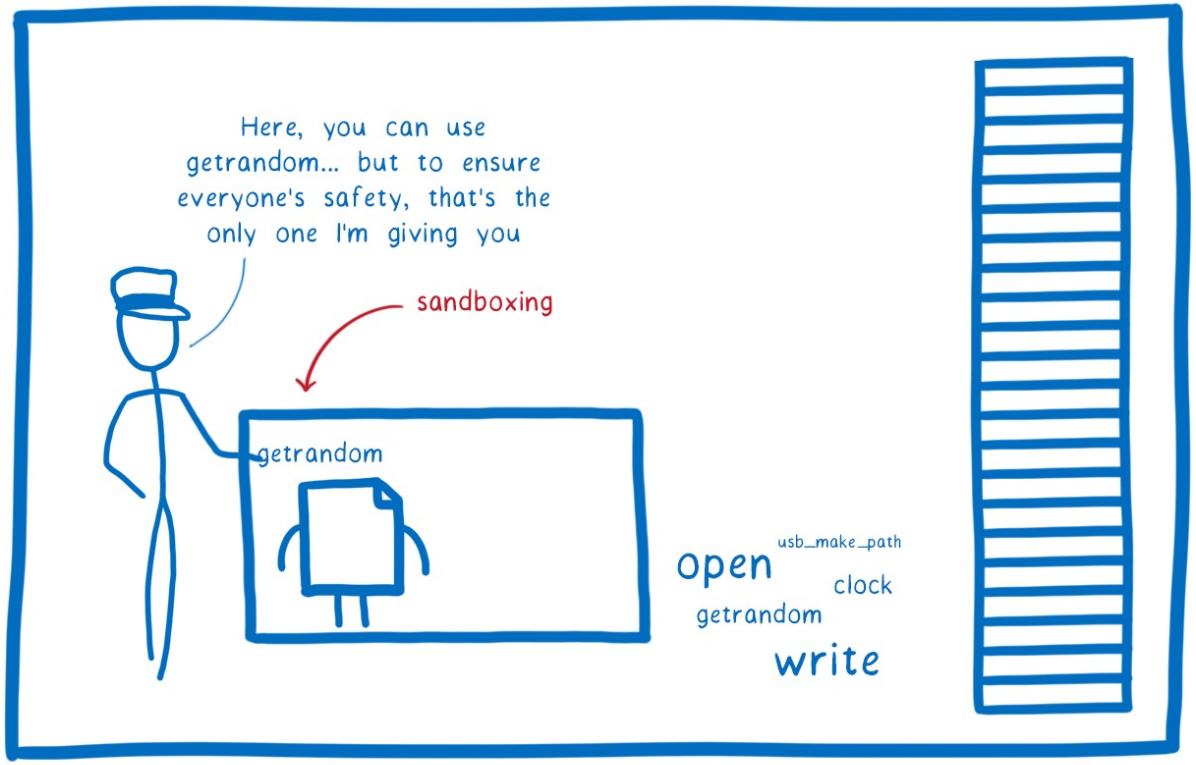
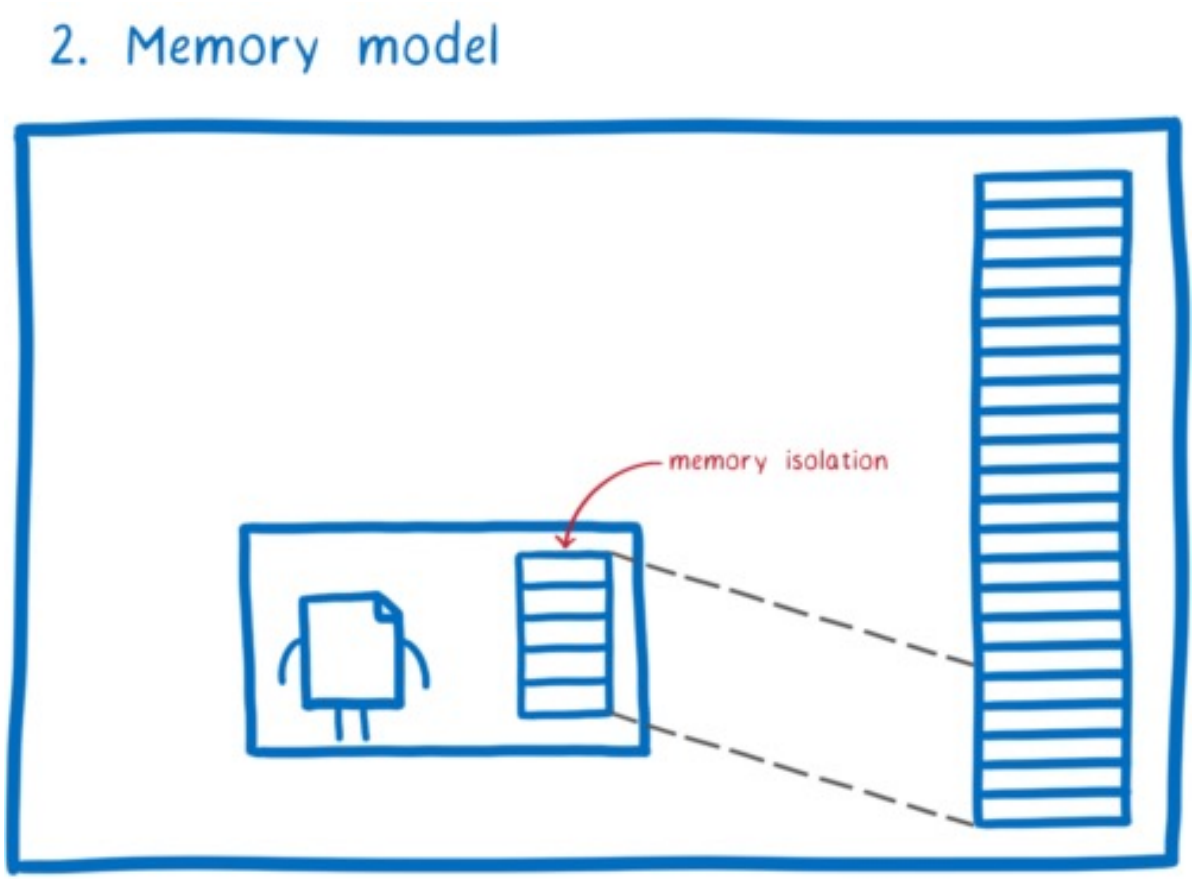
WebAssembly Nano-Process

