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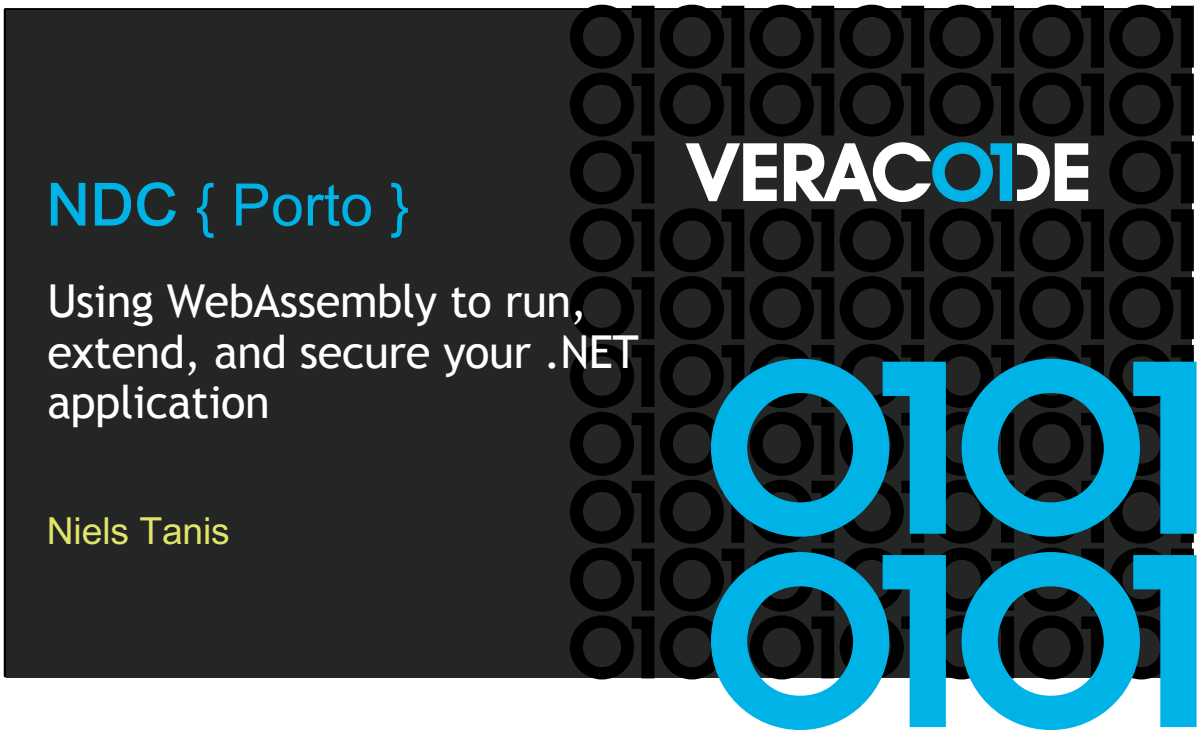
Using WebAssembly to run, extend, and secure your .NET application

Niels Tanis



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

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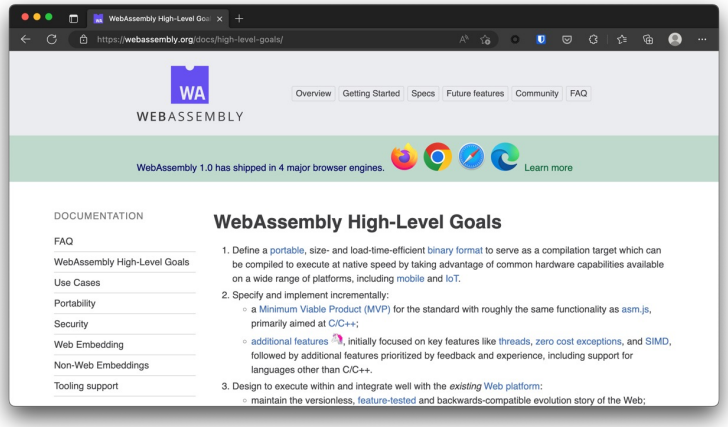
WebAssembly



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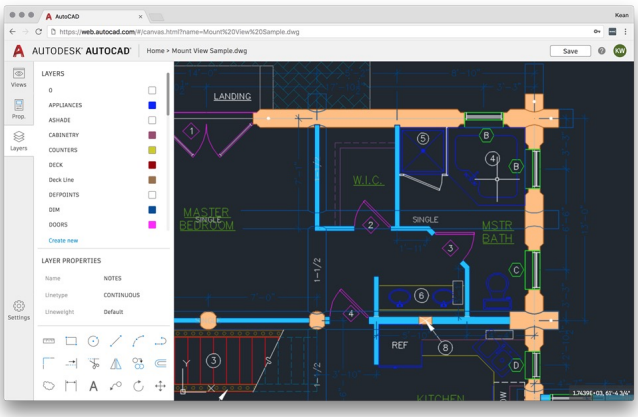
https://hacks.mozilla.org/files/2019/08/04-01-star-diagram.png

