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

Niels Tanis

NDC { Security }

Who am I?

- Niels Tanis
- Sr. Principal Security Researcher @ Veracode
  - Background .NET Development, Pentesting/ethical hacking, and software security consultancy
  - Research on static analysis for .NET apps

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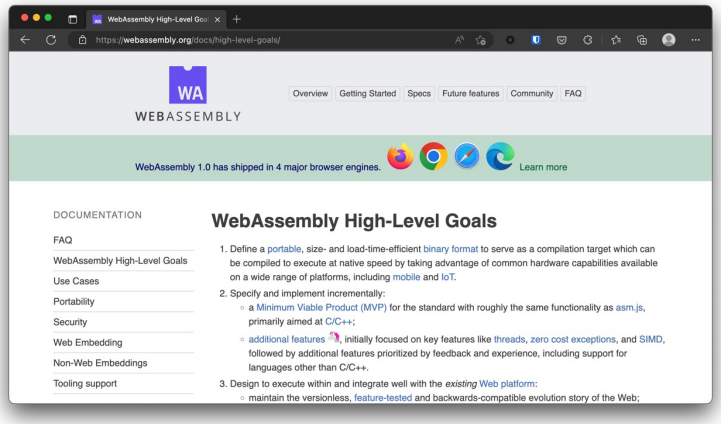
WebAssembly



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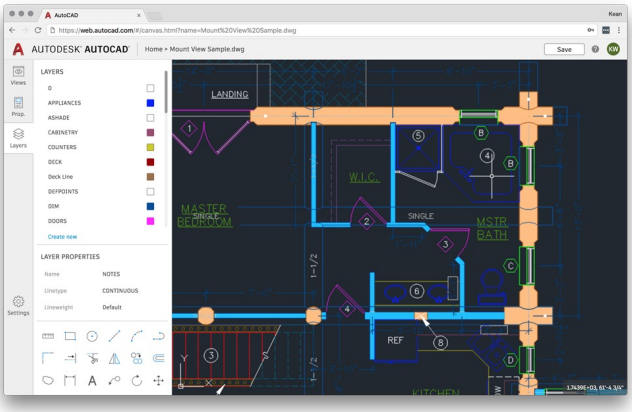
https://hacks.mozilla.org/files/2019/08/04-01-star-diagram.png

WebAssembly - AutoCAD



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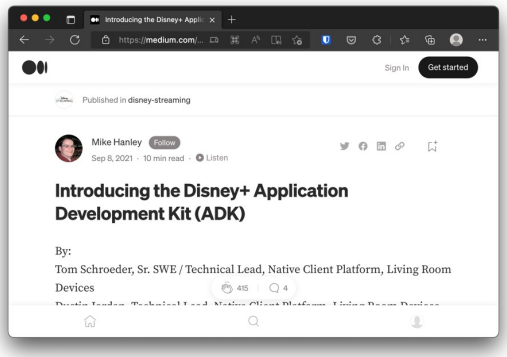
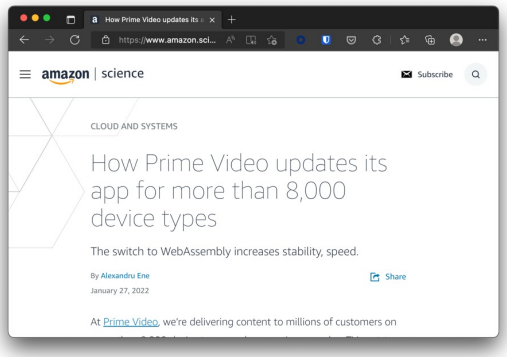
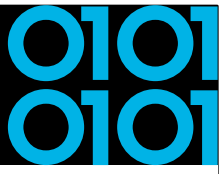
WebAssembly – SDK's





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

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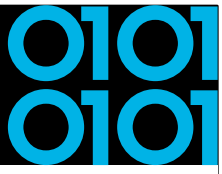
WebAssembly Design