1. Sandboxing



WebAssembly Nano-Process



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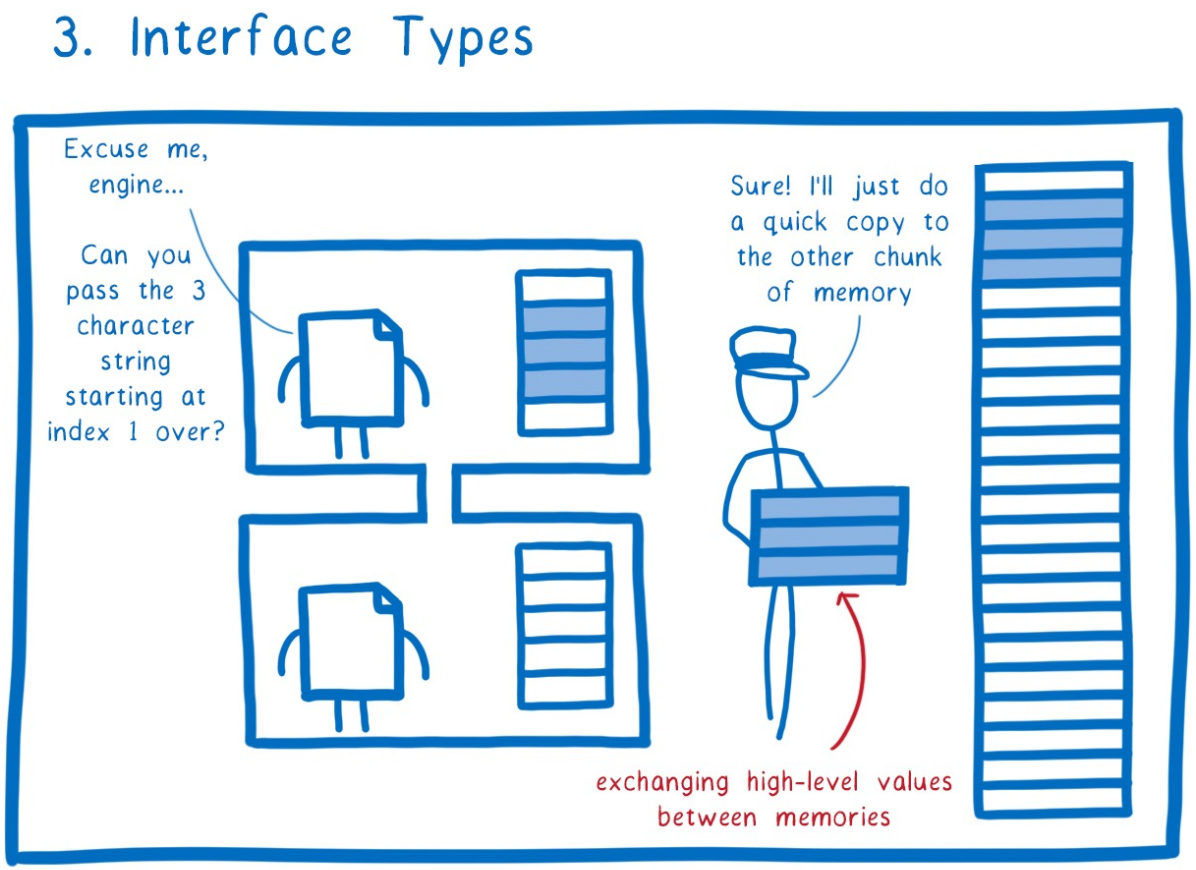
