NDC { Sydney }

Securing your .NET application software supply-chain

Niels Tanis

Who am I?

- Niels Tanis
- Principal Security Researcher @ Veracode
  - Background .NET Development, Pentesting/ethical hacking, and software security consultancy
  - ISC² CSSLP
  - Research on static analysis for .NET apps

Securing your .NET application software supply-chain

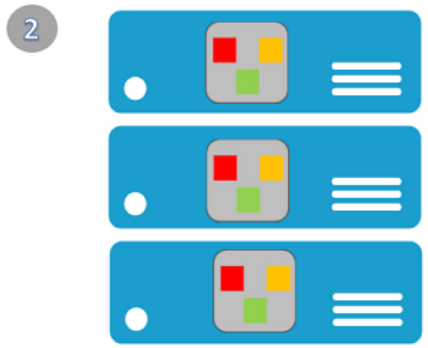
@nielstanis

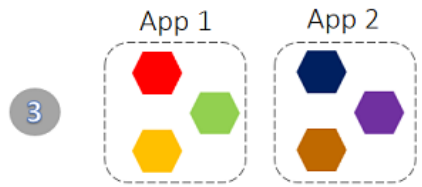
Agenda

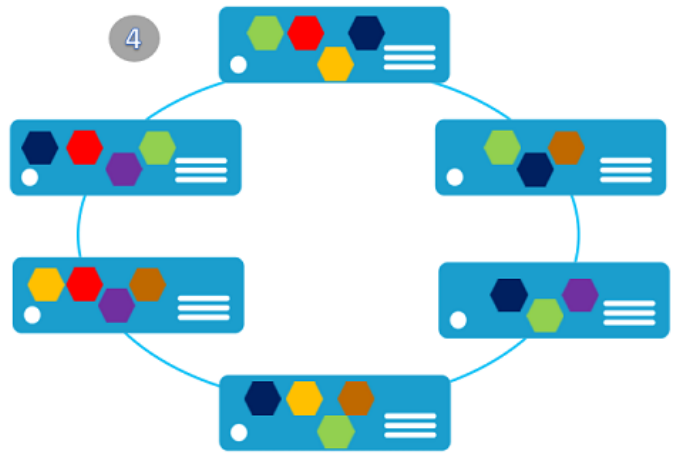
- Definition Software Supply-Chain
- Securing the Software Supply-Chain
  - Developer & Source
  - 3rd Party Libraries
  - Build & Release
- Conclusion and Q&A

Evolution in Software Architecture

- Monolith
- Microservices
- Serverless
  Cloud-Native

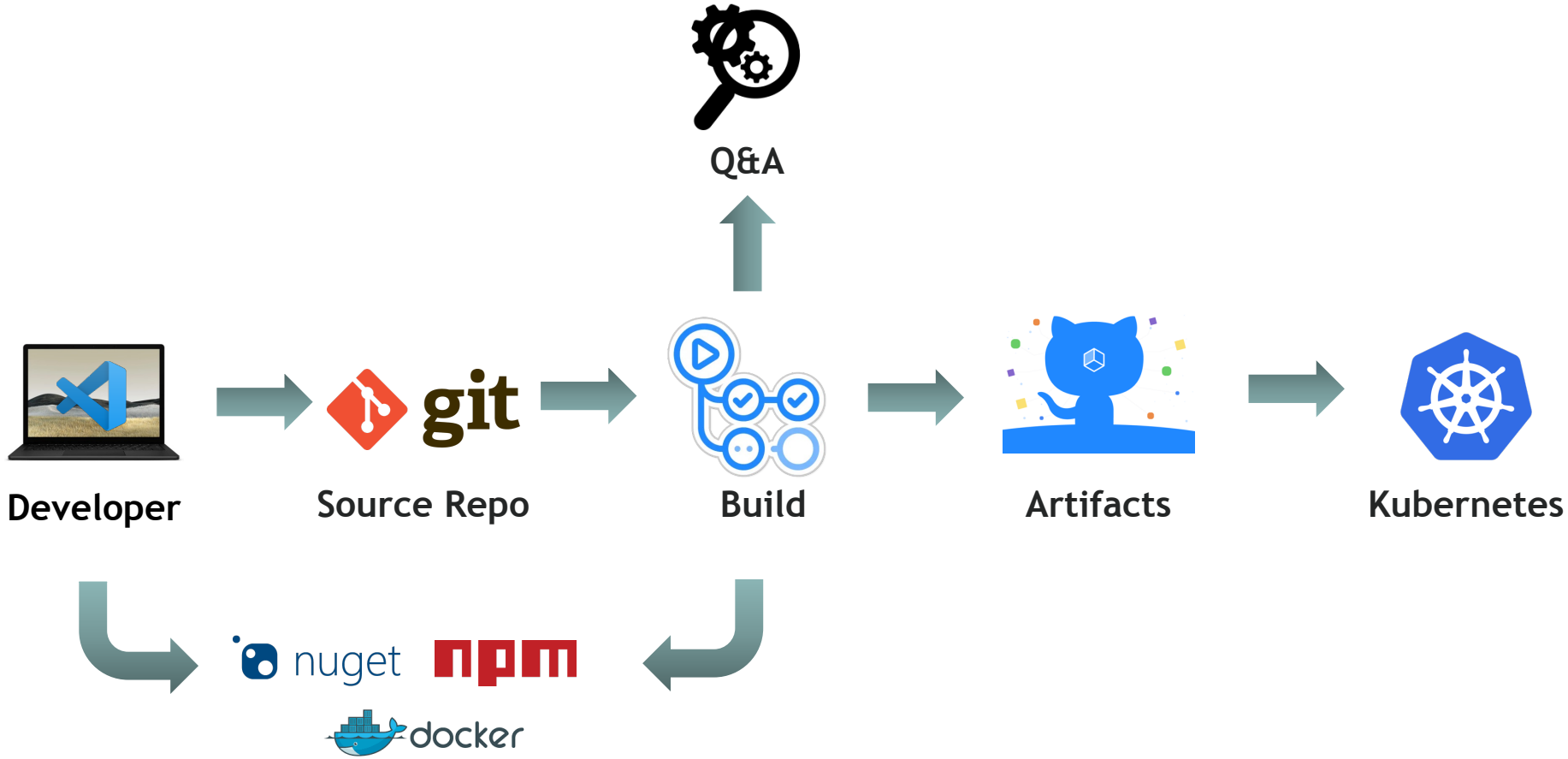




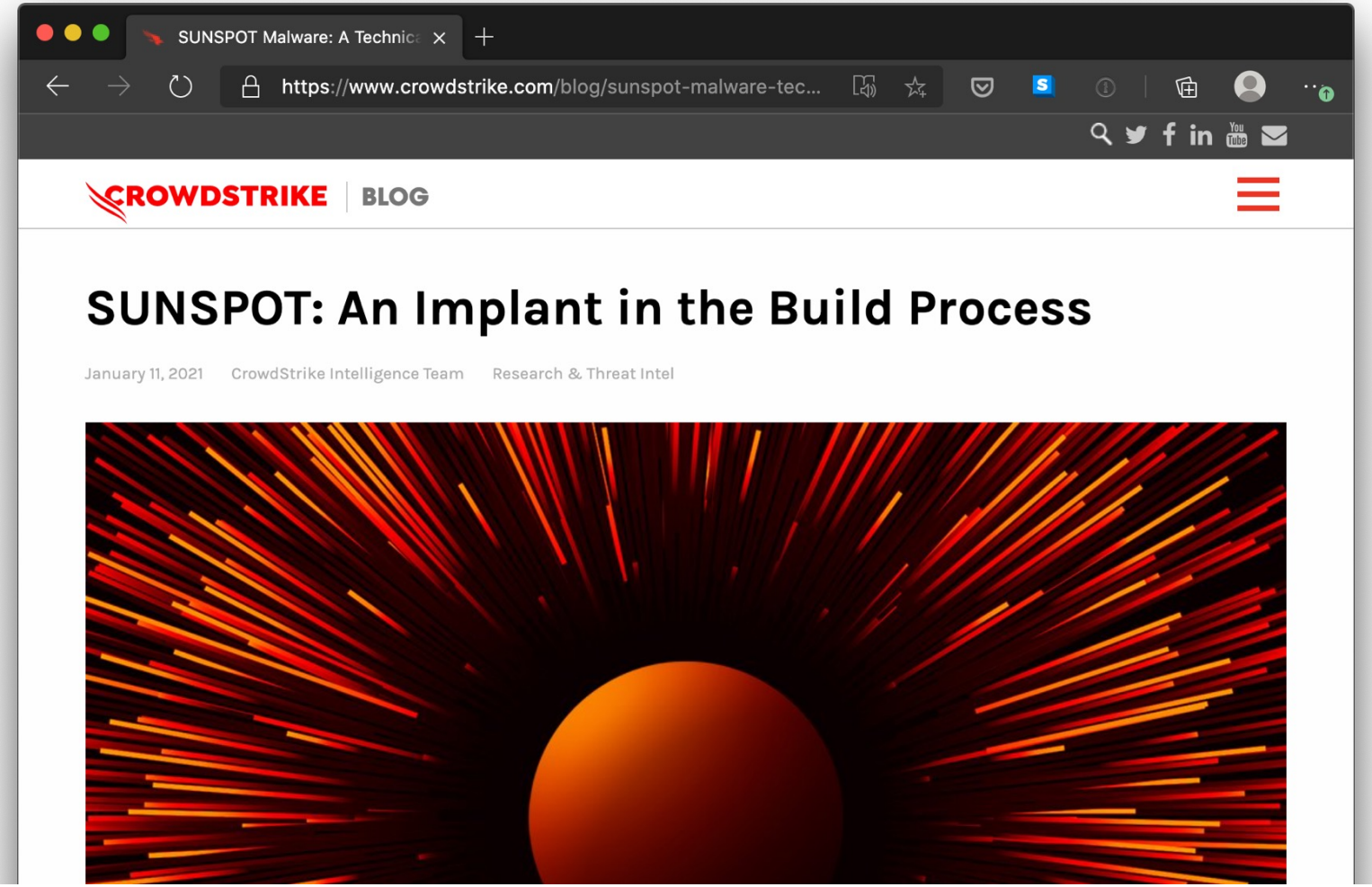


What is a Supply Chain?