- **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

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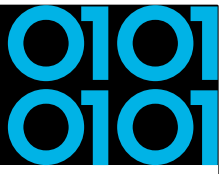
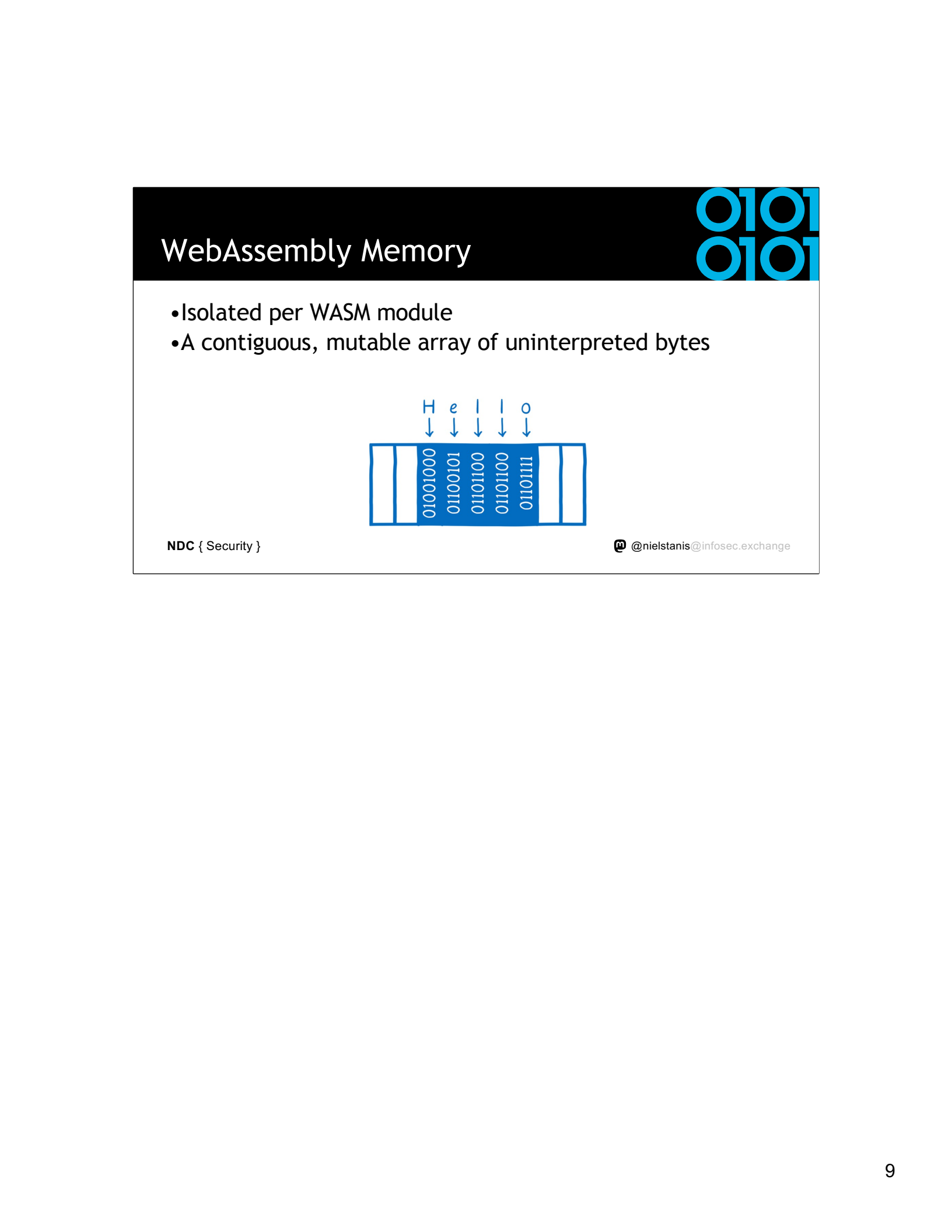
WebAssembly



- 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

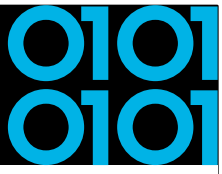
https://hacks.mozilla.org/2017/02/creating-and-working-with-webassembly-modules/
https://webassembly.org/