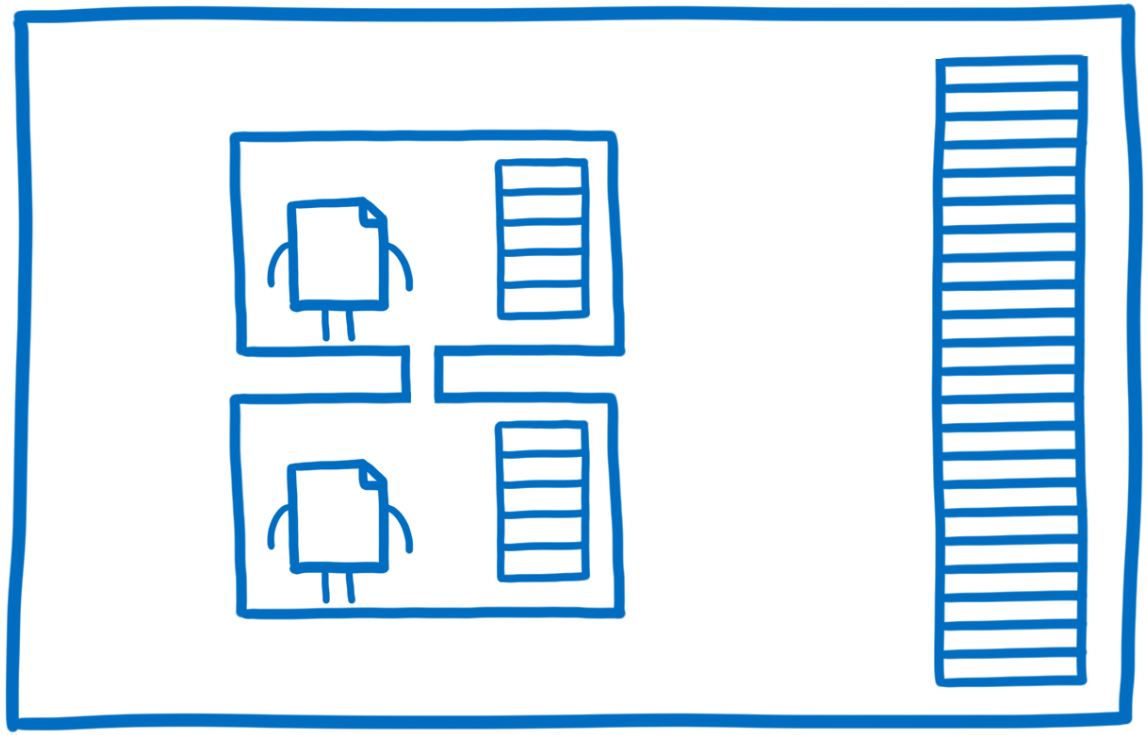
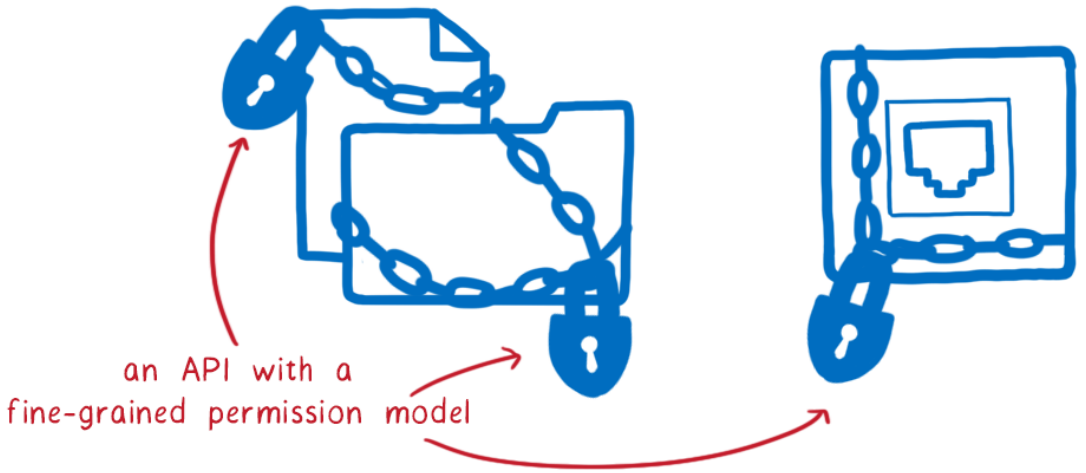
WebAssembly Nano-Process