WebAssembly - AutoCAD



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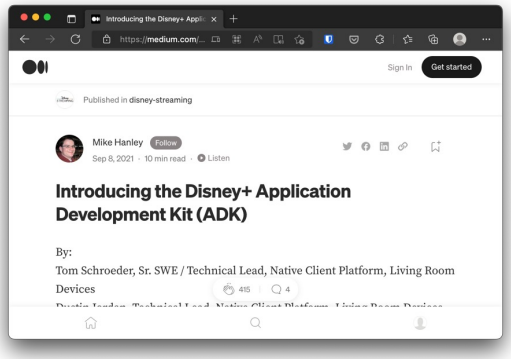
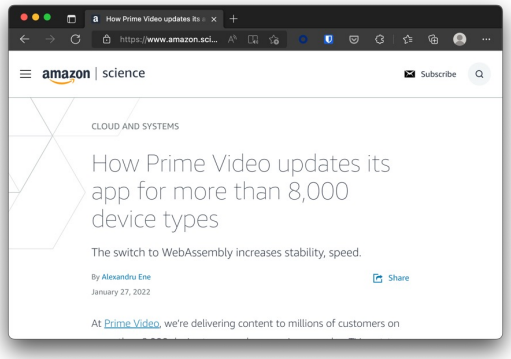
WebAssembly - SDK's





https://medium.com/disney-streaming/introducing-the-disney-application-development-kit-adk-ad85ca139073
https://www.amazon.science/blog/how-prime-video-updates-its-app-for-more-than-8-000-device-types

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

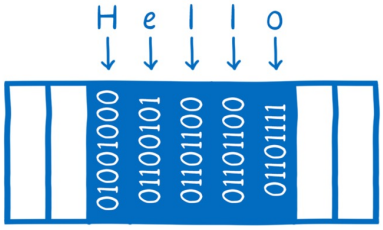
WebAssembly

- Binary instruction format for stack-based virtual machine similar to .NET running MSIL
- 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

https://hacks.mozilla.org/2017/02/creating-and-working-with-webassembly-modules/
https://webassembly.org/

WebAssembly Memory

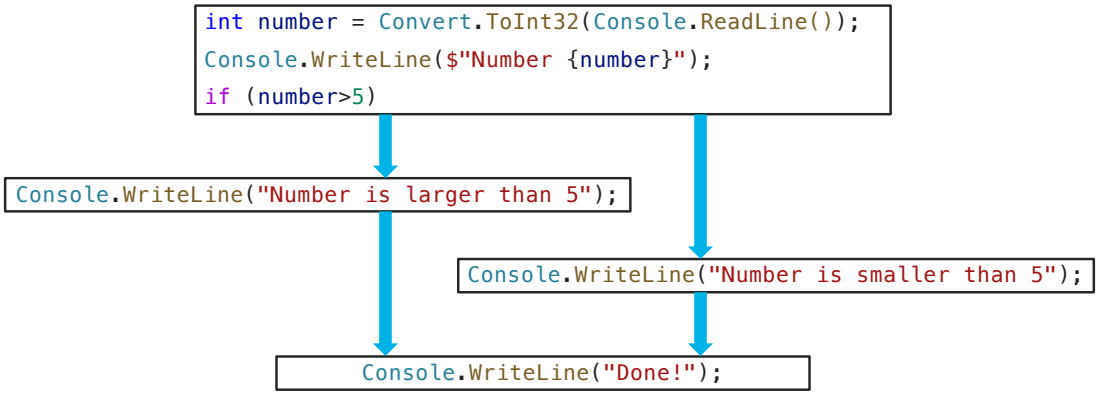
- Isolated per WASM module
- A contiguous, mutable array of uninterpreted bytes



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



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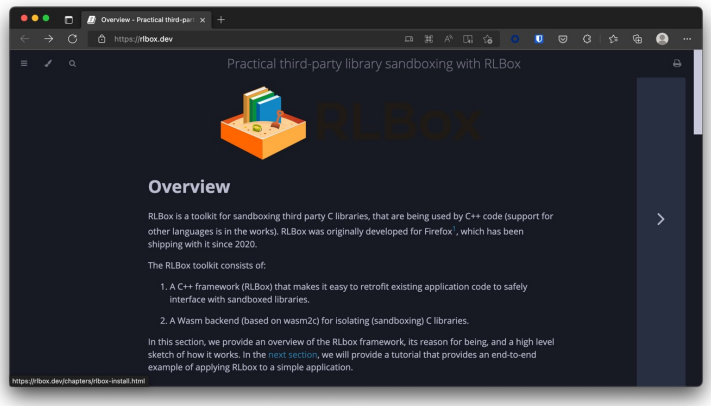
FireFox RLBox



https://rlbox.dev/
https://hacks.mozilla.org/2020/02/securing-firefox-with-webassembly/

Running .NET on WebAssembly

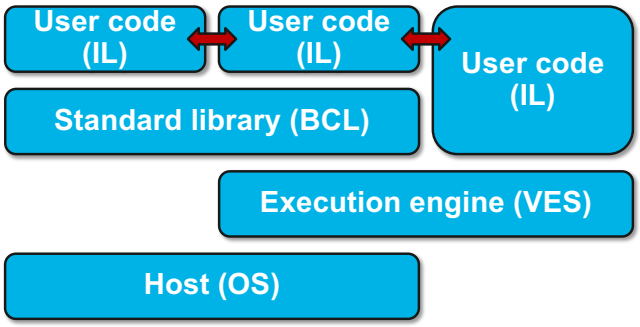


Diagram: https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

Running .NET on WebAssembly

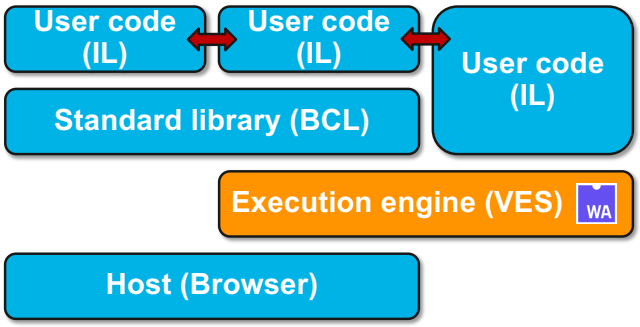
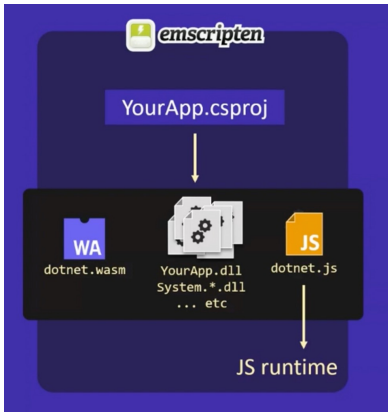