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!");
```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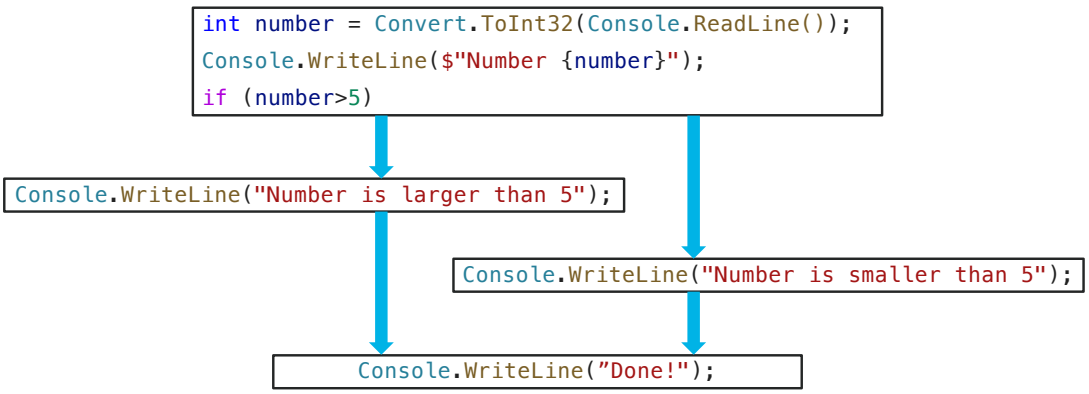
WebAssembly Control-Flow Integrity



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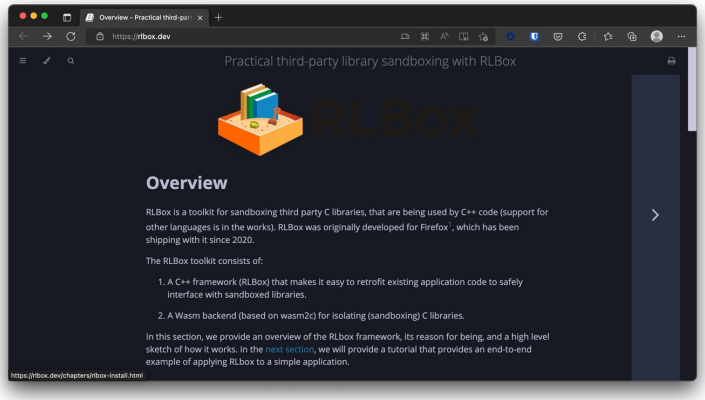
FireFox RLBox



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

Running .NET on WebAssembly

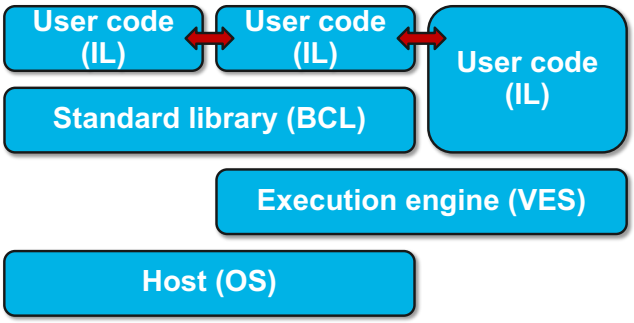


Diagram:
https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

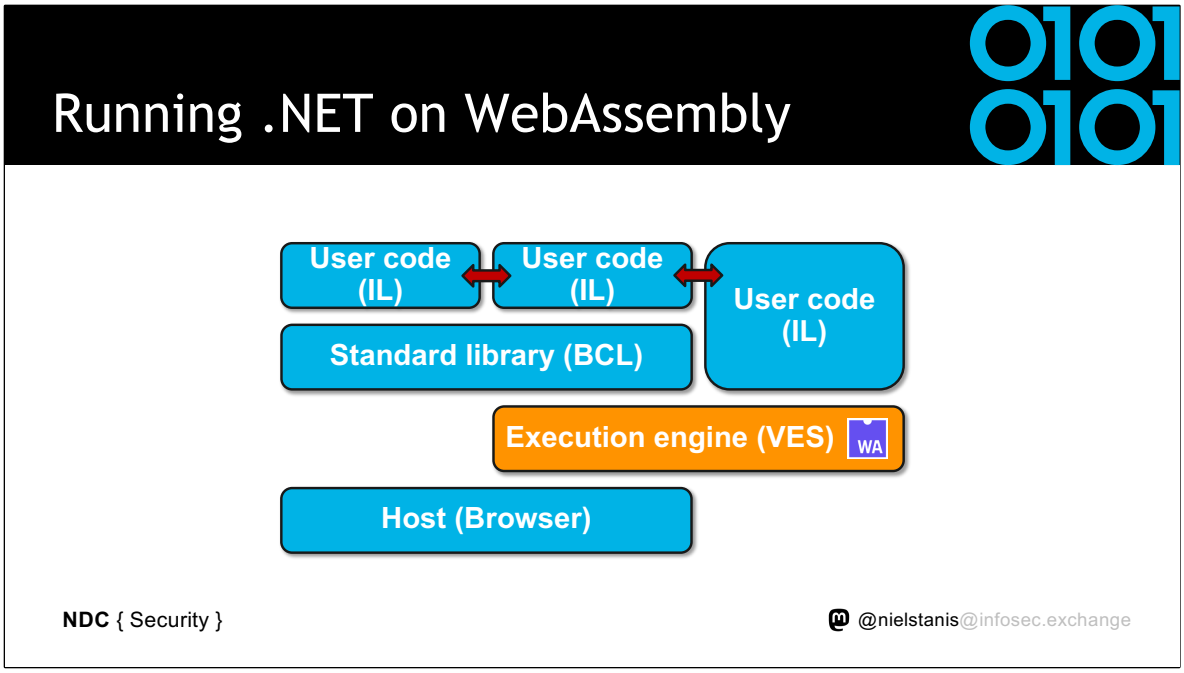
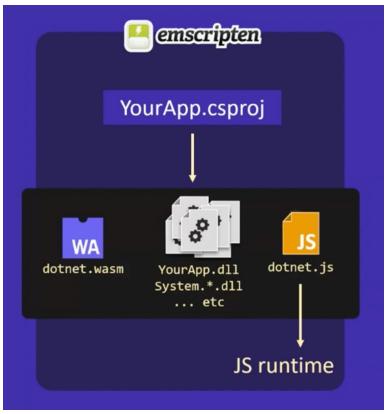
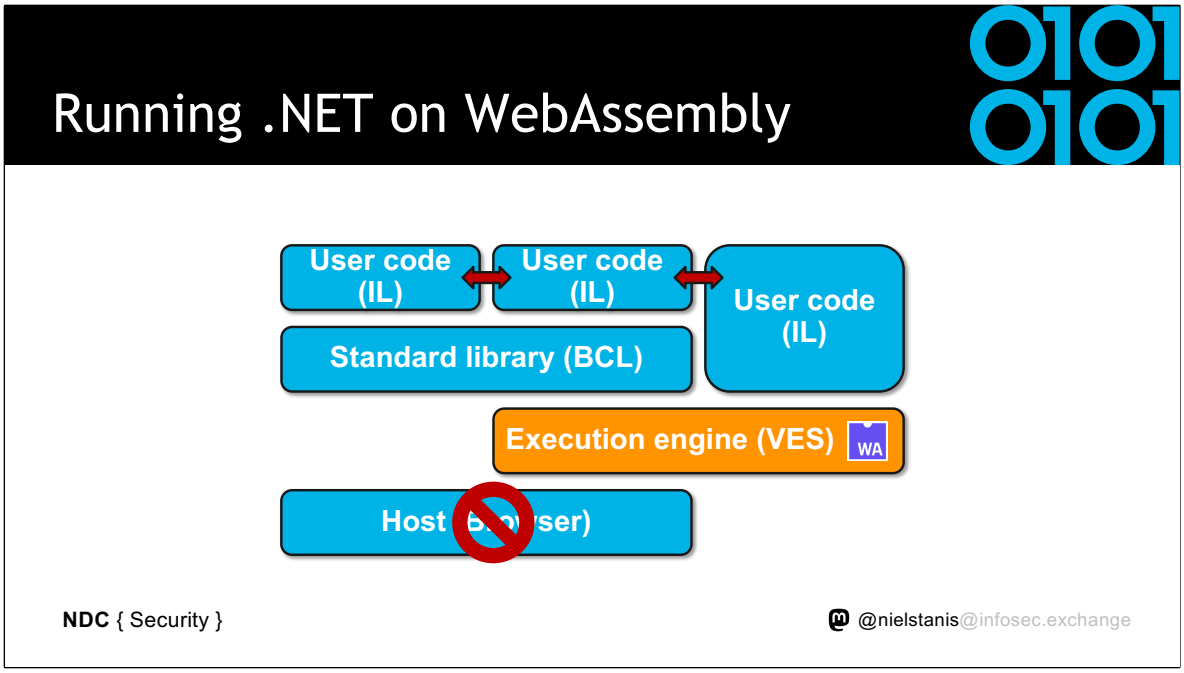


Diagram: https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