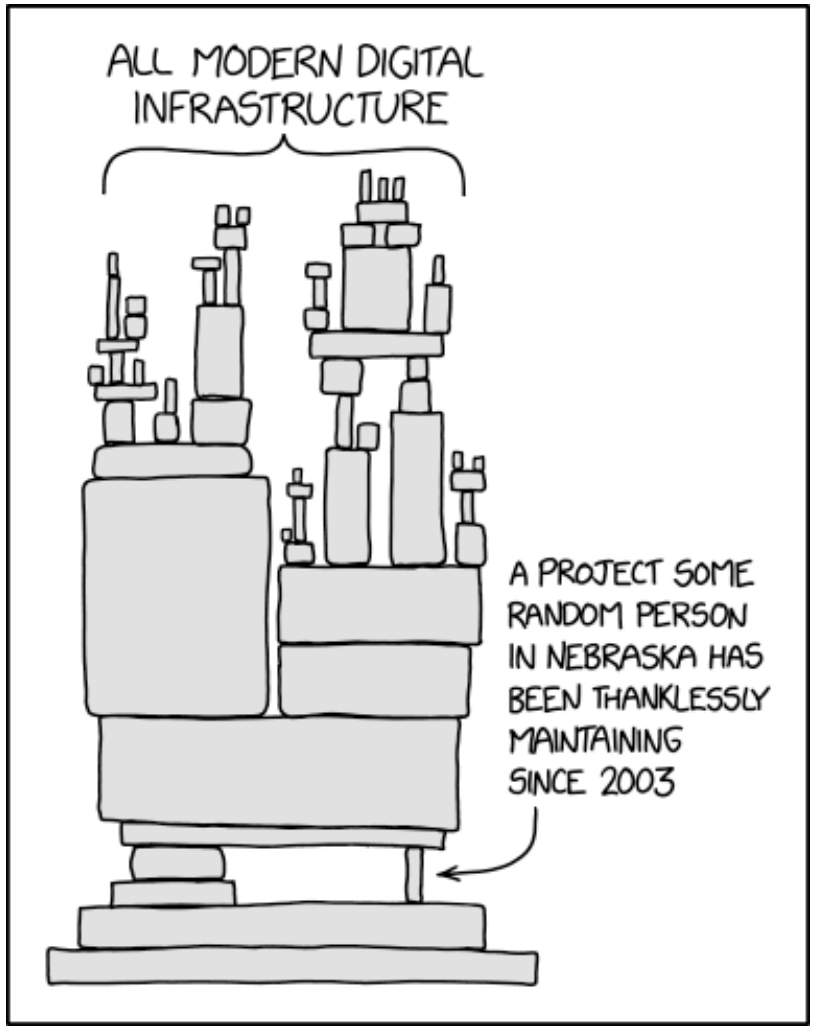
Software Supply Chain



SolarWinds SunSpot

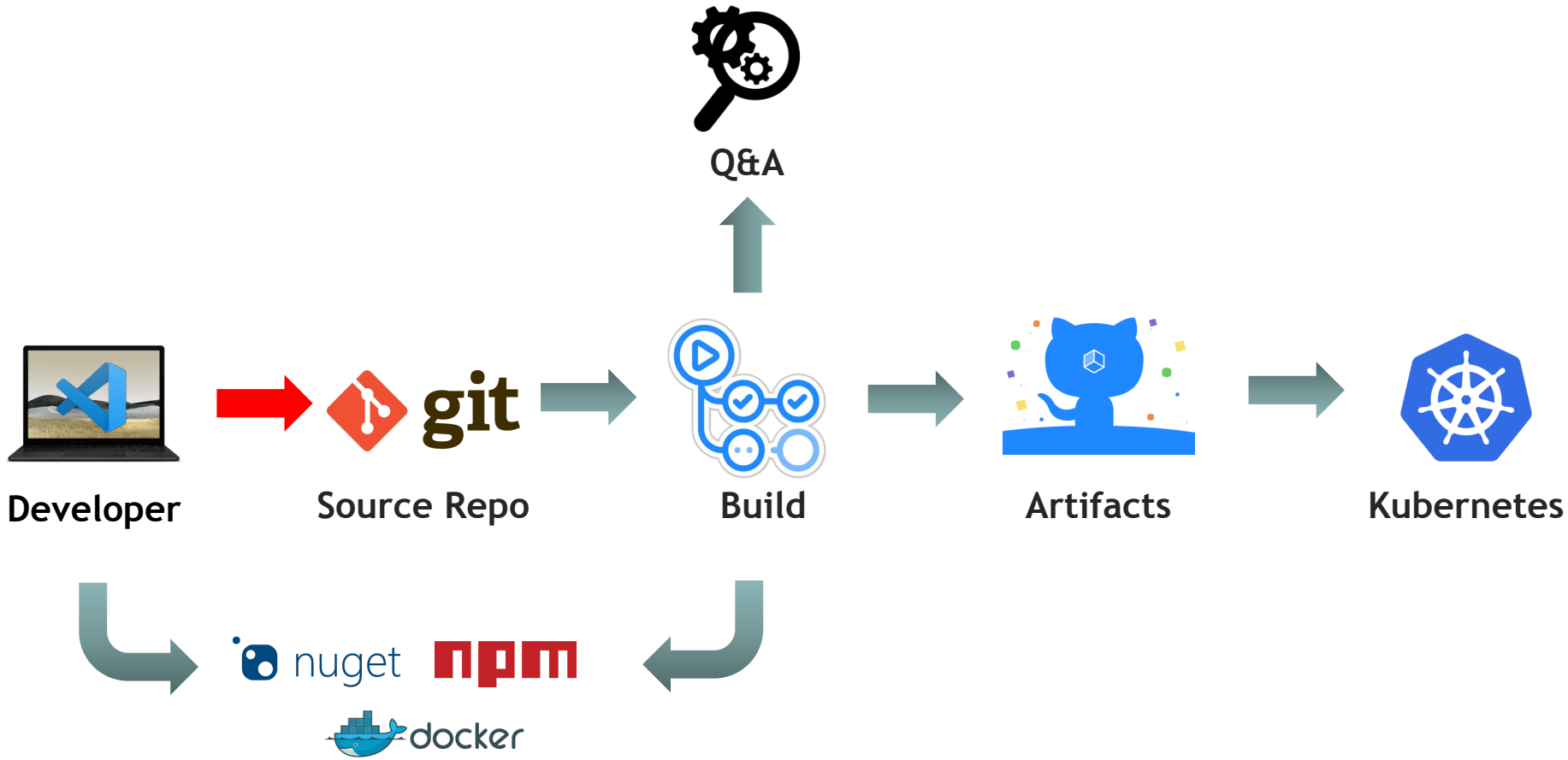


XKDC - Dependency



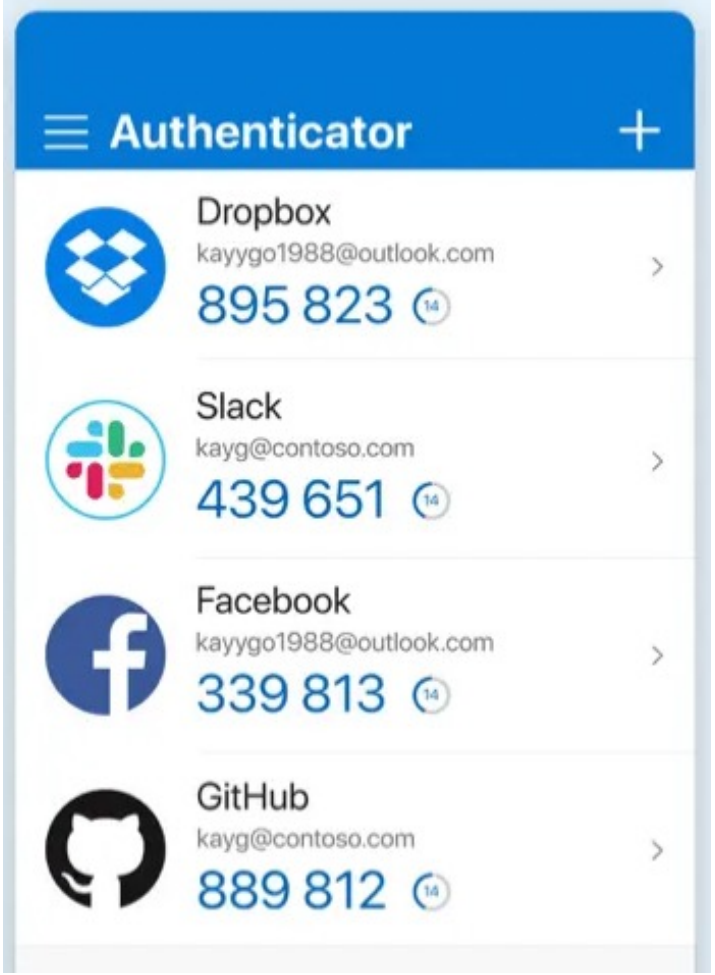
https://xkcd.com/2347/

Software Supply Chain

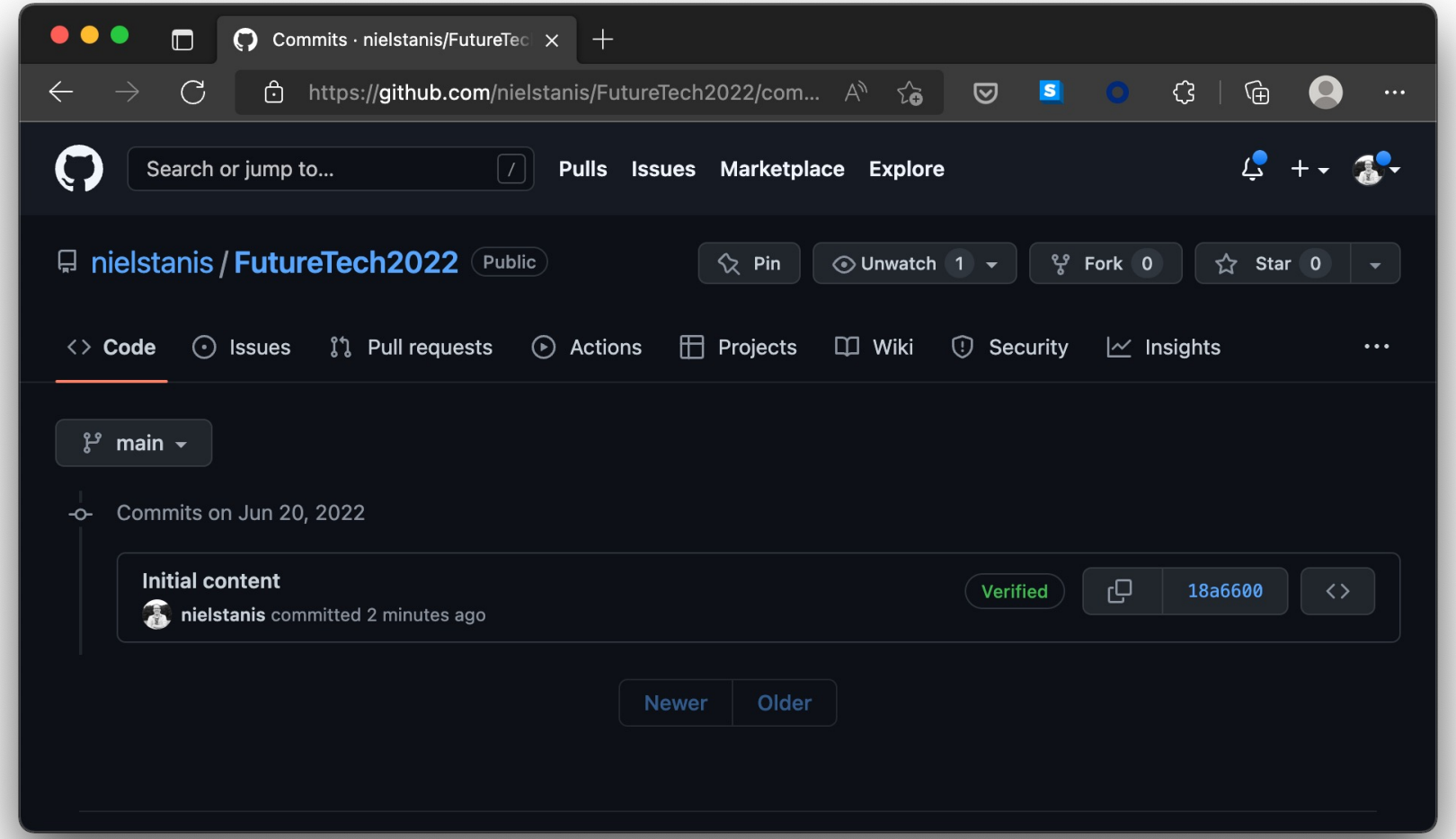


GitHub account

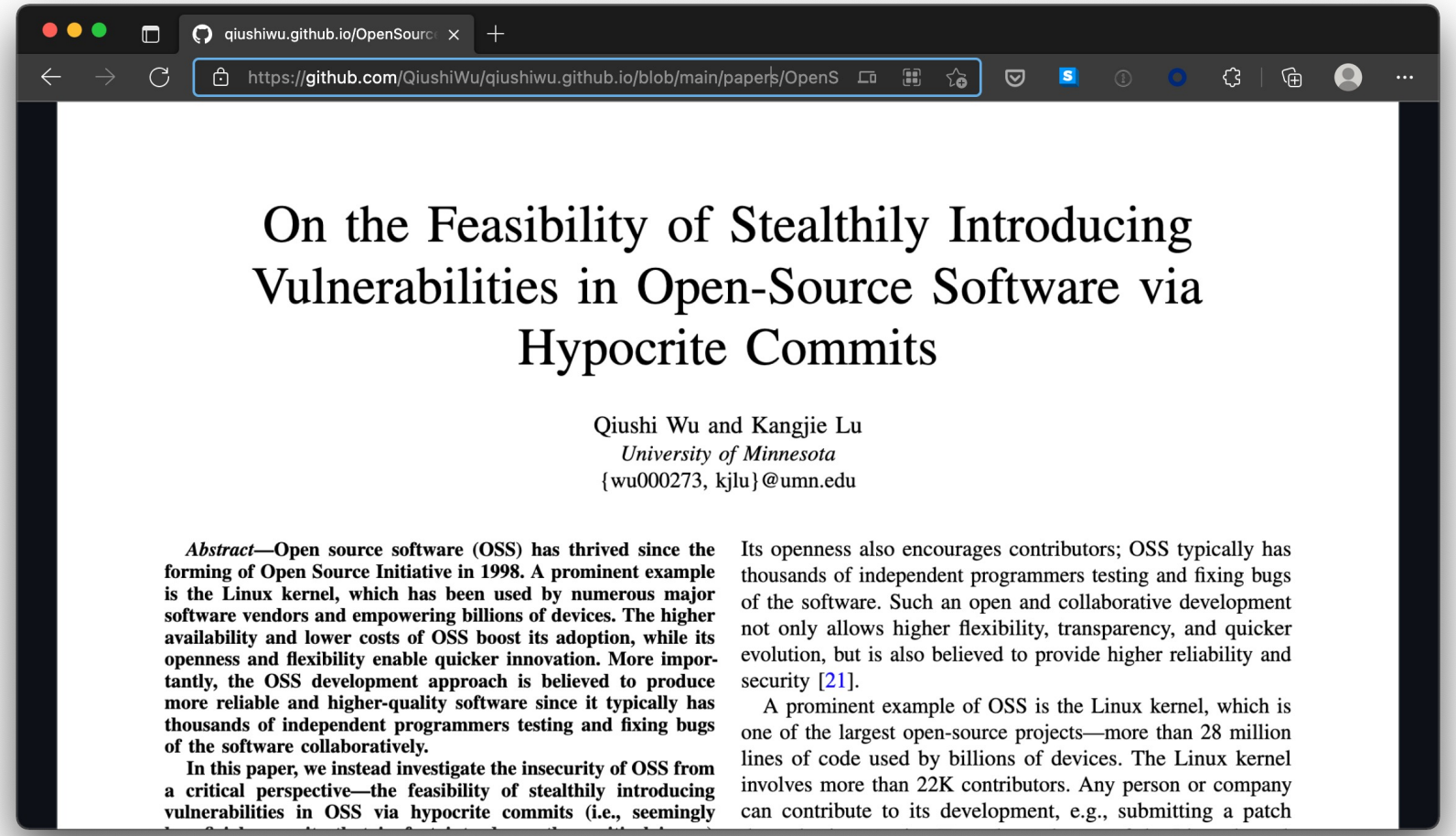
Use MFA on source-repository



GIT Commit Signing



Hypocrite Commits



On the Feasibility of Stealthily Introducing Vulnerabilities in Open-Source Software via Hypocrite Commits

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University of Minnesota
{wu000273, kjlu}@umn.edu

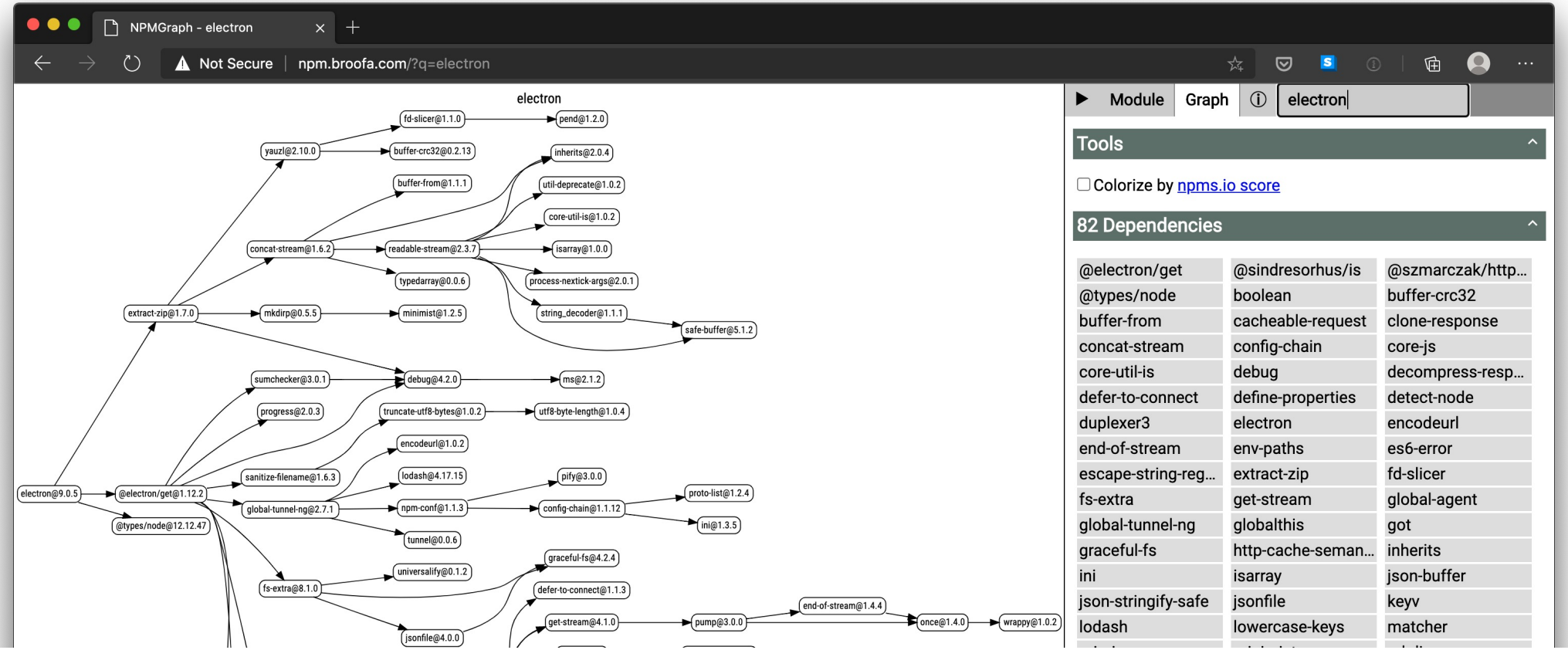
***Abstract*—Open source software (OSS) has thrived since the forming of Open Source Initiative in 1998. A prominent example is the Linux kernel, which has been used by numerous major software vendors and empowering billions of devices. The higher