WebAssembly Nano-Process

4. WebAssembly System Interface





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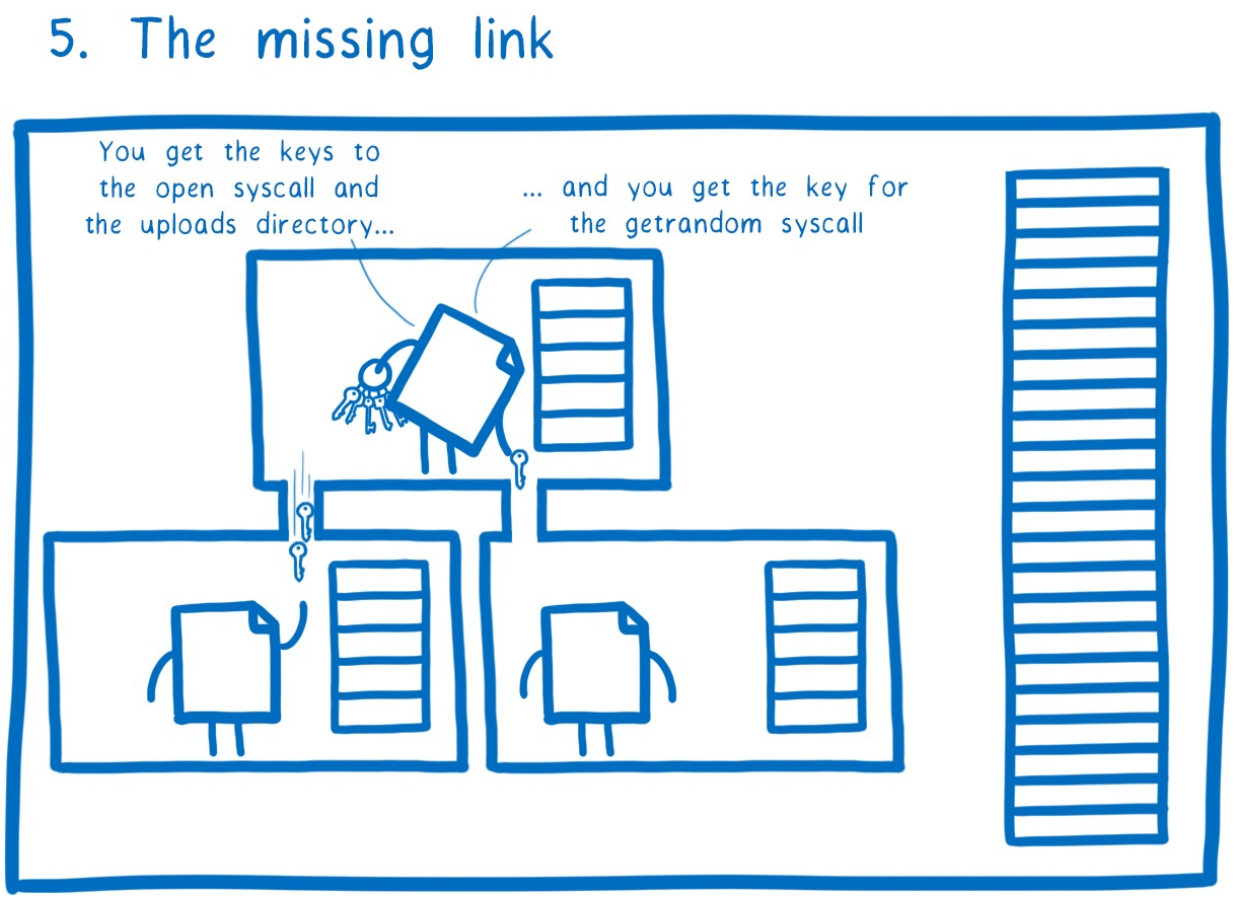
WebAssembly Nano-Process