Blazor WebAssembly





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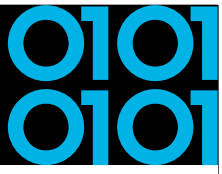
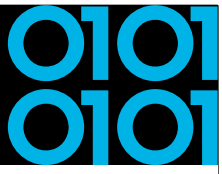
WebAssembly System Interface WASI



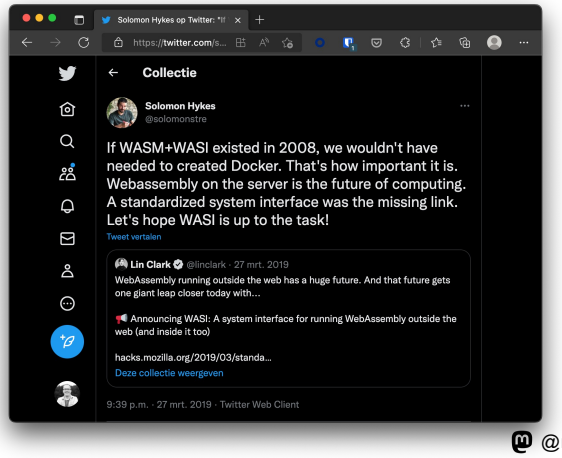
- Introduced in March 2019 by Bytecode Alliance
- WasmTime implementation as reference
- POSIX inspired, engine-independent, non-Web system-oriented API for WebAssembly

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



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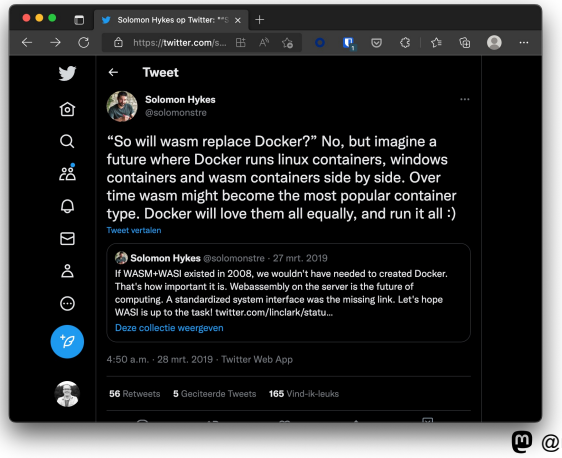
Docker vs WASM & WASI



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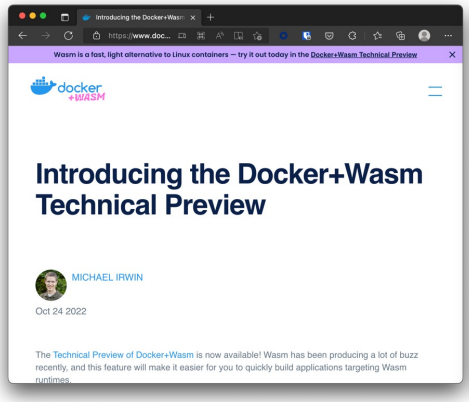