Diagram: https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

Blazor WebAssembly



Running .NET on WebAssembly

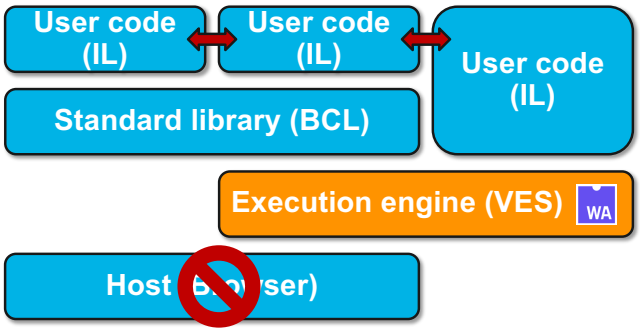


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Diagram: https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

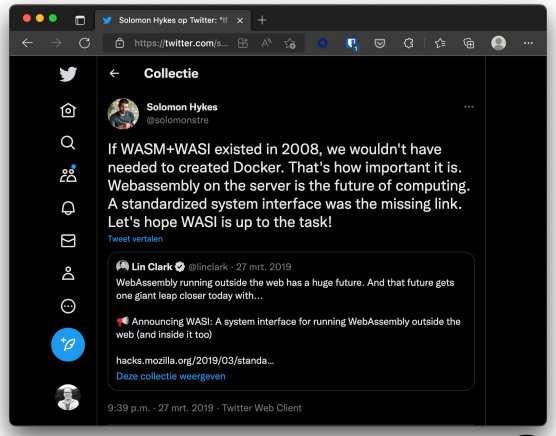
WebAssembly System Interface WASI

- 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

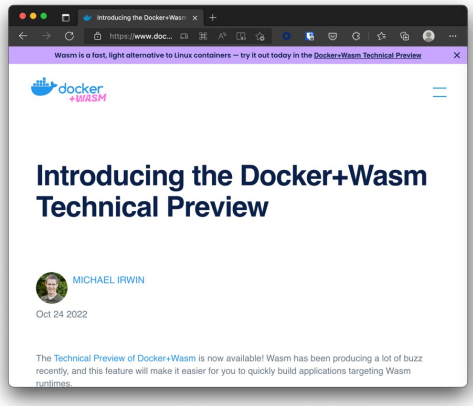
- Strong sandbox with Capability Based Security
- Right now, supports e.g. FileSystem actions
- Future support for sockets and other system resources.
- Anyone recall .NET Standard? ☺

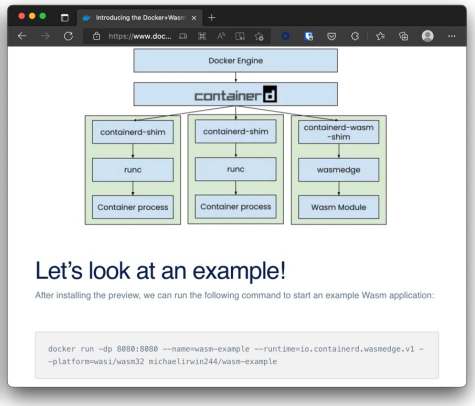
Docker vs WASM & WASI



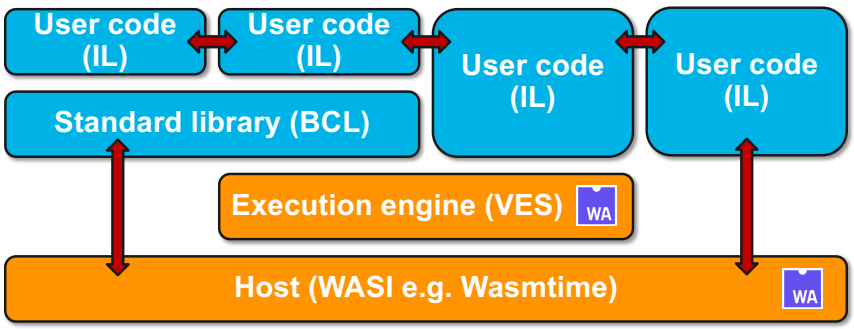
Docker vs WASM & WASI

Docker & WASM


Wasm is a fast, light alternative to Linux containers — try it out today in the Docker+Wasm Technical Preview
docker +WASM
Introducing the Docker+Wasm Technical Preview
MICHAEL IRWIN
Oct 24 2022
The Technical Preview of Docker+Wasm is now available! Wasm has been producing a lot of buzz recently, and this feature will make it easier for you to quickly build applications targeting Wasm runtimes.