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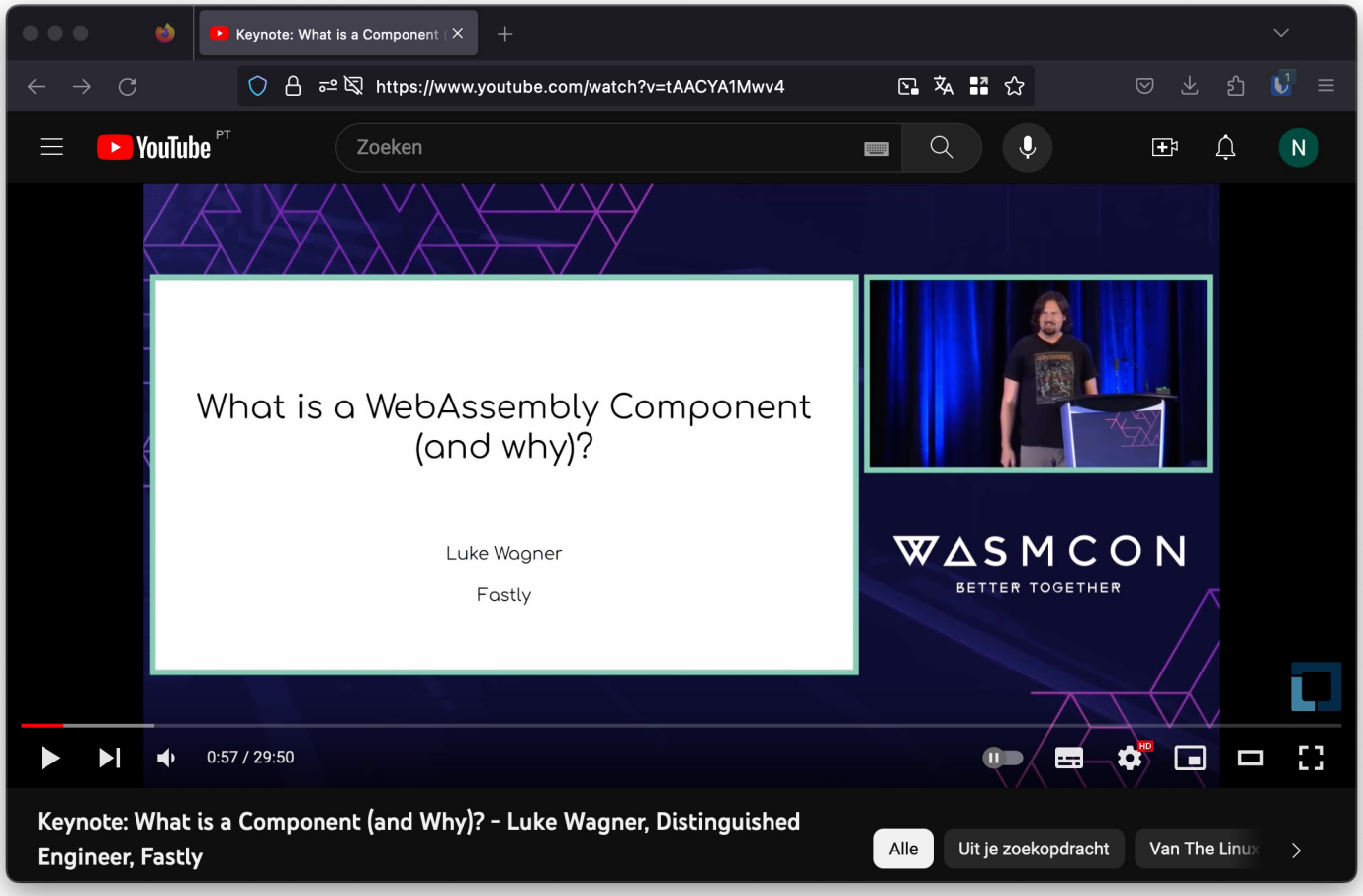