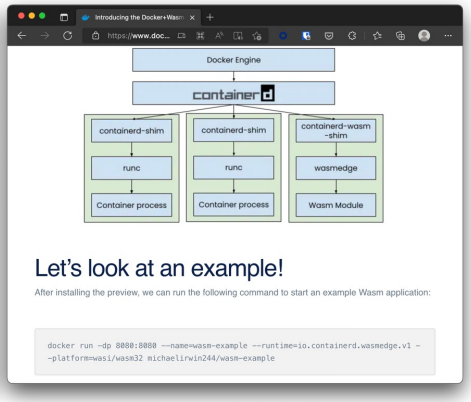
Docker & WASM





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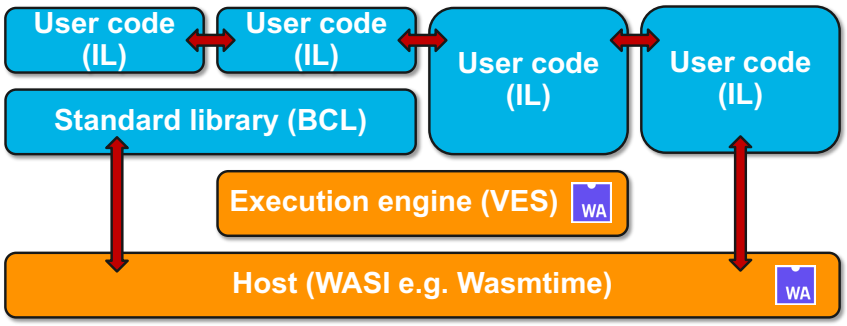
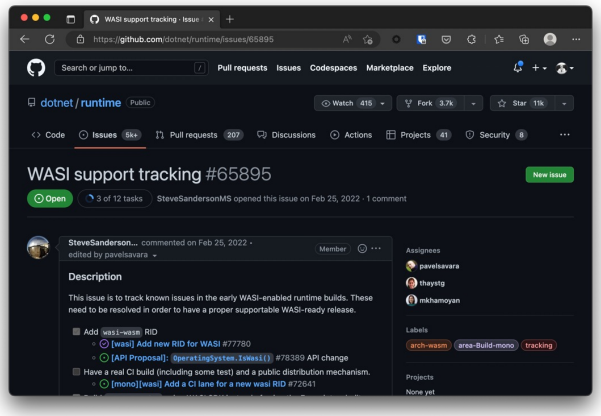
WebAssembly System Interface WASI



Experimental WASI SDK for .NET

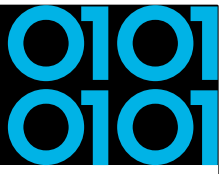
https://github.com/SteveSandersonMS/dotnet-wasi-sdk

Experimental WASI SDK for .NET



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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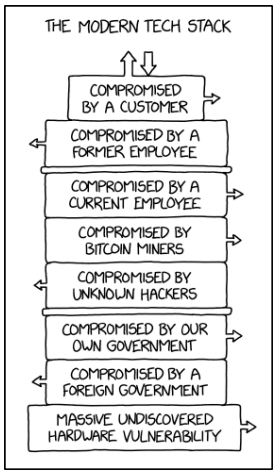
Trusted Computing – XKCD 2166



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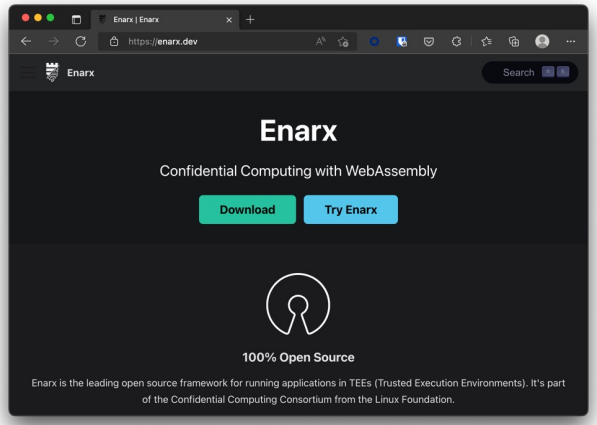