Docker Engine
containerd
containerd-shim
runc
Container process
containerd-shim
runc
Container process
containerd-wasm-shim
wasmedge
Wasm Module
Let's look at an example!
After installing the preview, we can run the following command to start an example Wasm application:
docker run -dp 8080:8080 --name=wasm-example --runtime=io.containerd.wasmedge.v1 --platform=wasi/wasm32 michaelirwin244/wasm-example

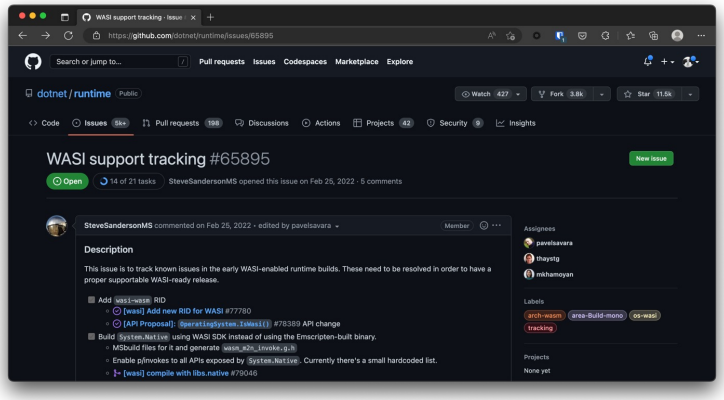
WebAssembly System Interface WASI



Experimental WASI SDK for .NET

https://github.com/SteveSandersonMS/dotnet-wasi-sdk

Experimental WASI SDK for .NET



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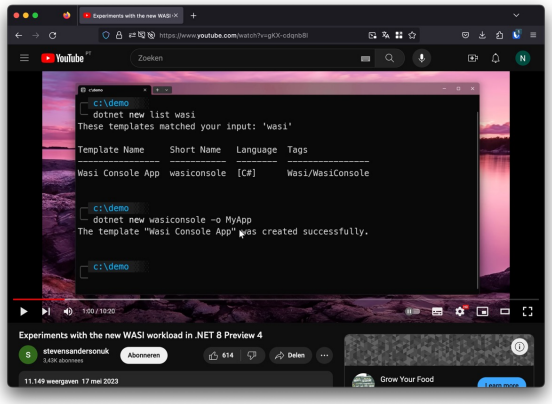
https://github.com/dotnet/runtime/issues/65895
https://github.com/SteveSandersonMS/dotnet-wasi-sdk

Experimental WASI workload .NET8



https://github.com/dotnet/runtime/issues/65895
https://github.com/SteveSandersonMS/dotnet-wasi-sdk

Extending .NET with WASM

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

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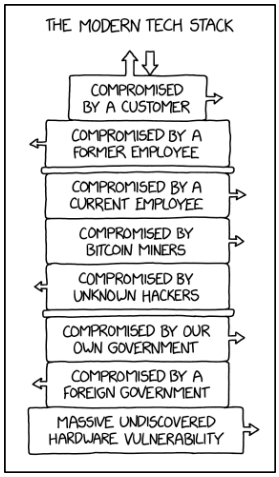
Trusted Computing – XKCD 2166



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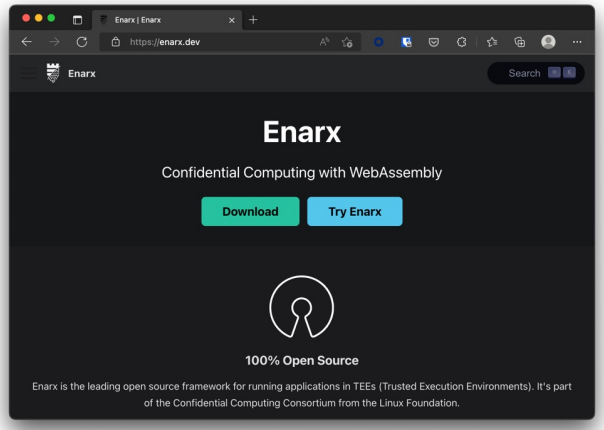
https://xkcd.com/2166/

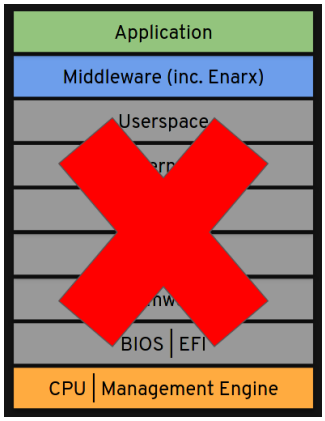
Enarx



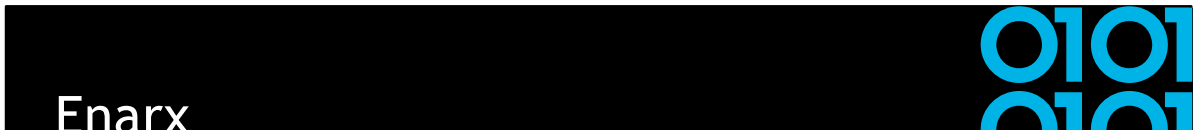
https://enarx.dev/

Enarx Threat Model

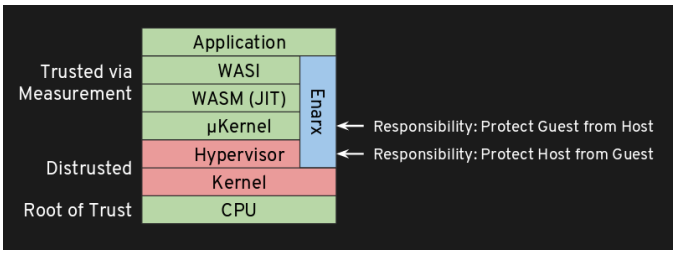
- Don’t trust the host
- Don’t trust the host owner
- Don’t trust the host operator
- Hardware cryptographically verified
- Software audited and cryptographically verified