availability and lower costs of OSS boost its adoption, while its openness and flexibility enable quicker innovation. More importantly, the OSS development approach is believed to produce more reliable and higher-quality software since it typically has thousands of independent programmers testing and fixing bugs of the software collaboratively.**

In this paper, we instead investigate the insecurity of OSS from a critical perspective—the feasibility of stealthily introducing vulnerabilities in OSS via hypocrite commits (i.e., seemingly

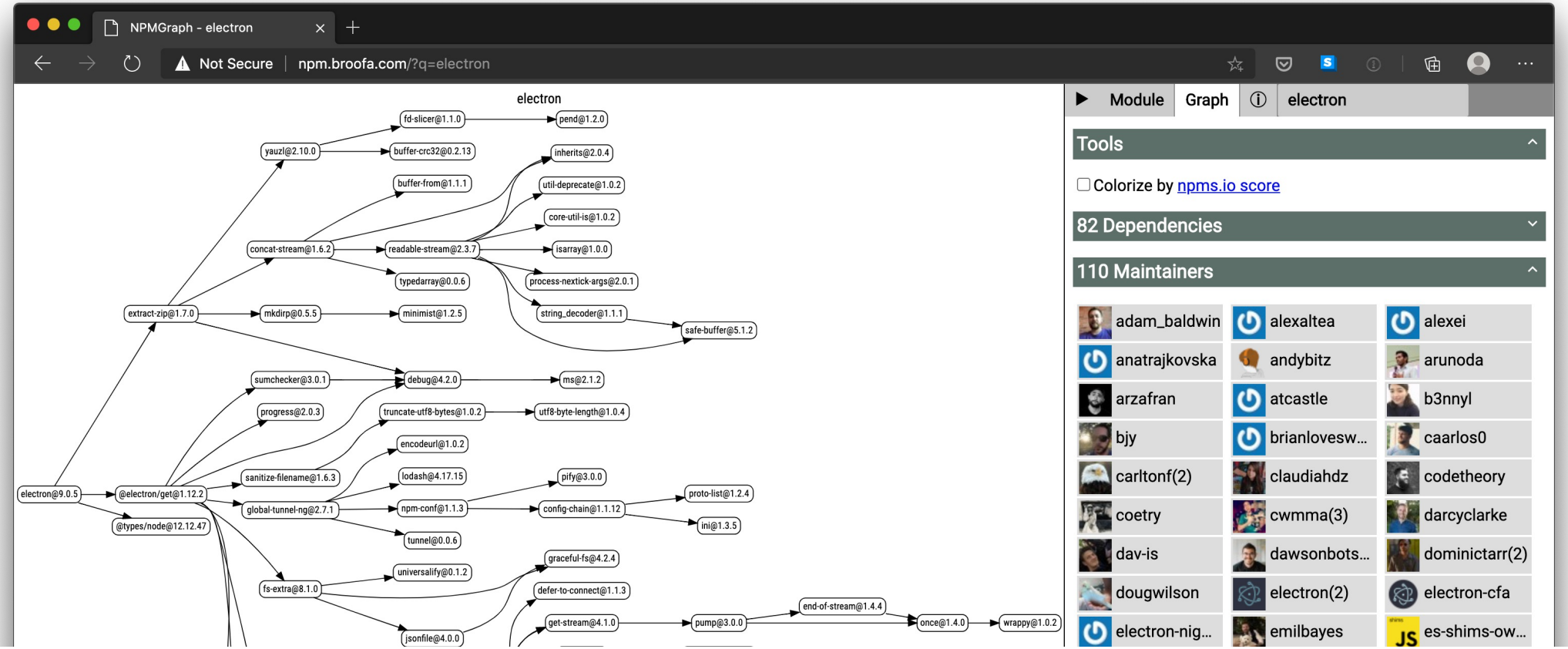
Its openness also encourages contributors; OSS typically has thousands of independent programmers testing and fixing bugs of the software. Such an open and collaborative development not only allows higher flexibility, transparency, and quicker evolution, but is also believed to provide higher reliability and security [21].