https://xkcd.com/2166/

Enarx



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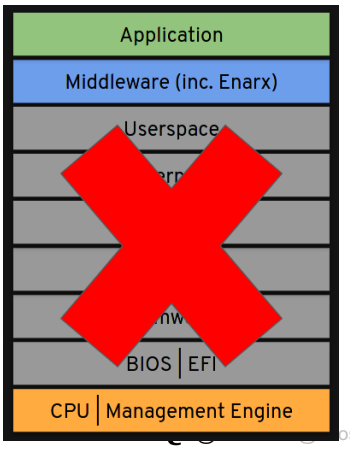
https://enarx.dev/

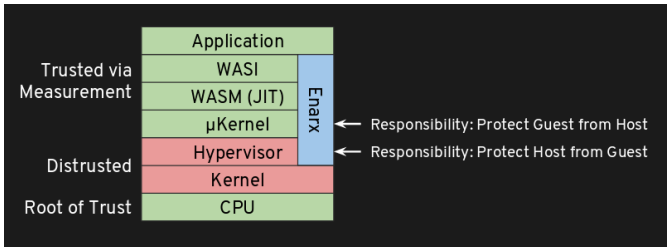
Enarx Threat Model

- 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

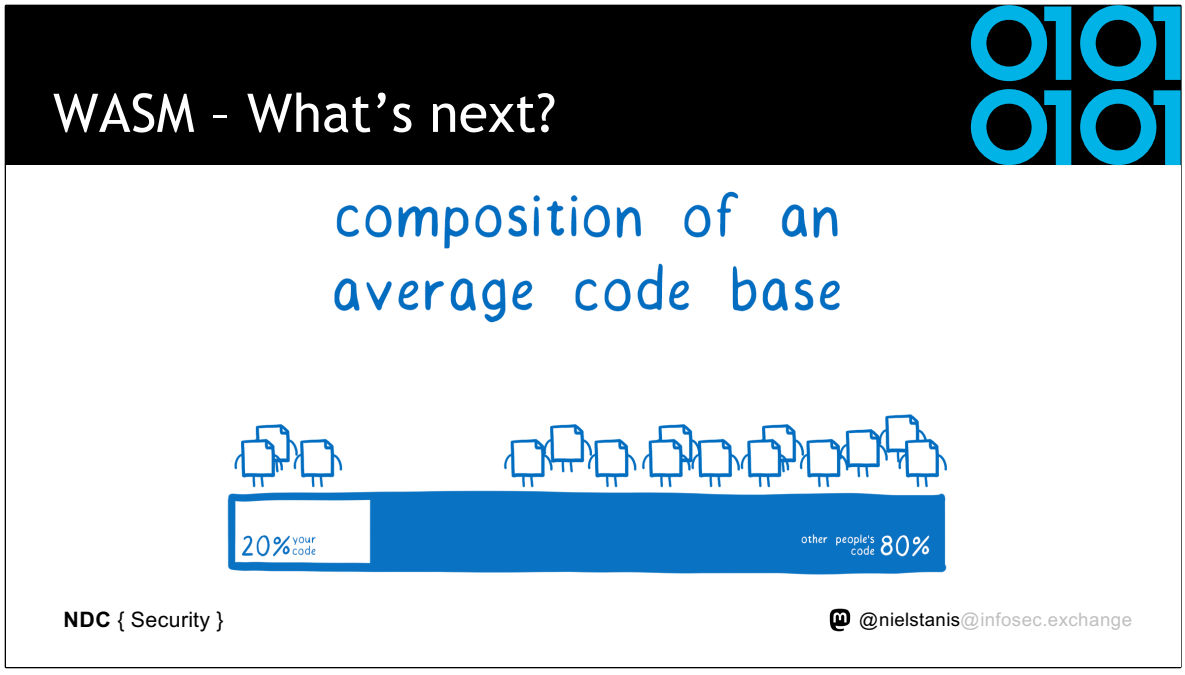


Enarx

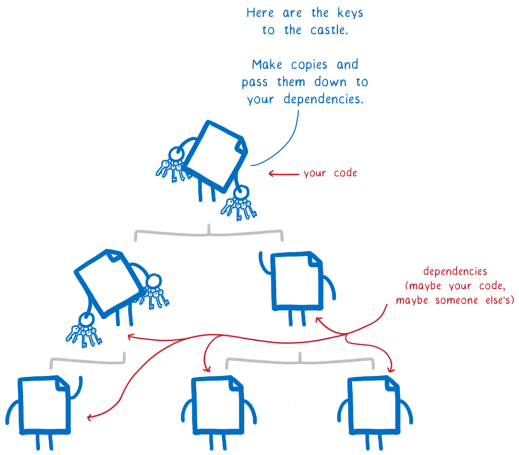
- Leverages Trusted Execution Environment (TEE) direct on processor
  - AMD's SEV, Intel's SGX and IBM's PEF
- Attestation of hardware and Enarx runtime



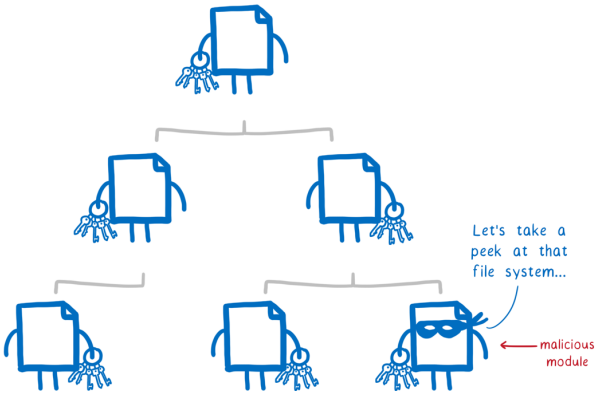
WASM – What's next?



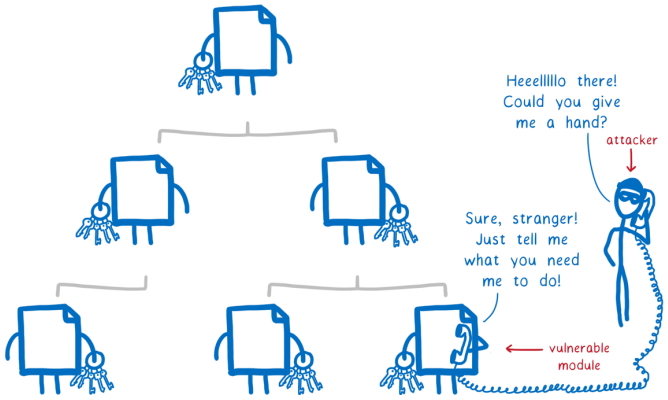
Dependencies



Malicious module



