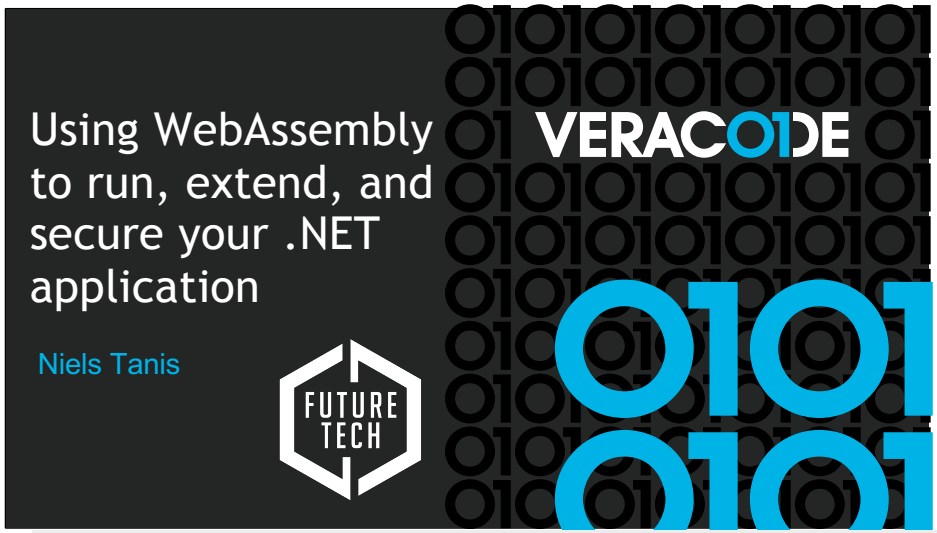
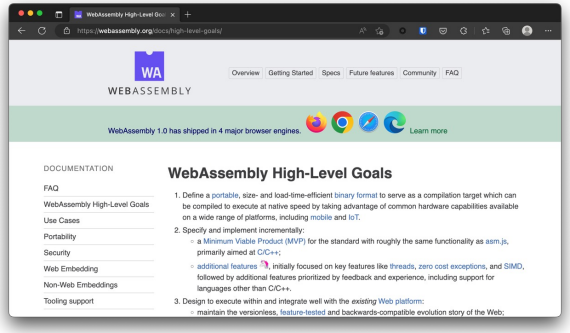

Using WebAssembly to run, extend, and secure your .NET application
Niels Tanis
FUTURE TECH
VERACODE
0101
0101

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
- Microsoft MVP – Developer Technologies

@nielstanis@infosec.exchange

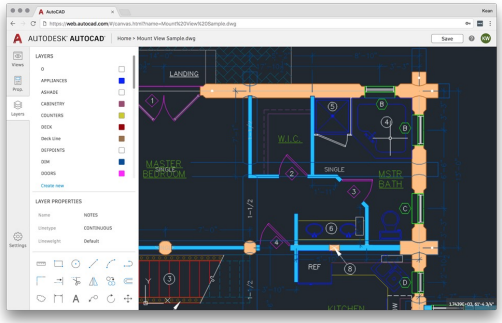
WebAssembly



@nielstanis@infosec.exchange

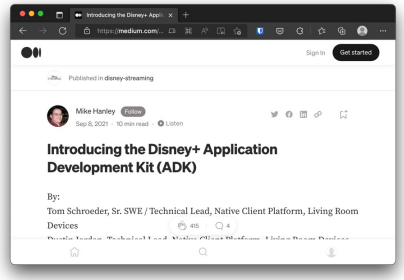
https://hacks.mozilla.org/files/2019/08/04-01-star-diagram.png

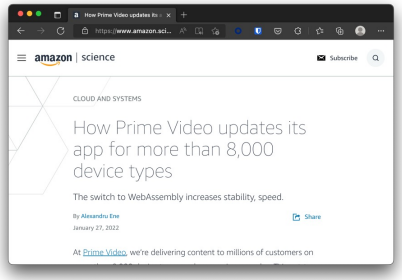
WebAssembly - AutoCAD



@nielstanis@infosec.exchange

WebAssembly – SDK's





@nielstanis@infosec.exchange

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

@nielstanis@infosec.exchange

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

@nielstanis@infosec.exchange

WebAssembly

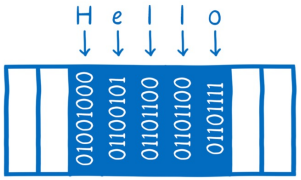
- Binary instruction format for stack-based virtual machine similar to .NET running MSIL
- Designed as a portable compilation target
- The security model of WebAssembly:
  - Protect users from buggy or malicious modules
  - Provide developers with useful primitives and mitigations for developing safe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