A prominent example of OSS is the Linux kernel, which is one of the largest open-source projects—more than 28 million lines of code used by billions of devices. The Linux kernel involves more than 22K contributors. Any person or company can contribute to its development, e.g., submitting a patch

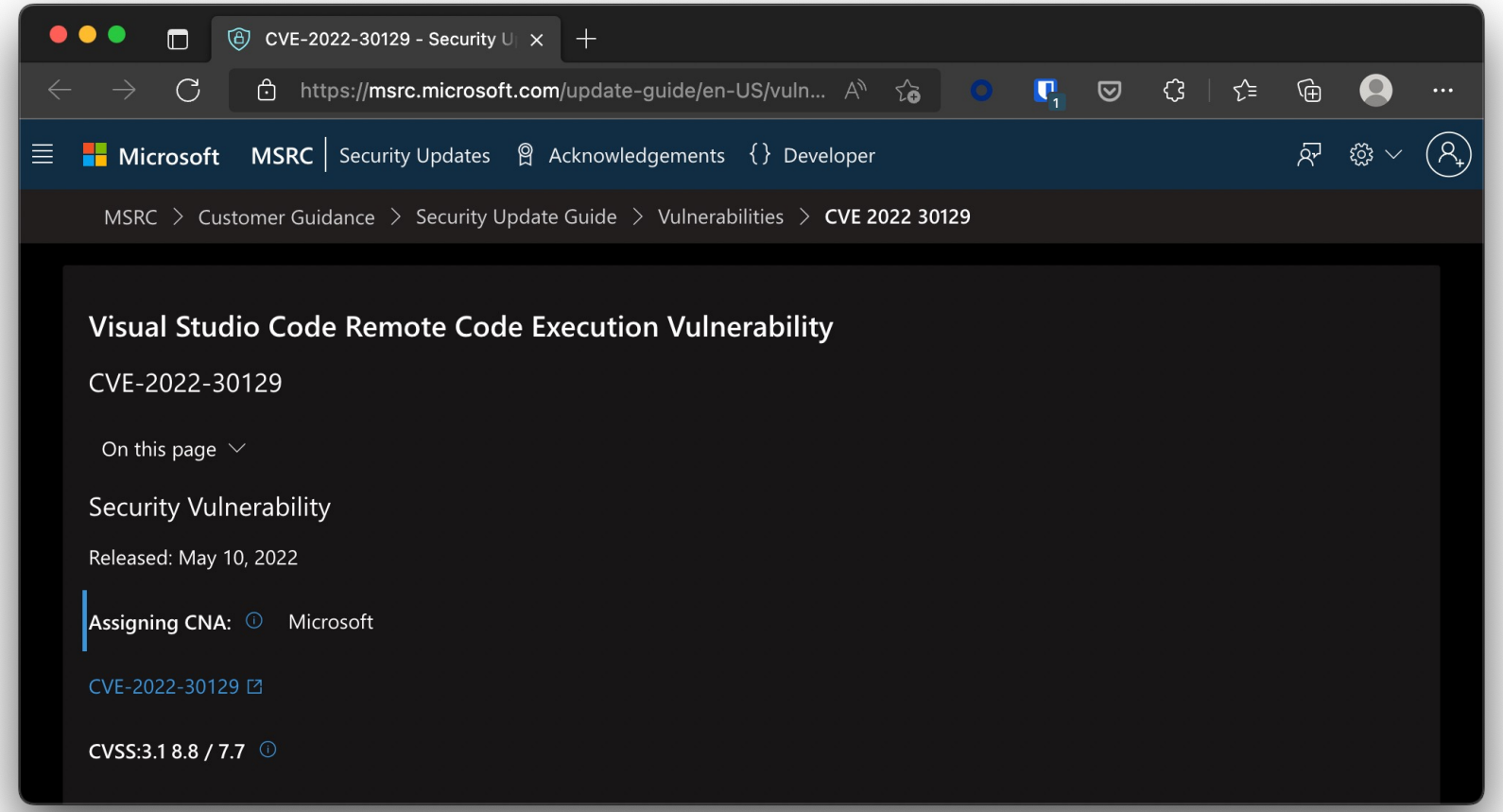
Visual Studio Code



Visual Studio Code

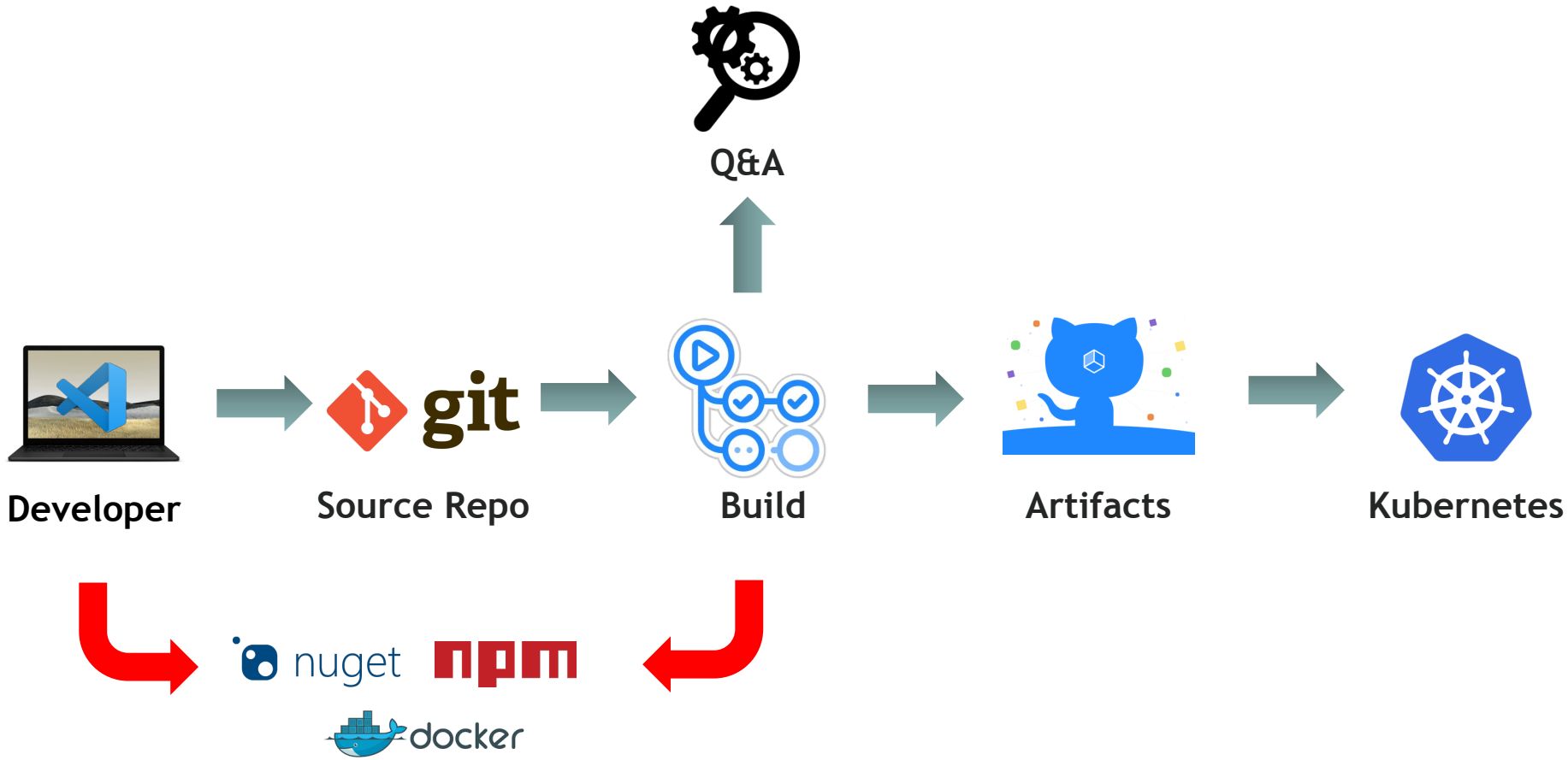


Visual Studio Code



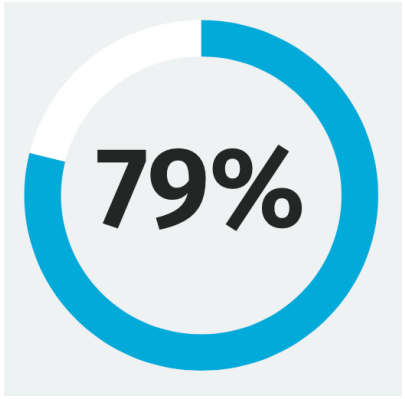
Visual Studio Code

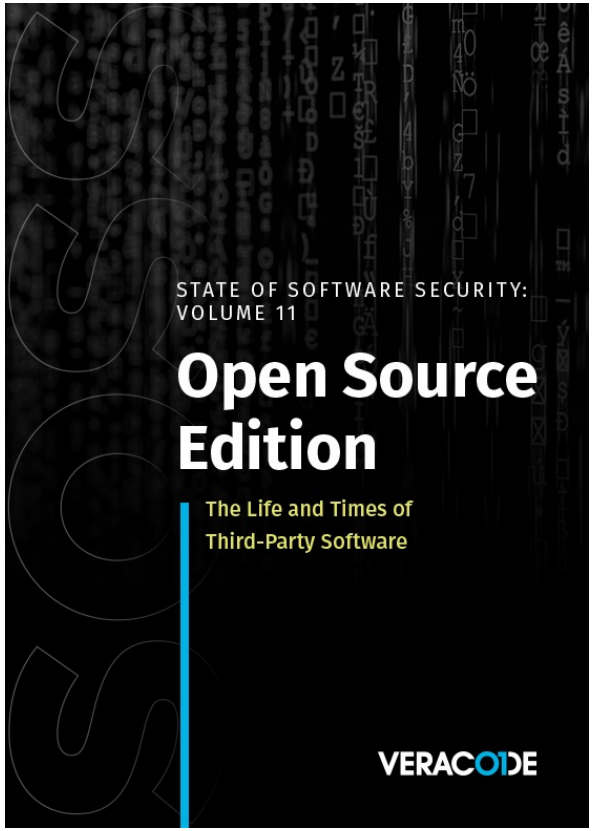
3rd Party Libraries



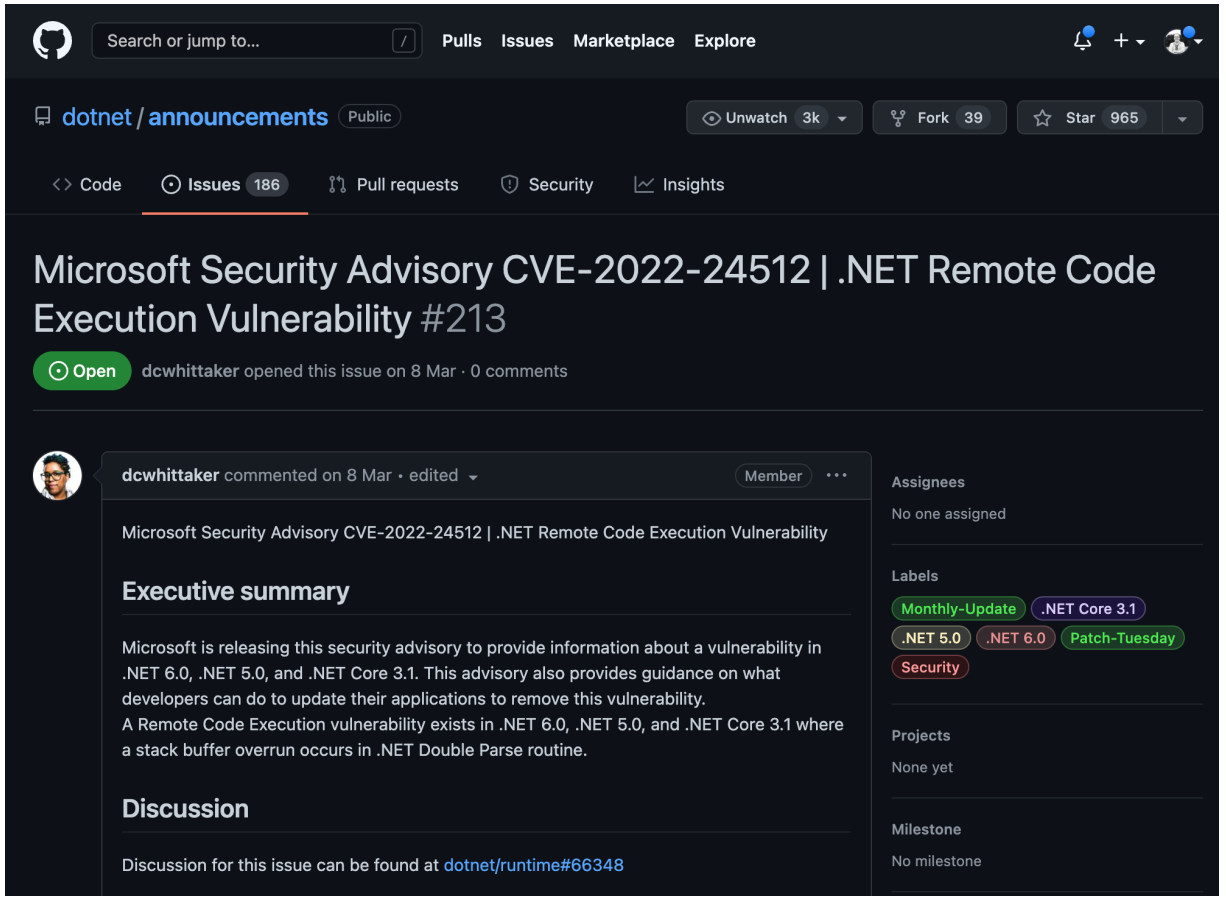
State Of Software Security v11 2021

”Despite this dynamic landscape, 79 percent of the time, developers never update third-party libraries after including them in a codebase.”





Vulnerabilities in libraries