Vulnerable module



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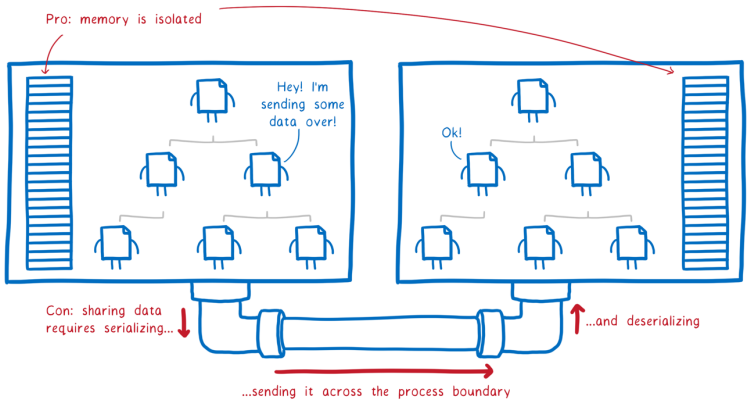
Process Isolation



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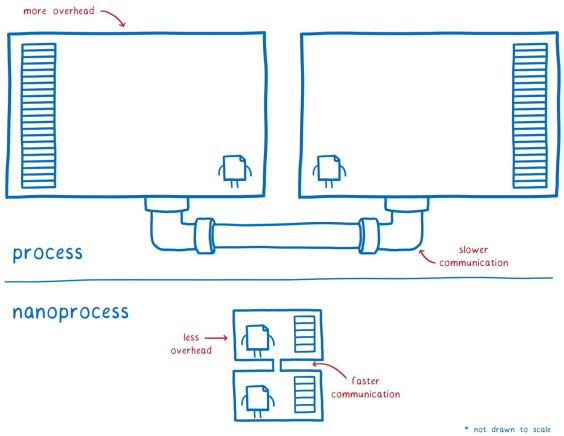
WebAssembly Nano-Process



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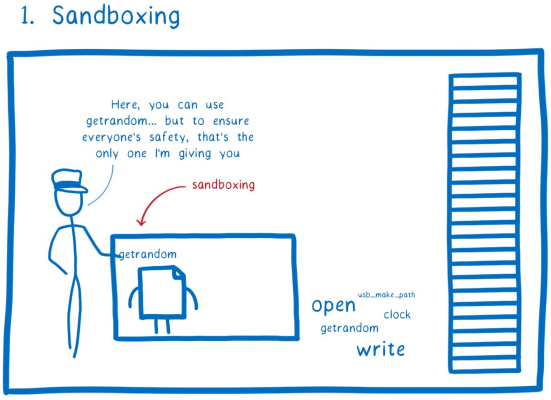
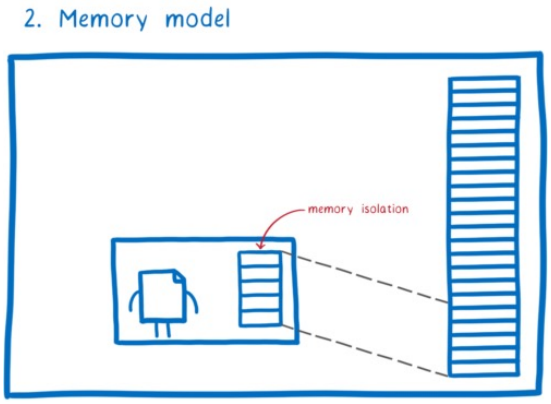


WebAssembly Nano-Process



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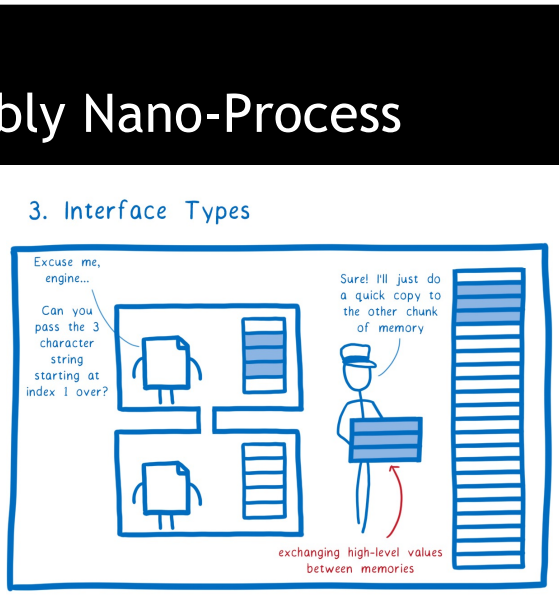

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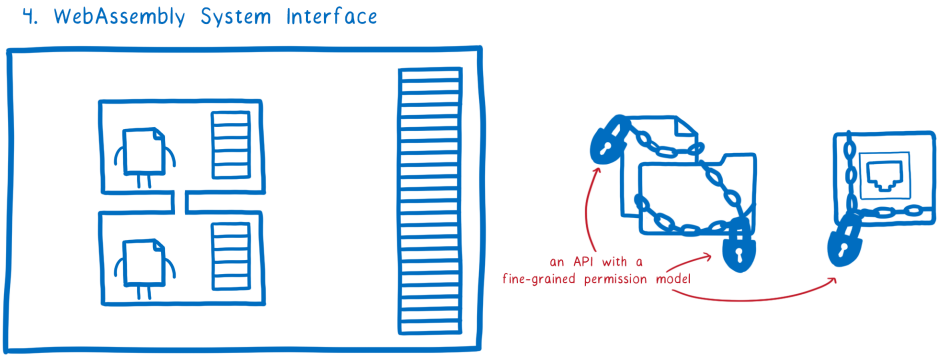
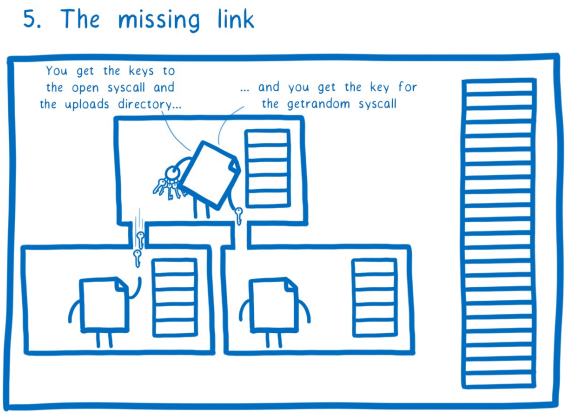