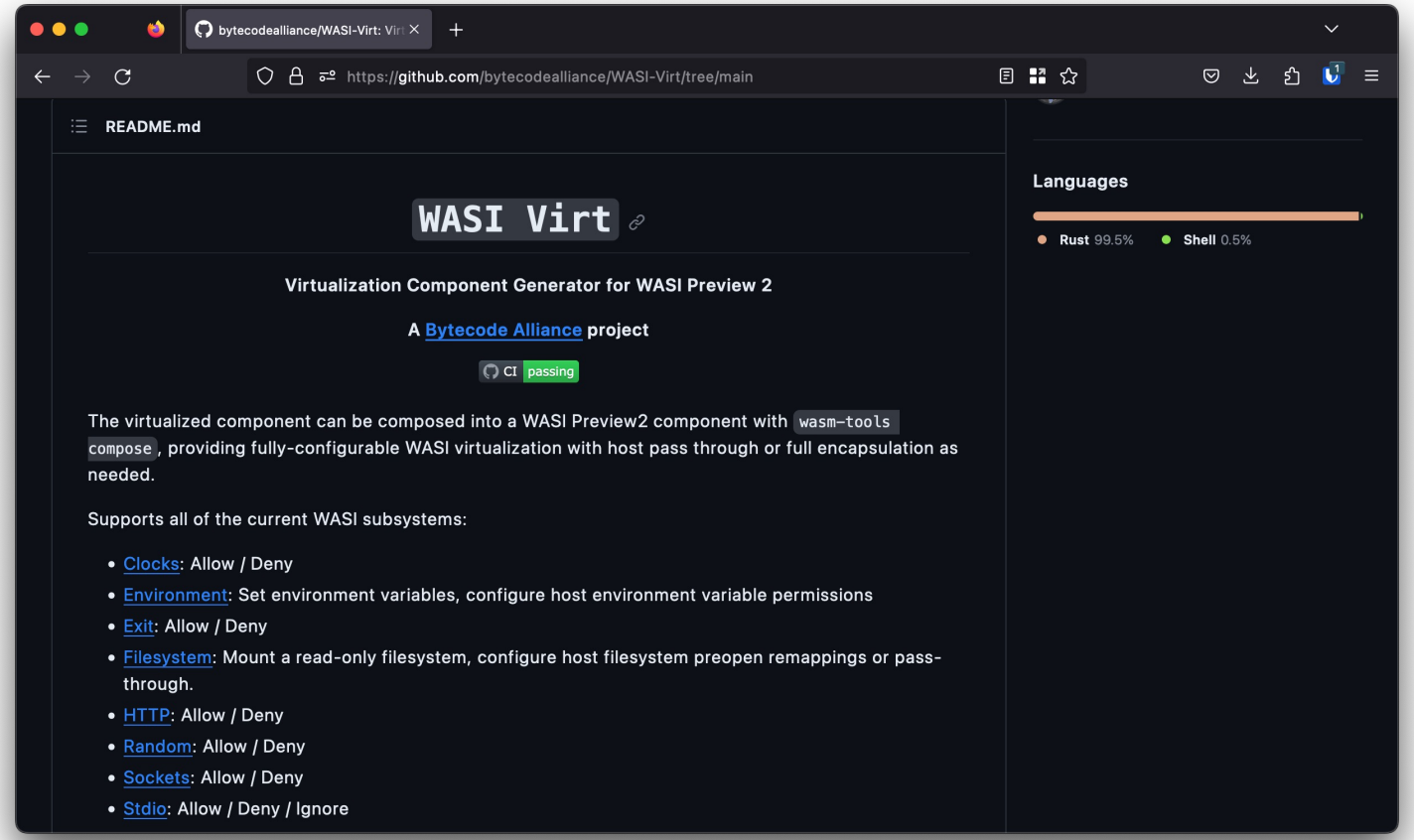
WebAssembly Component Model