Vulnerabilities in libraries

CYBERSECURITY & INFRASTRUCTURE SECURITY AGENCY

Alerts and Tips | Resources | Industrial Control Systems

National Cyber Awareness System > Current Activity > Malware Discovered in Popular NPM Package, ua-parser-js

Malware Discovered in Popular NPM Package, ua-parser-js

Original release date: October 22, 2021

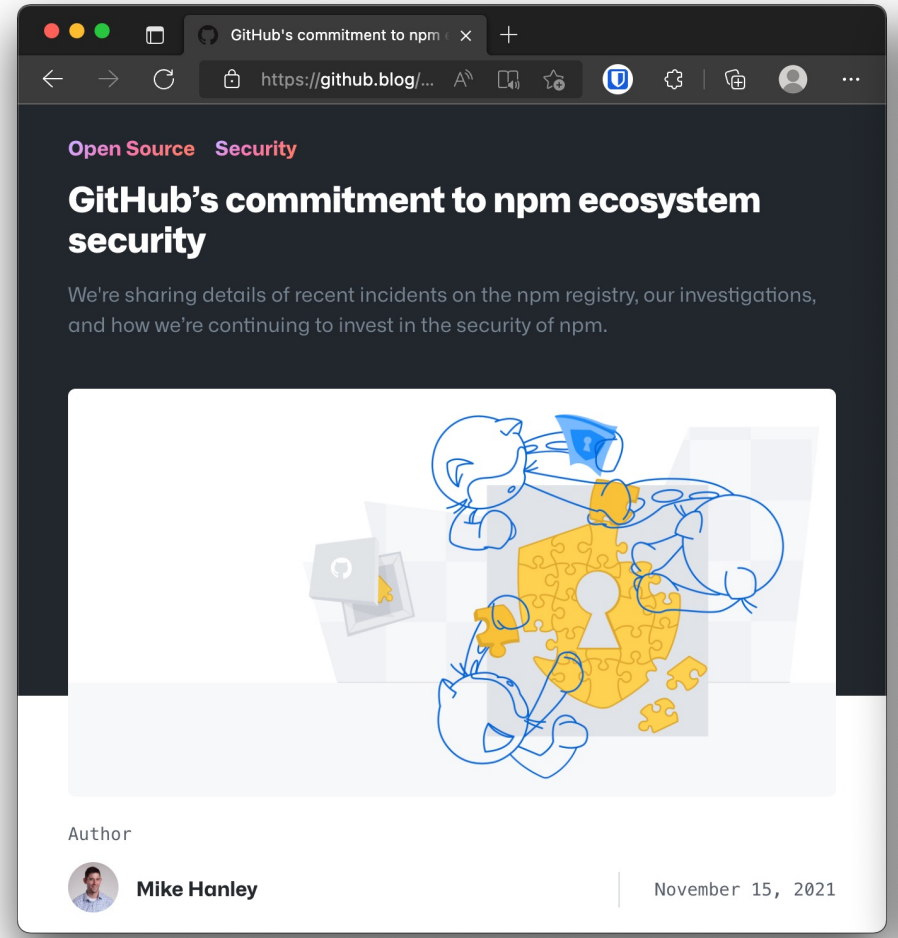
Print | Tweet | Send | Share

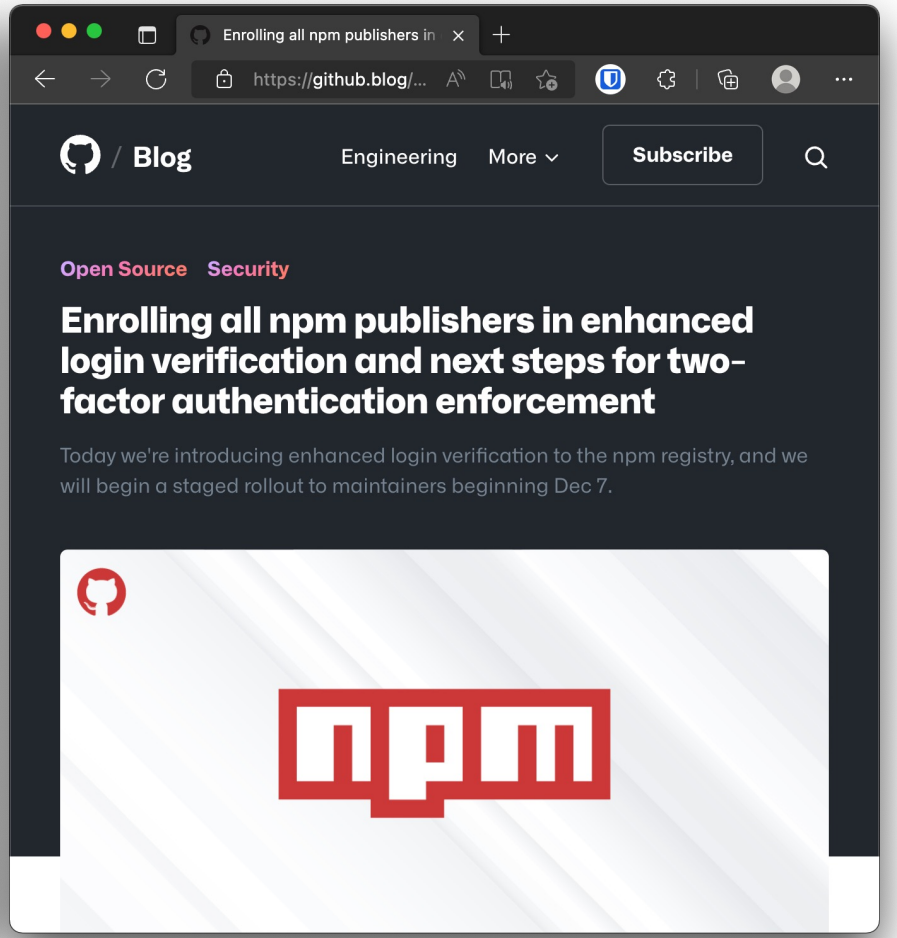
Versions of a popular NPM package named `ua-parser-js` was found to contain malicious code. `ua-parser-js` is used in apps and websites to discover the type of device or browser a person is using from User-Agent data. A computer or device with the affected software installed or running could allow a remote attacker to obtain sensitive information or take control of the system.