@nielstanis@infosec.exchange

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



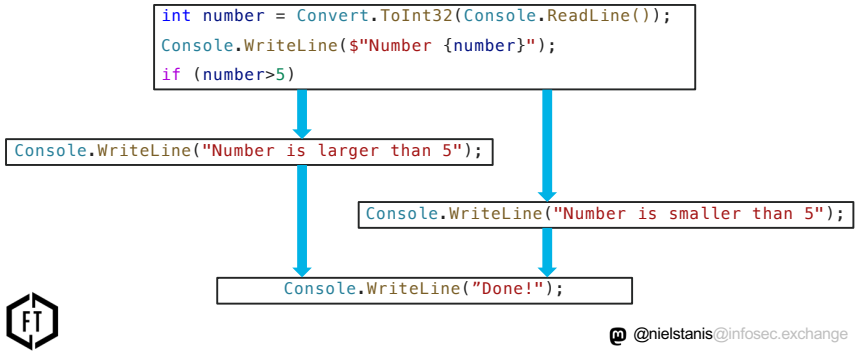
@nielstanis@infosec.exchange

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!");
```

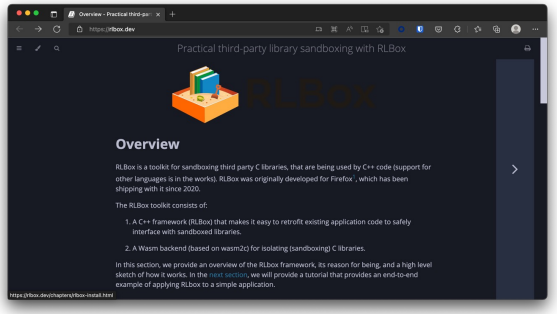
@nielstanis@infosec.exchange

WebAssembly Control-Flow Integrity



@nielstanis@infosec.exchange

FireFox RLBox



@nielstanis@infosec.exchange

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

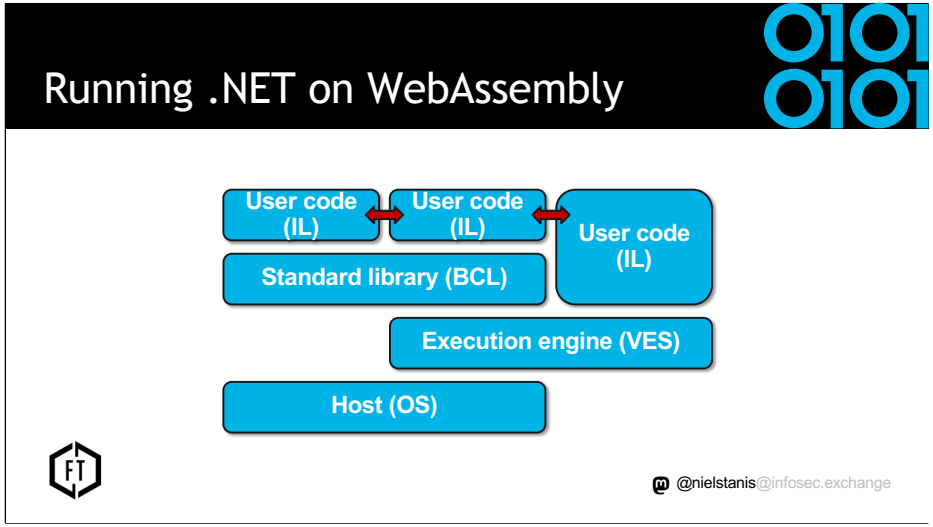


Diagram:
https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

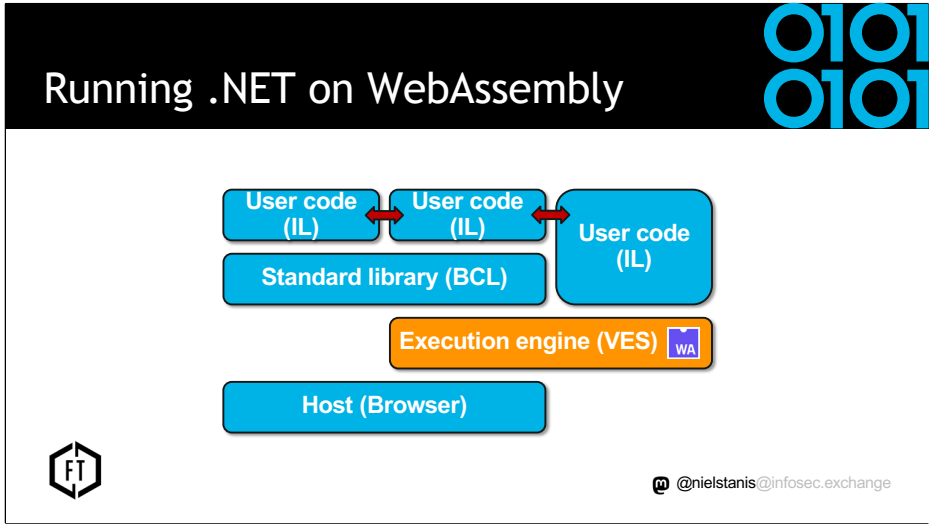
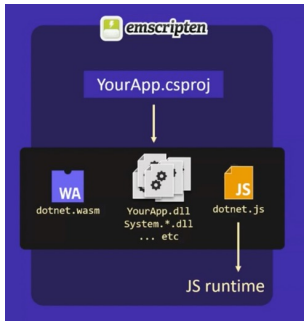


Diagram:
https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

Blazor WebAssembly



@nielstanis@infosec.exchange

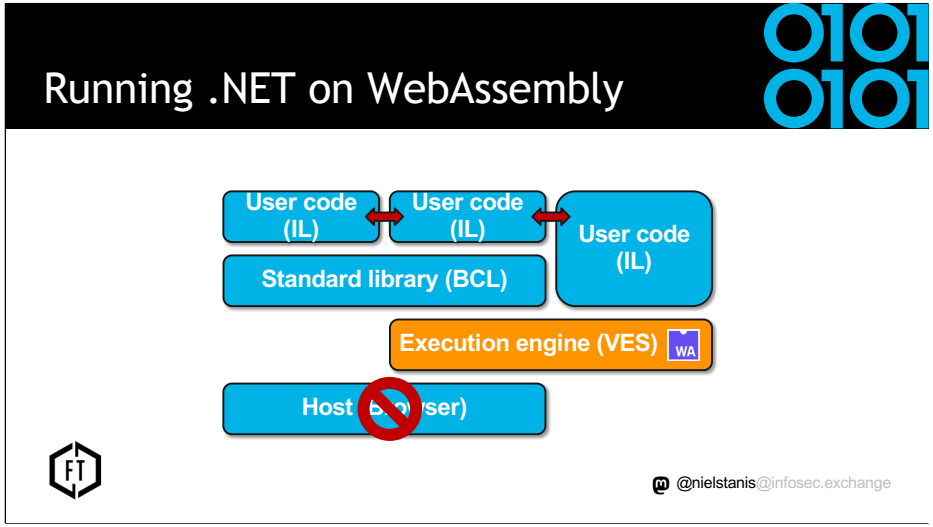


Diagram:
https://github.com/itowlson/wasmday22/blob/main/slides/Wasm%20Interfaces%20and%20.NET.pptx

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

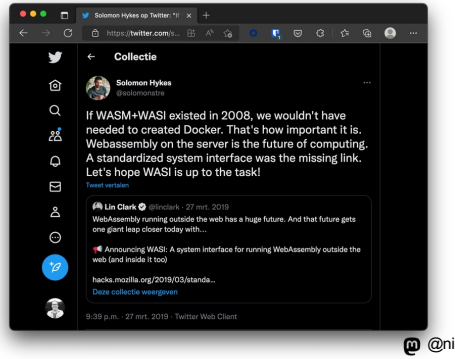
@nielstanis@infosec.exchange

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? ☺

@nielstanis@infosec.exchange

Docker vs WASM & WASI

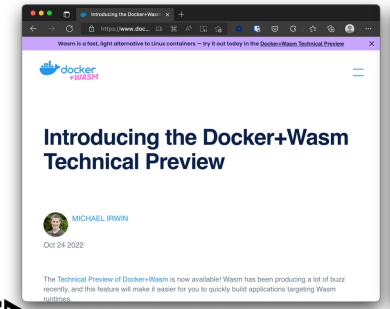


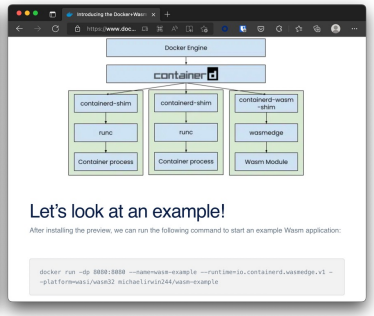
@nielstanis@infosec.exchange

Docker vs WASM & WASI

@nielstanis@infosec.exchange

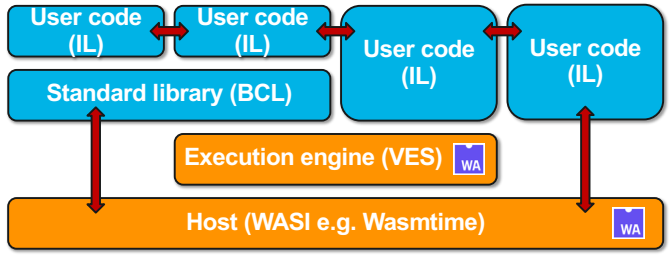