WebAssembly Component Model



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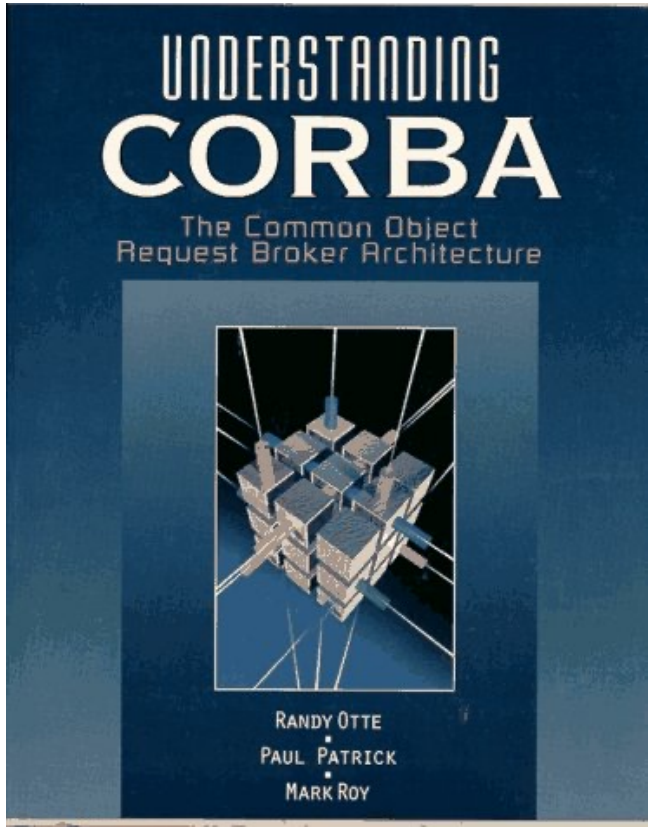
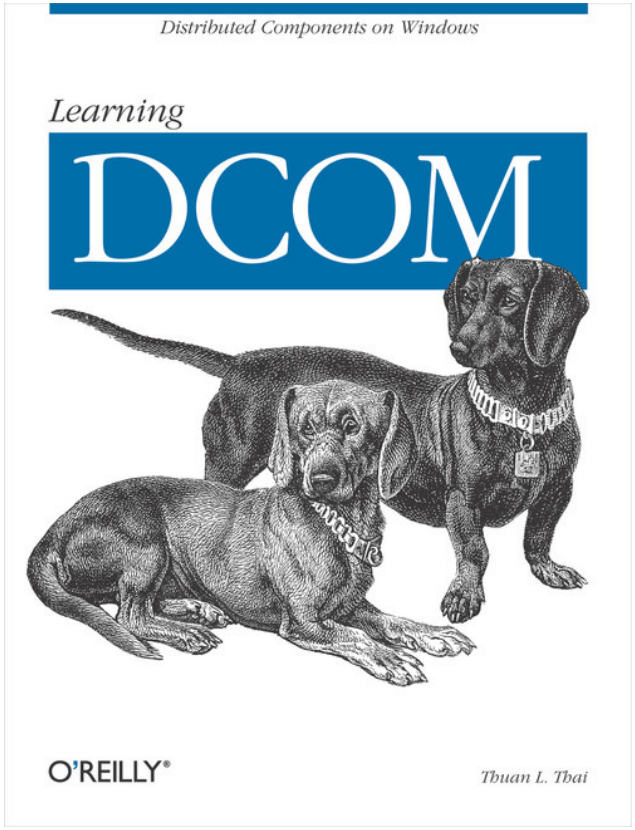
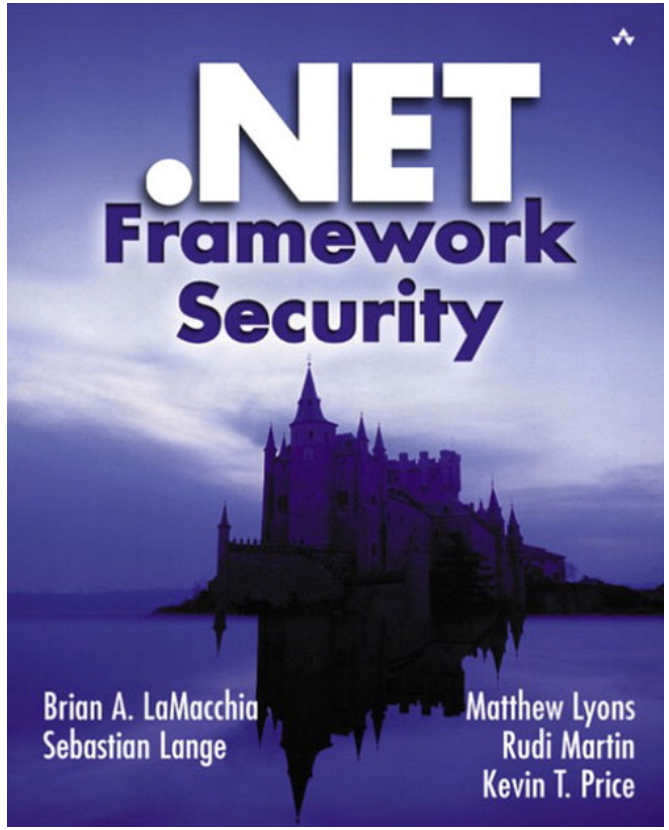
Have we seen this before?