CISA urges users and administers using compromised ua-parser-js versions 0.7.29, 0.8.0, and 1.0.0 to update to the respective patched versions: 0.7.30, 0.8.1, 1.0.1

For more information, see Embedded malware in ua-parser-js.

Vulnerabilities in libraries





Dependency Confusion

Microsoft Whitepaper

3 ways to mitigate risk when using private package feeds

Secure Your Hybrid Software Supply Chain

An always-up-to-date version of this whitepaper is located at: https://aka.ms/pkg-sec-wp

Dependency Confusion - NuGet

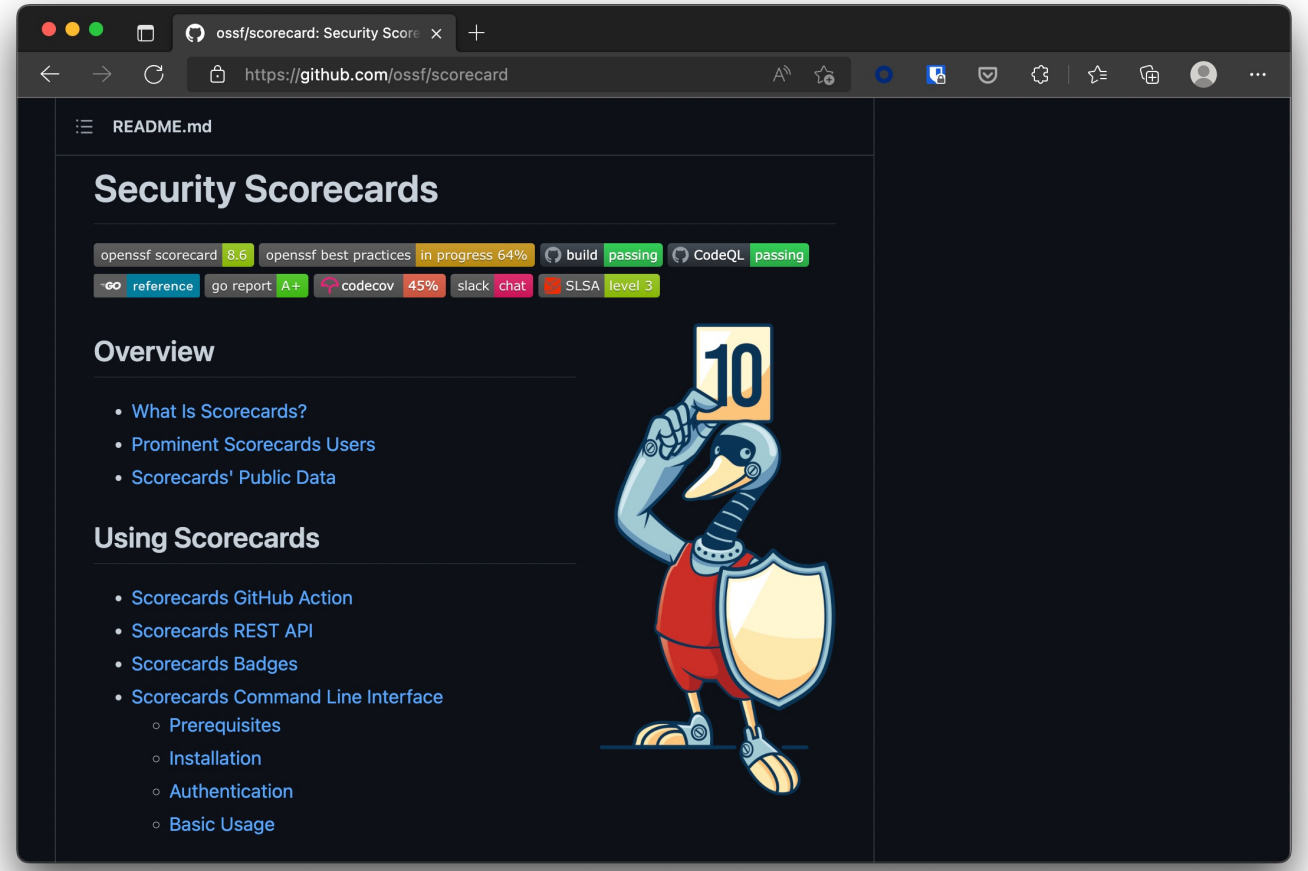
- Use single private repository
- Azure Artifacts can help manage and control upstream
- If your company has public packages consider registering prefix
- Lock packages with config

3rd Party Libraries

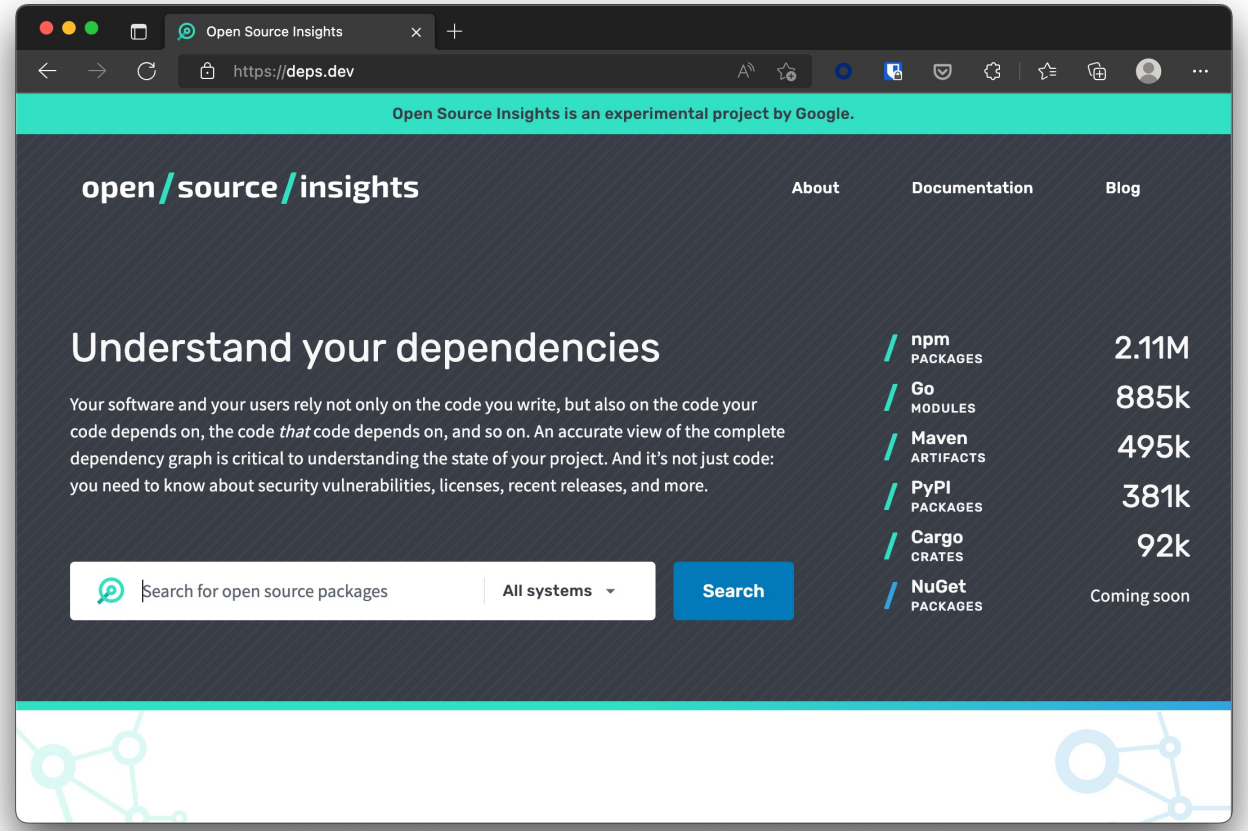
- Intent of library, know what's inside!
- Keep in mind that's a transitive list of dependencies
- My talk 'Sandboxing .NET Assemblies' Tomorrow @ 3PM in Room 4

- Open Source Security Foundation - OpenSSF
- Security Scorecards - Security health metrics for Open Source

Security Scorecards - OpenSSF



Deps.Dev by Google



Deps.Dev by Google

OpenSSF scorecard

The Open Source Security Foundation is a cross-industry collaboration to improve the security of open source software (OSS). The Scorecard provides security health metrics for open source projects.

View information about checks and how to fix failures.

SCORE

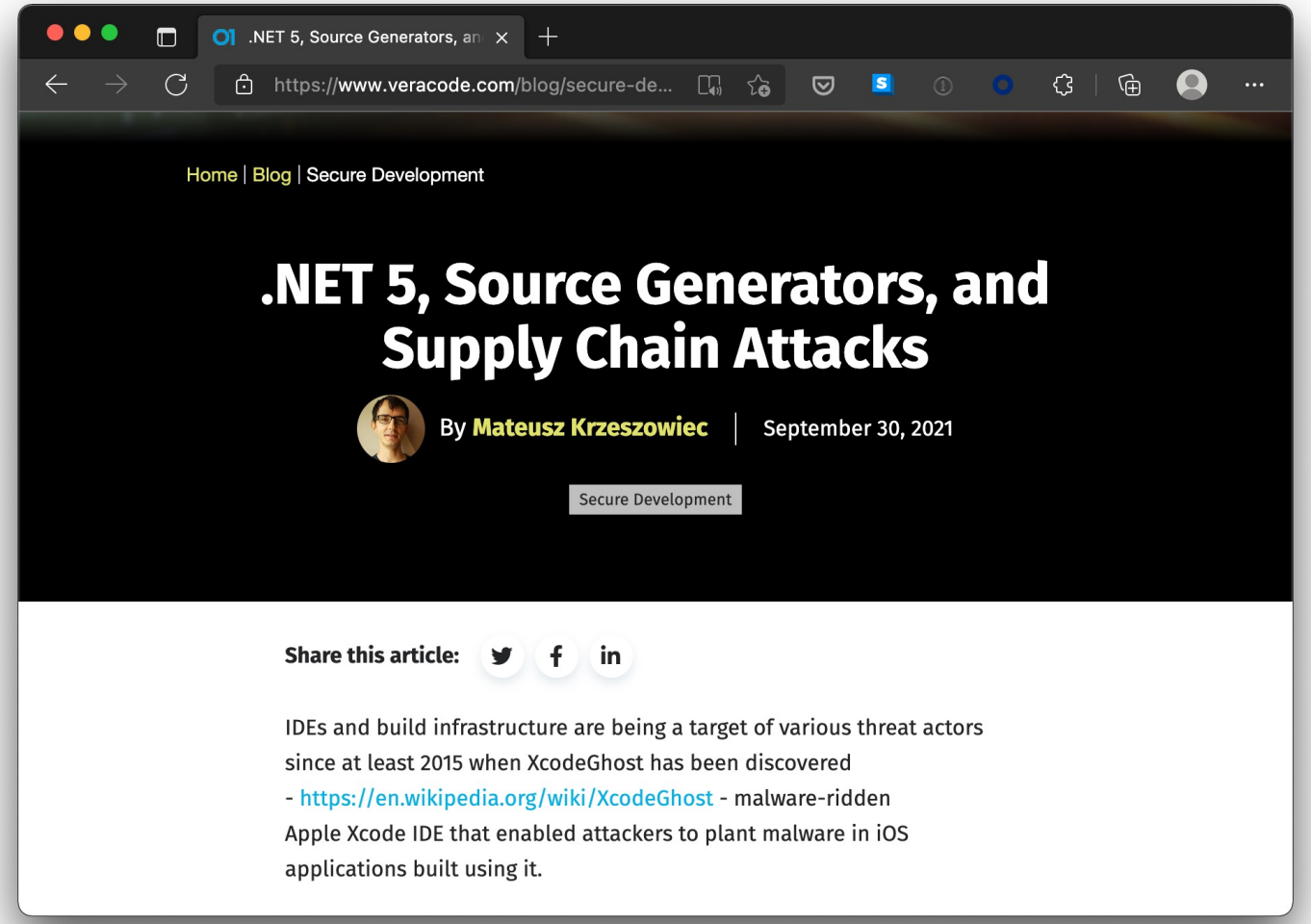
6.6/10

Scorecard as of September 12, 2022.