Docker & WASM





@nielstanis@infosec.exchange

WebAssembly System Interface WASI



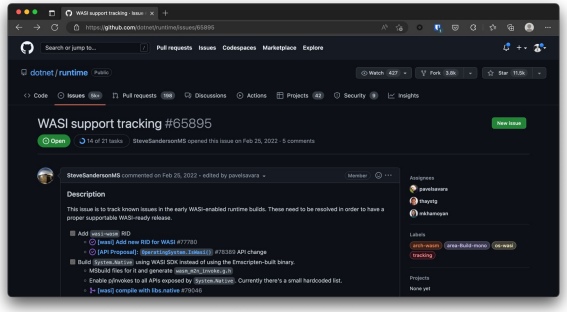
@nielstanis@infosec.exchange

Experimental WASI SDK for .NET

@nielstanis@infosec.exchange

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

Experimental WASI SDK for .NET



@nielstanis@infosec.exchange

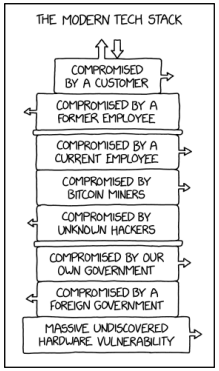
https://github.com/dotnet/runtime/issues/65895
https://github.com/SteveSandersonMS/dotnet-wasi-sdk

Extending .NET with WASM

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

@nielstanis@infosec.exchange

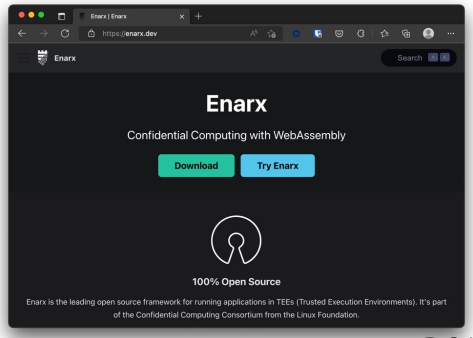
Trusted Computing – XKCD 2166