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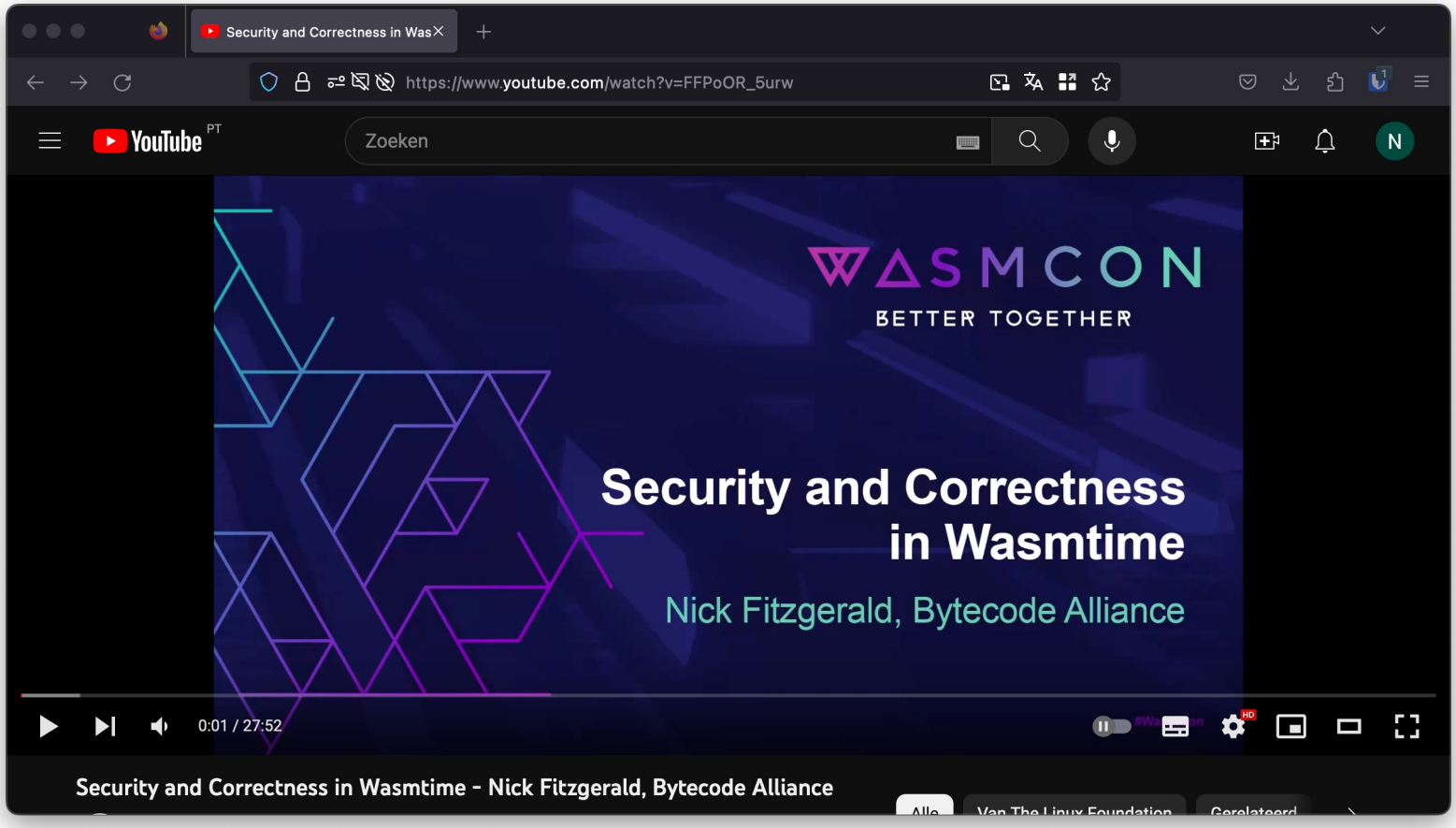
Runtimes and Security

- Most security research published focusses on correctness of WASM runtimes/VM's based on e.g. fuzzing

- Bytecode Alliance Blogpost September 2022 by Nick Fitzgerald:
  - "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



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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!
- I like top-down approach Bytecode Alliance is taking in moving forward, feedback will change/influence

Questions?

- https://github.com/nielstanis/appsecdc2023
- ntanis at Veracode.com
- @nielstanis@infosec.exchange
- https://blog.fennec.dev
- Thank you!


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DC
OCT 30 • NOV 3
THANK YOU