Maintained	10/10
Code-Review	8/10
CII-Best-Practices	0/10
Vulnerabilities	10/10
Security-Policy	10/10
Dangerous-Workflow	10/10
Token-Permissions	0/10
License	10/10
Pinned-Dependencies	7/10
Binary-Artifacts	10/10
Fuzzing	0/10
Dependency-Update-Tool	10/10
Signed-Releases	0/10
SAST	0/10
Branch-Protection	8/10

Project metadata as of September 18, 2022.

Source Generators

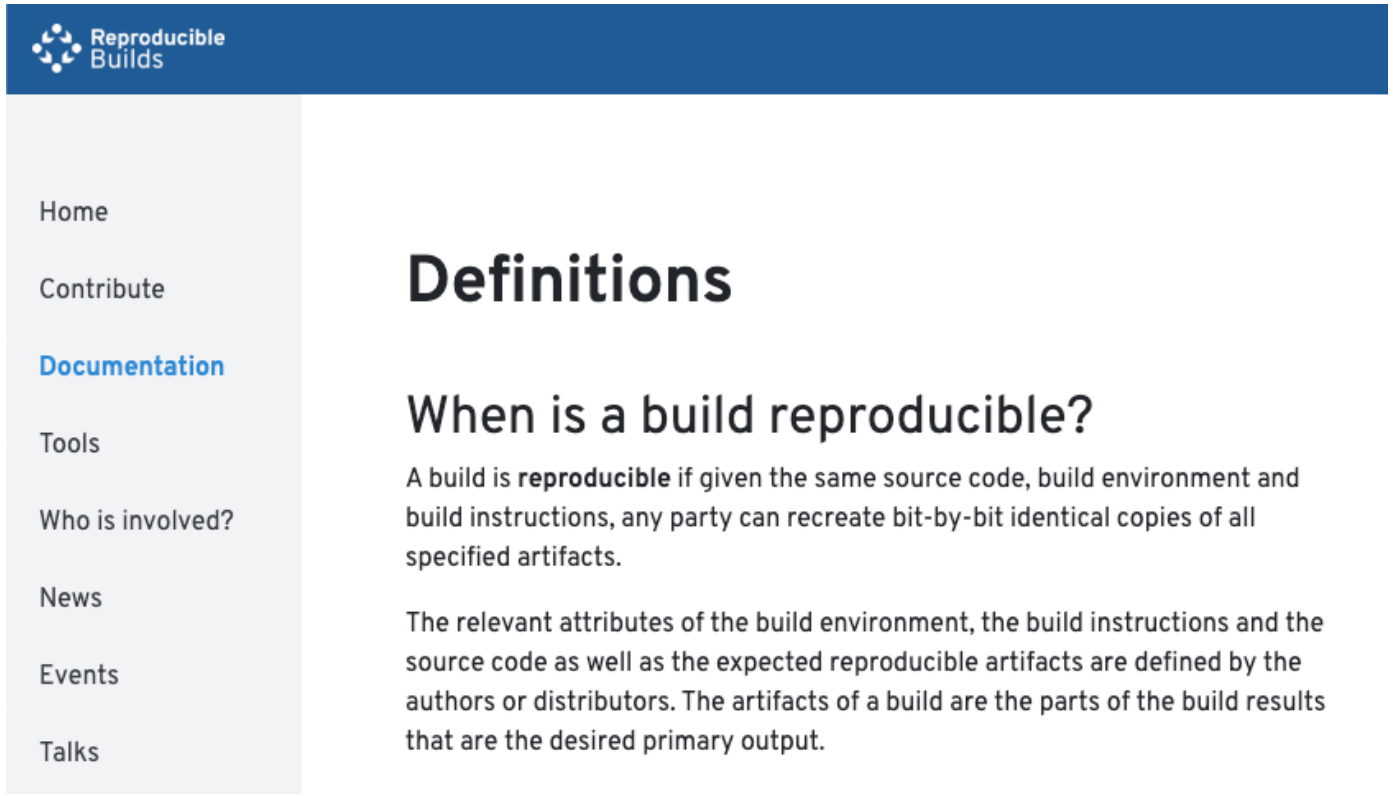


Source Generators

- Any 3rd party library can contain Source Generator!
- Consider disabling on project-level:

```
<Target Name="DisableAnalyzers"
        BeforeTargets="CoreCompile">
  <ItemGroup>
    <Analyzer Remove="@(Analyzer)" />
  </ItemGroup>
</Target>
```

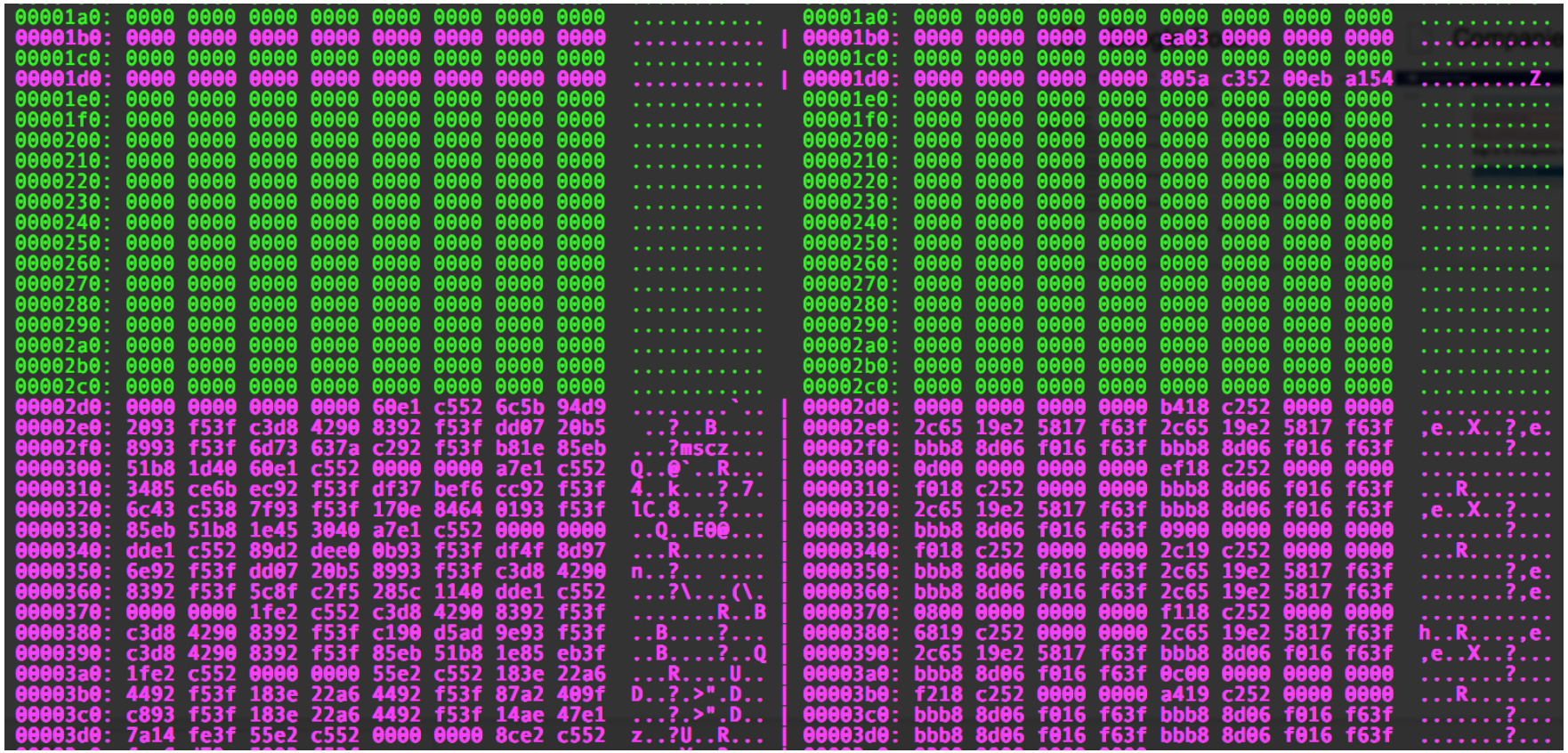
Reproducible/Deterministic Builds



Reproducible/Deterministic Builds

- Roslyn v1.1 started supporting some kind of determinism on how items are emitted
- Given same inputs, the compiled output will always be deterministic
- Inputs can be found in Roslyn compiler docs ‘Deterministic Inputs’