@nielstanis@infosec.exchange

https://xkcd.com/2166/

Enarx

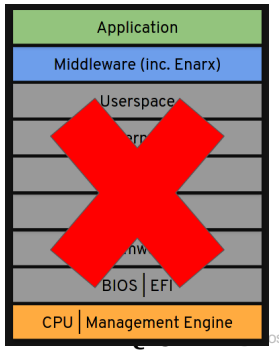


@nielstanis@infosec.exchange

https://enarx.dev/

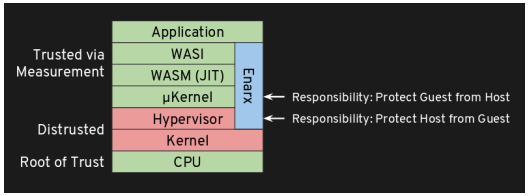
Enarx Threat Model

- 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



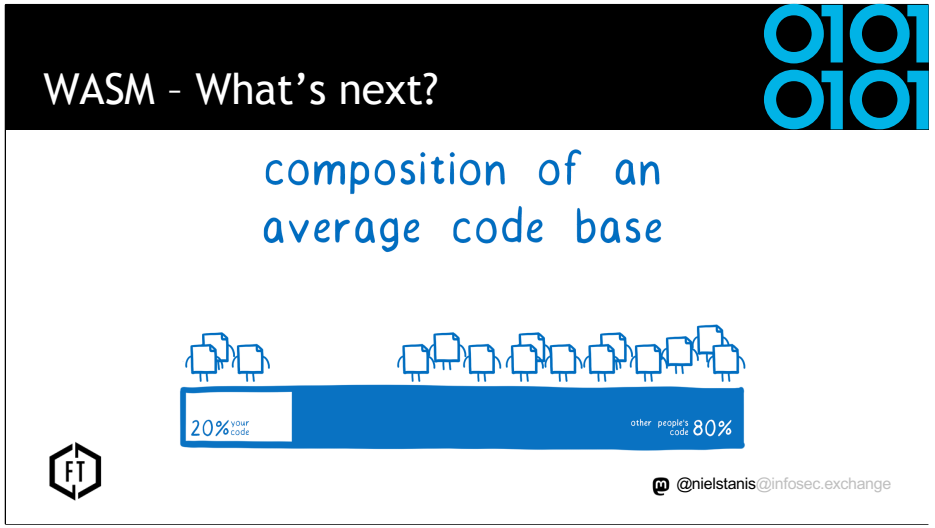
Enarx

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

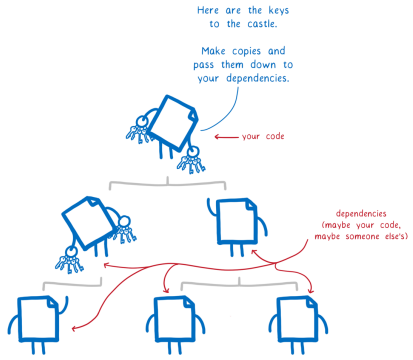


@nielstanis@infosec.exchange

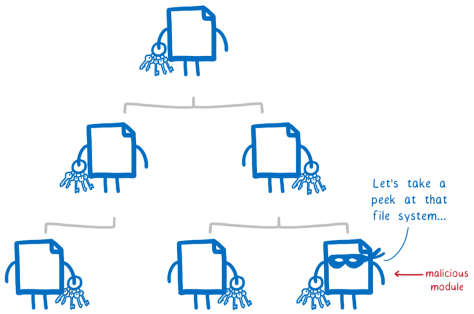
WASM – What's next?



Dependencies

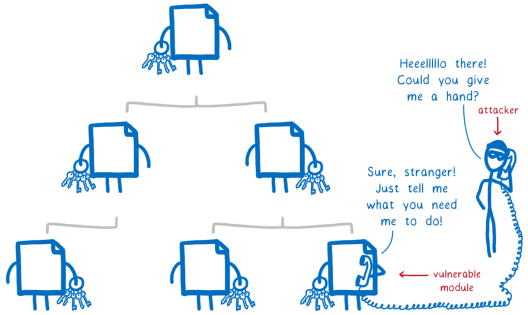


Malicious module



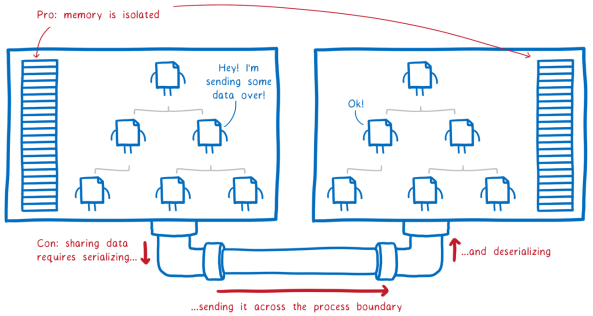
@nielstanis@infosec.exchange

Vulnerable module