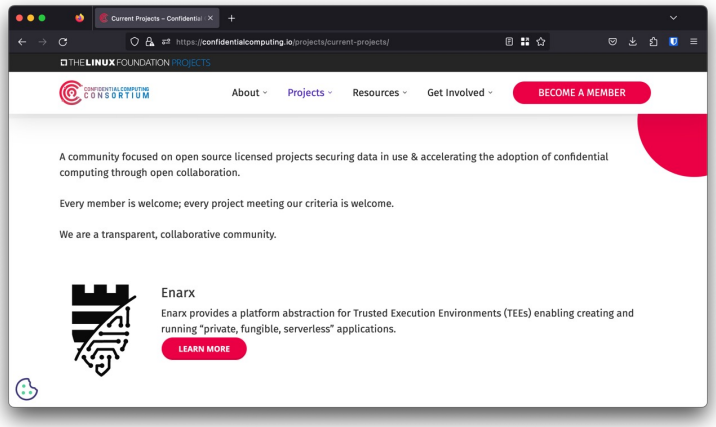
Enarx



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



Confidentional Computing Consortium



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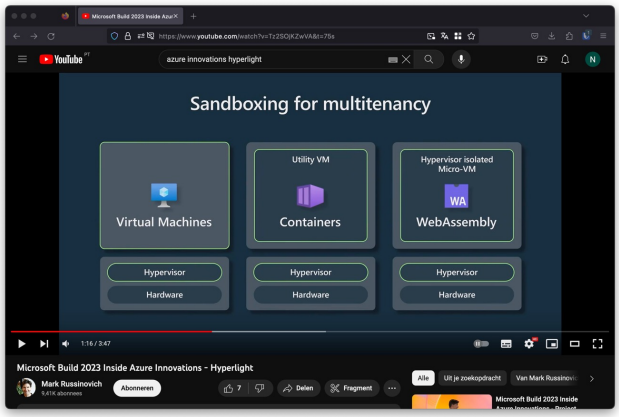
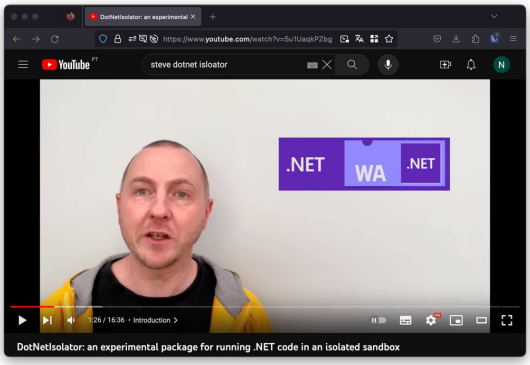
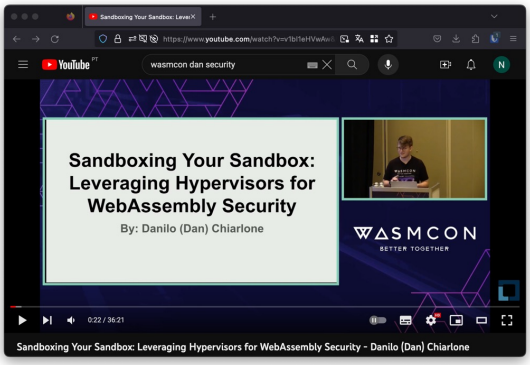
Project Hyperlight



DotNetIsolator & Project Hyperlight





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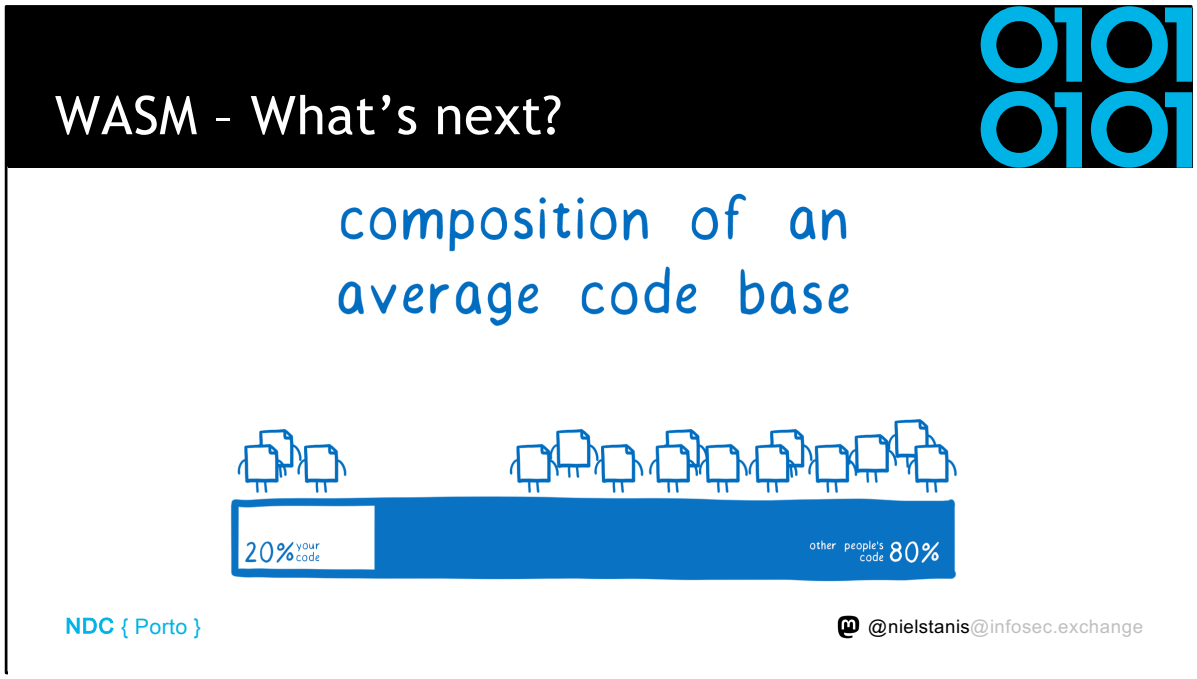
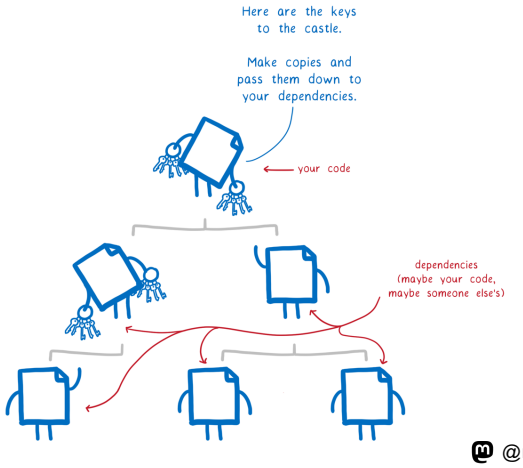
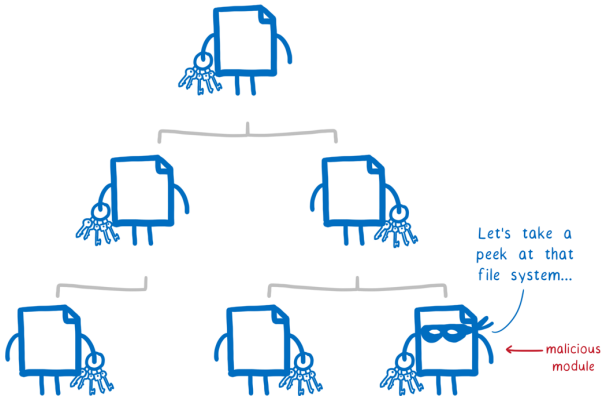
WASM – What's next?