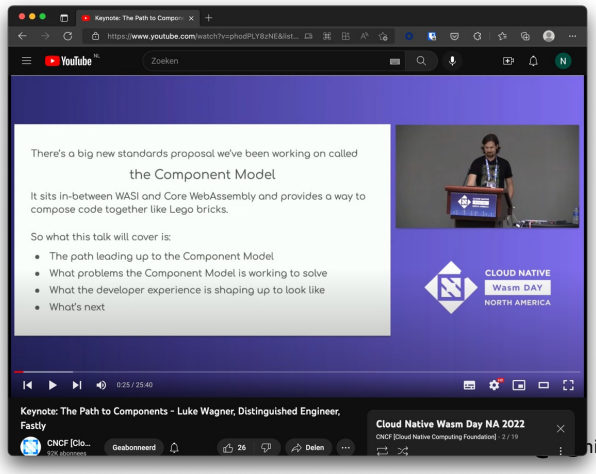


WebAssembly Nano-Process



WebAssembly Component Model



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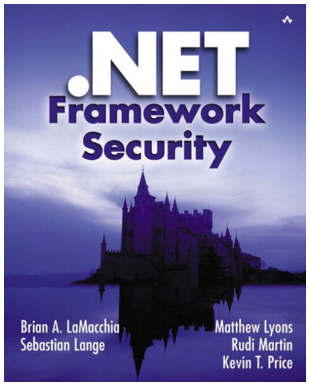
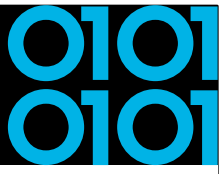
https://www.youtube.com/watch?v=JotItWTHD5s

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

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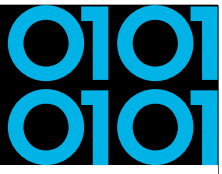
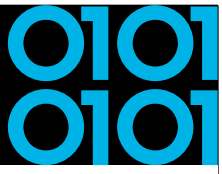
https://bytecodealliance.org/articles/security-and-correctness-in-wasmtime

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

Questions?



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- Takk! Thank you!