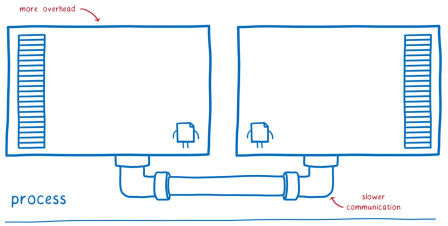
@nielstanis@infosec.exchange

Process Isolation



@nielstanis@infosec.exchange

WebAssembly Nano-Process

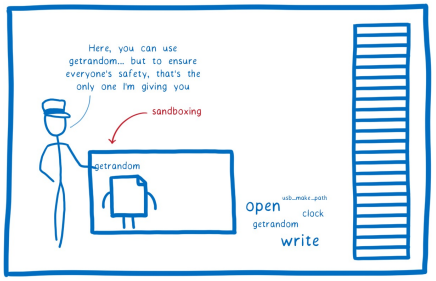


* not drawn to scale

@nielstanis@infosec.exchange

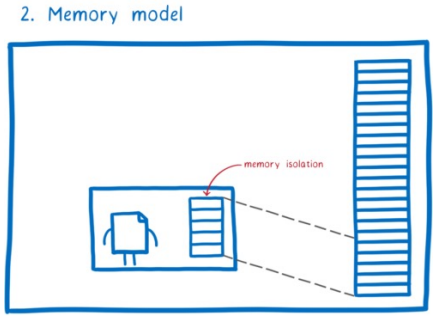
WebAssembly Nano-Process

1. Sandboxing



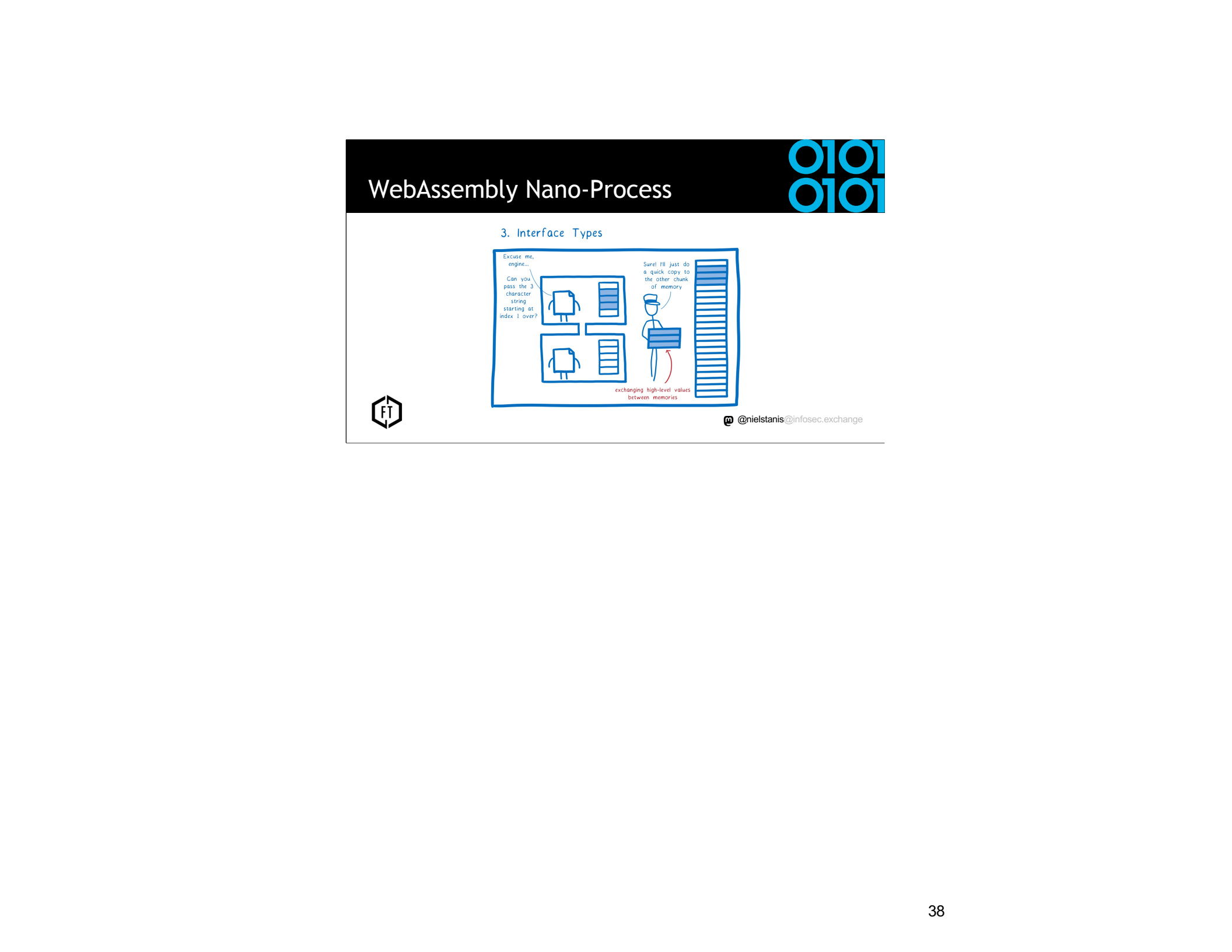
@nielstanis@infosec.exchange

WebAssembly Nano-Process



@nielstanis@infosec.exchange

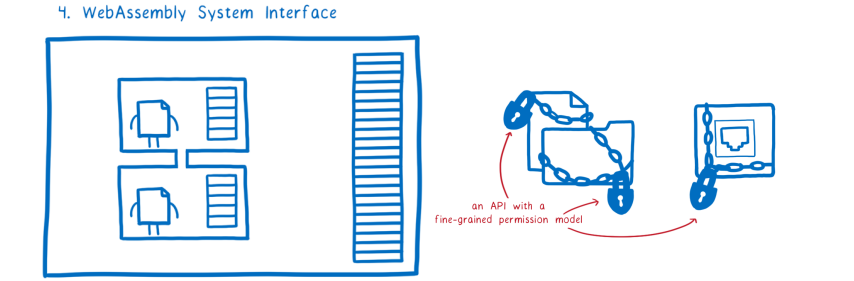
WebAssembly Nano-Process



3. Interface Types

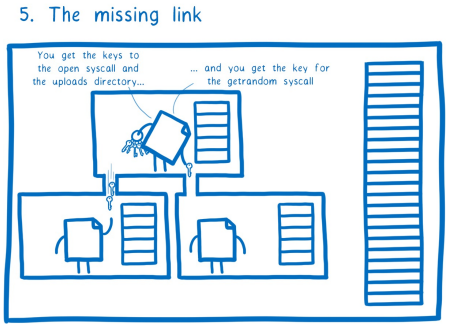
@nielstanis@infosec.exchange

WebAssembly Nano-Process



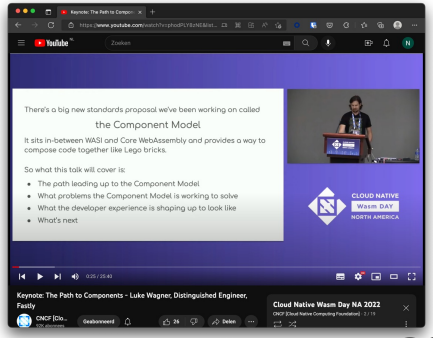
@nielstanis@infosec.exchange

WebAssembly Nano-Process



@nielstanis@infosec.exchange

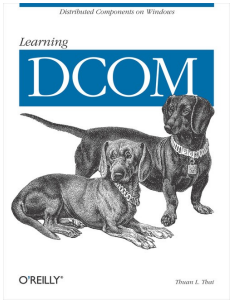
WebAssembly Component Model

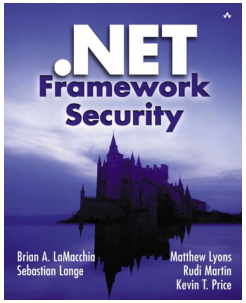


@nielstanis@infosec.exchange

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

Have we seen this before?





@nielstanis@infosec.exchange

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

@nielstanis@infosec.exchange

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/influence

@nielstanis@infosec.exchange

Questions?

- https://github.com/nielstanis/futuretech2023
- ntanis at Veracode.com
- @nielstanis@infosec.exchange
- https://blog.fennec.dev
- Bedankt! Thank you!