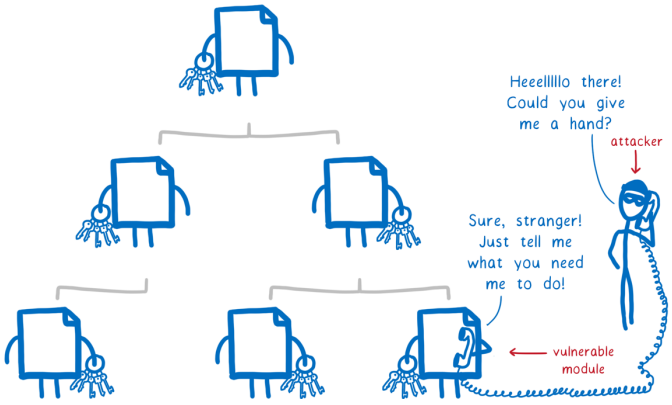
Dependencies



Malicious module



Vulnerable module



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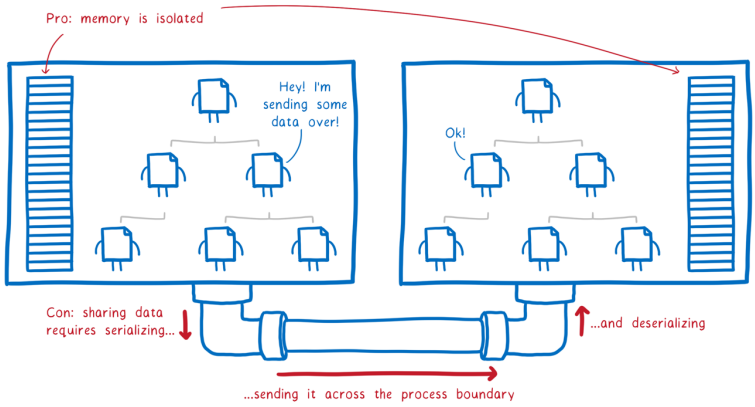
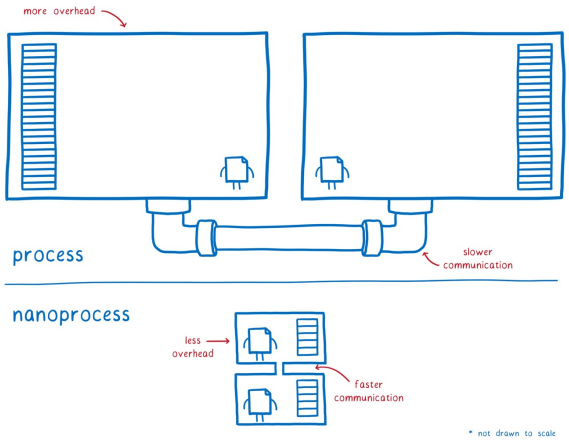
Process Isolation



WebAssembly Nano-Process



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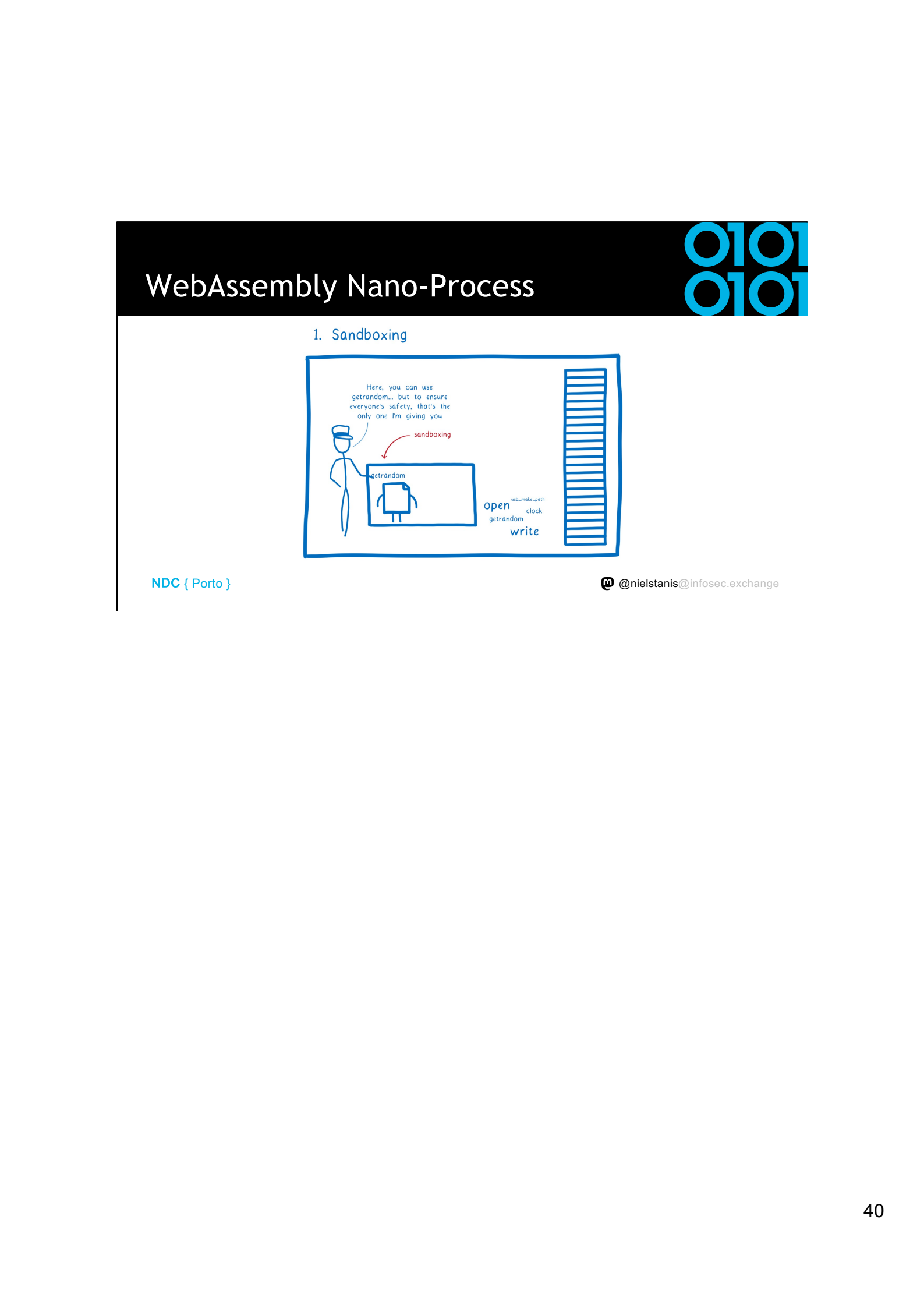
WebAssembly Nano-Process



1. Sandboxing

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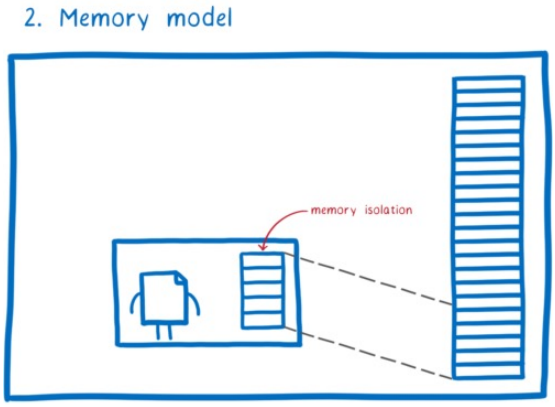
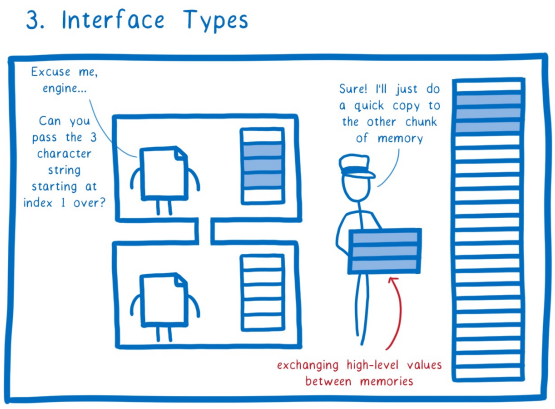
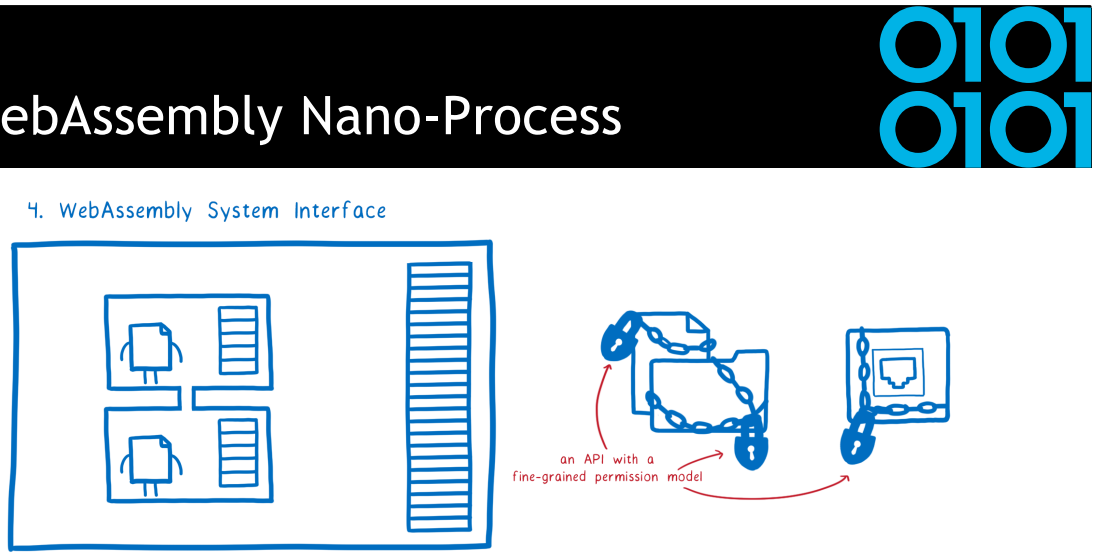
WebAssembly Nano-Process



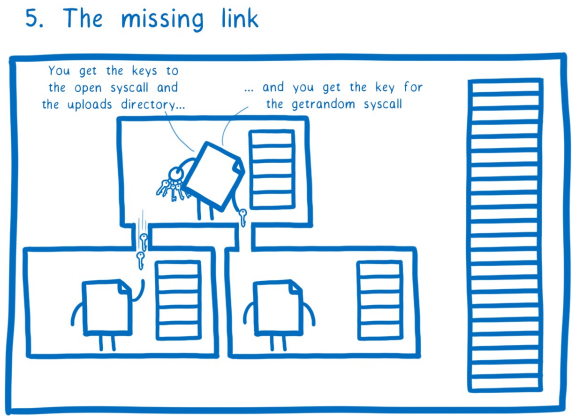
WebAssembly Nano-Process



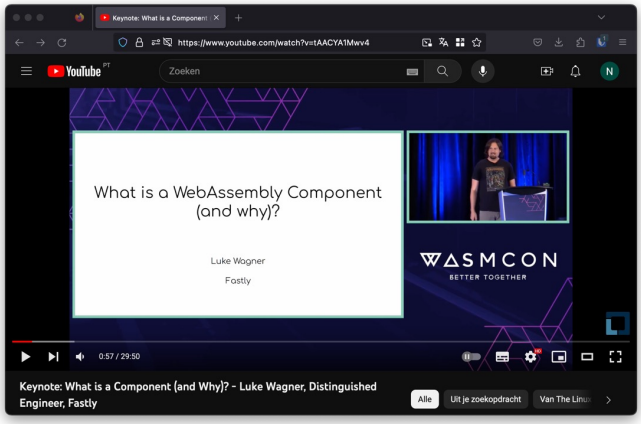
WebAssembly Nano-Process



WebAssembly Nano-Process



WebAssembly Component Model



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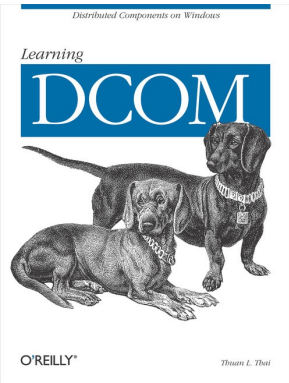
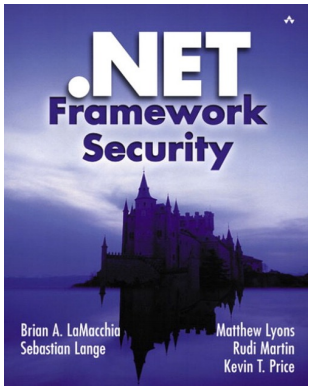
https://www.youtube.com/watch?v=tAACYA1Mwv4

Have we seen this before?





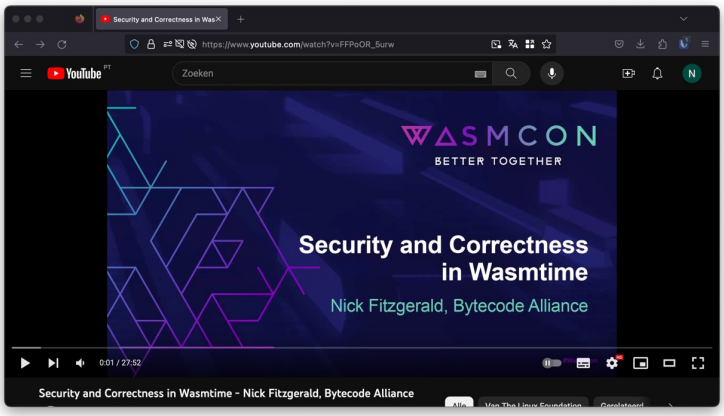
Runtimes and Security

- 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

https://bytecodealliance.org/articles/security-and-correctness-in-wasmtime

Runtimes and Security



https://www.youtube.com/watch?v=FFPoOR_5urw

Conclusion

- Cloud Native ❤️ WebAssembly
- WebAssembly has a lot of potential to be used to run, extend, and secure your .NET 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/ndcporto2023-wasm
- ntanis at Veracode.com
- @nielstanis@infosec.exchange
- https://blog.fennec.dev
- Obrigado! Thank you!