Reproducible Build .NET6



```
00001a0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001b0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001c0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001d0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001e0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001f0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000200: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000210: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000220: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000230: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000240: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000250: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000260: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000270: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000280: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000290: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002a0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002b0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002c0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002d0: 0000 0000 0000 0000 60e1 c552 6c5b 94d9  ........`..
00002e0: 2093 f53f c3d8 4290 8392 f53f dd07 20b5   ..?..B....
00002f0: 8993 f53f 6d73 637a c292 f53f b81e 85eb  ...?mscz...
0000300: 51b8 1d40 60e1 c552 0000 0000 a7e1 c552  Q..@`..R...
0000310: 3485 ce6b ec92 f53f df37 bef6 cc92 f53f  4..k...?.7.
0000320: 6c43 c538 7f93 f53f 170e 8464 0193 f53f  lC.8...?...
0000330: 85eb 51b8 1e45 3040 a7e1 c552 0000 0000  ..Q..E0@...
0000340: dde1 c552 89d2 dee0 0b93 f53f df4f 8d97  ...R.......
0000350: 6e92 f53f dd07 20b5 8993 f53f c3d8 4290  n..?.. ....
0000360: 8392 f53f 5c8f c2f5 285c 1140 dde1 c552  ...?\...(\.
0000370: 0000 0000 1fe2 c552 c3d8 4290 8392 f53f  .......R..B
0000380: c3d8 4290 8392 f53f c190 d5ad 9e93 f53f  ..B....?...
0000390: c3d8 4290 8392 f53f 85eb 51b8 1e85 eb3f  ..B....?..Q
00003a0: 1fe2 c552 0000 0000 55e2 c552 183e 22a6  ...R....U..
00003b0: 4492 f53f 183e 22a6 4492 f53f 87a2 409f  D..?.>".D..
00003c0: c893 f53f 183e 22a6 4492 f53f 14ae 47e1  ...?.>".D..
00003d0: 7a14 fe3f 55e2 c552 0000 0000 8ce2 c552  z..?U..R...
```

```
00001a0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001b0: 0000 0000 0000 0000 ea03 0000 0000 0000  ..........
00001c0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001d0: 0000 0000 0000 0000 805a c352 00eb a154  .........Z.
00001e0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00001f0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000200: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000210: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000220: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000230: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000240: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000250: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000260: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000270: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000280: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
0000290: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002a0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002b0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002c0: 0000 0000 0000 0000 0000 0000 0000 0000  ..........
00002d0: 0000 0000 0000 0000 b418 c252 0000 0000  ...........
00002e0: 2c65 19e2 5817 f63f 2c65 19e2 5817 f63f  ,e..X..?,e.
00002f0: bbb8 8d06 f016 f63f bbb8 8d06 f016 f63f  .......?....
0000300: 0d00 0000 0000 0000 ef18 c252 0000 0000  ...........
0000310: f018 c252 0000 0000 bbb8 8d06 f016 f63f  ...R........
0000320: 2c65 19e2 5817 f63f bbb8 8d06 f016 f63f  ,e..X..?....
0000330: bbb8 8d06 f016 f63f 0900 0000 0000 0000  .......?....
0000340: f018 c252 0000 0000 2c19 c252 0000 0000  ...R....,...
0000350: bbb8 8d06 f016 f63f 2c65 19e2 5817 f63f  .......?,e..
0000360: bbb8 8d06 f016 f63f 2c65 19e2 5817 f63f  .......?,e..
0000370: 0800 0000 0000 0000 f118 c252 0000 0000  ...........
0000380: 6819 c252 0000 0000 2c65 19e2 5817 f63f  h..R....,e..
0000390: 2c65 19e2 5817 f63f bbb8 8d06 f016 f63f  ,e..X..?....
00003a0: bbb8 8d06 f016 f63f 0c00 0000 0000 0000  .......?....
00003b0: f218 c252 0000 0000 a419 c252 0000 0000  ...R........
00003c0: bbb8 8d06 f016 f63f bbb8 8d06 f016 f63f  .......?....
00003d0: bbb8 8d06 f016 f63f bbb8 8d06 f016 f63f  .......?....
```

Reproducible/Deterministic Builds

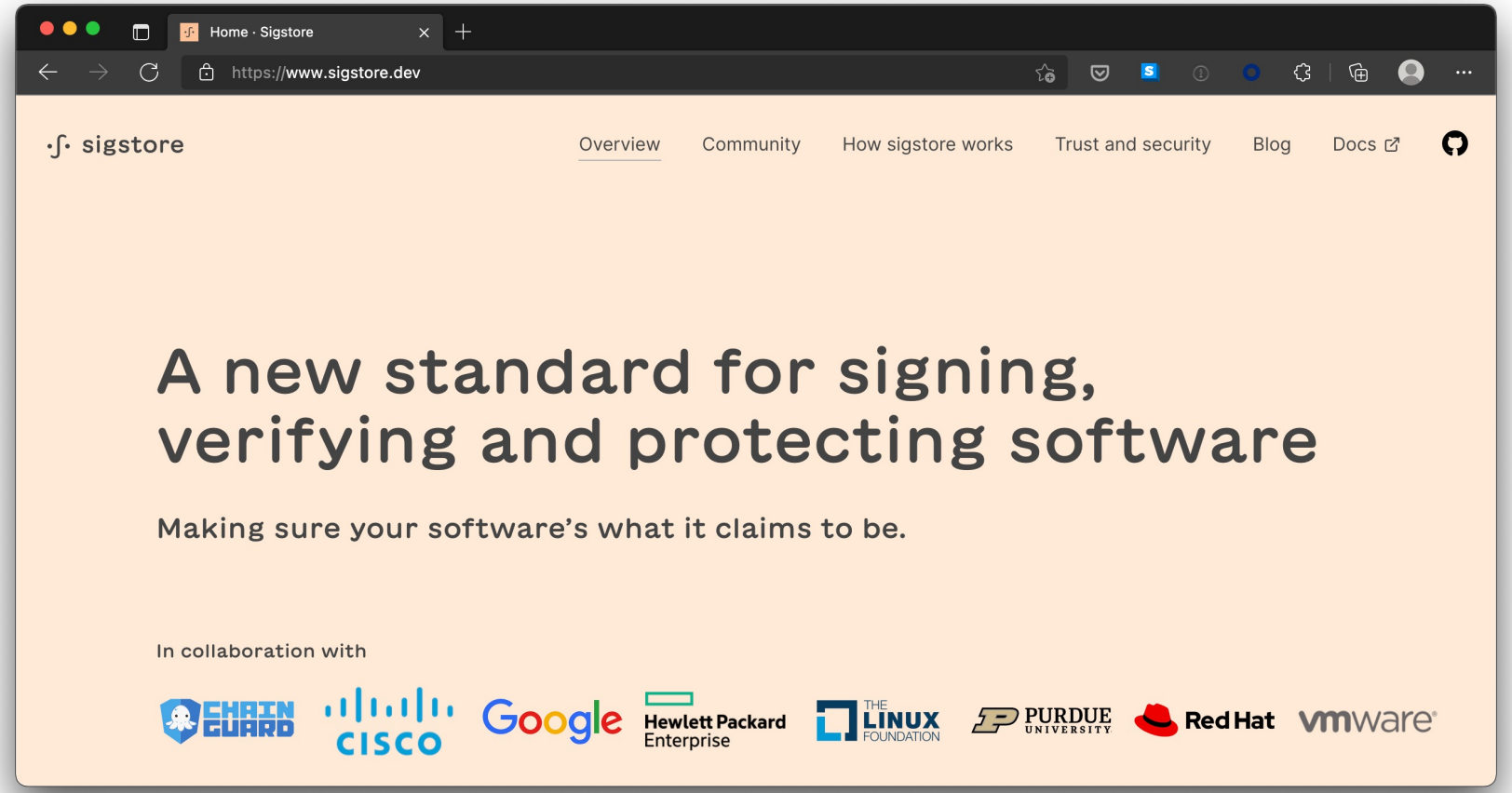
- DotNet.Reproducible NuGet Package
  - MSBuild *ContinuousIntegrationBuild*
  - SourceLink

- Dotnet.Reproducible.Isolated NuGet Package
  - Hermetic builds

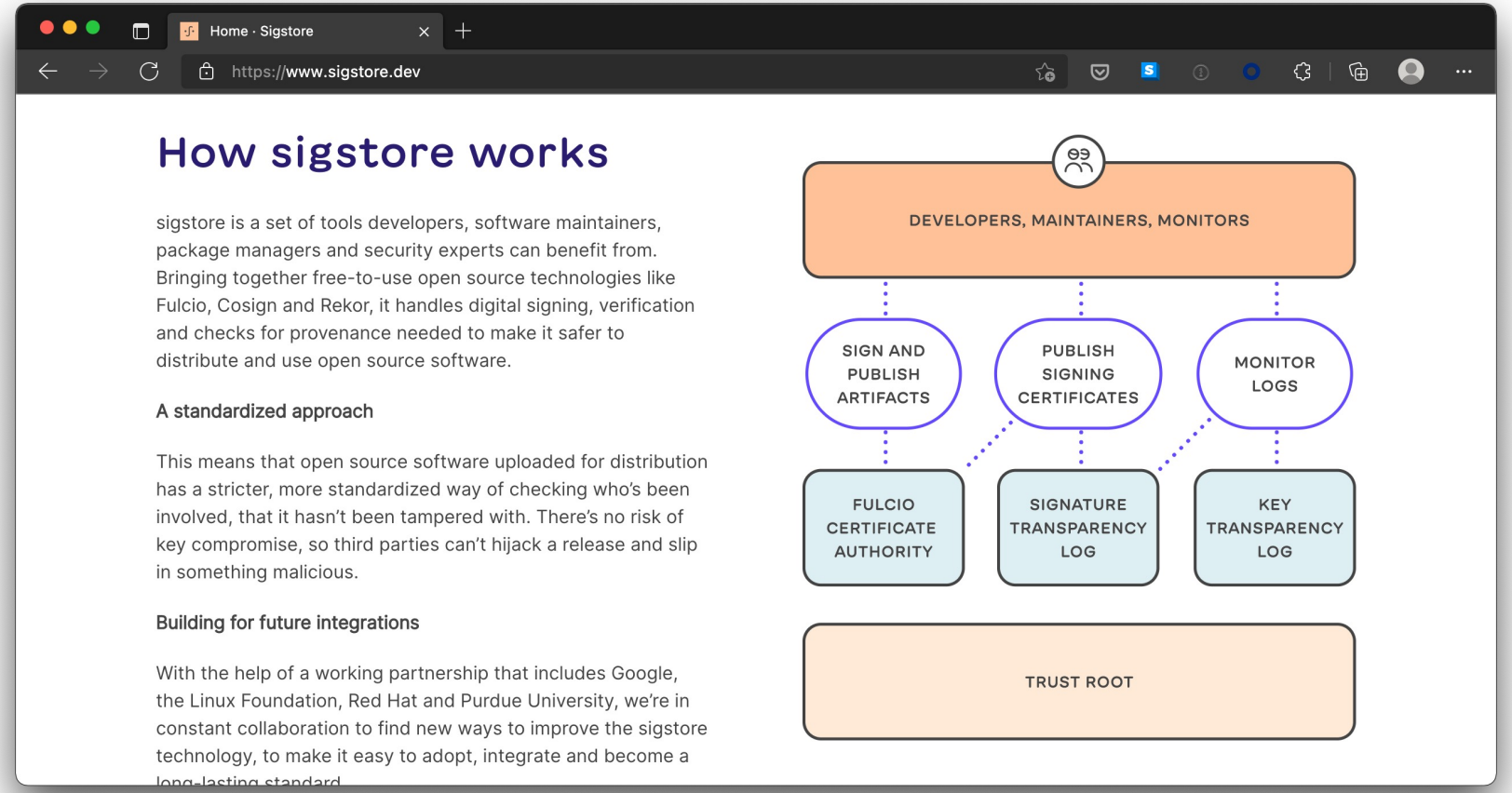
Reproducible Build Validation

- Design to validate NuGet packages & .NET binaries
  - Does linked source code match binaries?
  - Ability to rebuild reproducible based on given inputs
  - .NET CLI Validate tool `dotnet validate`

Signing artifacts



Signing artifacts

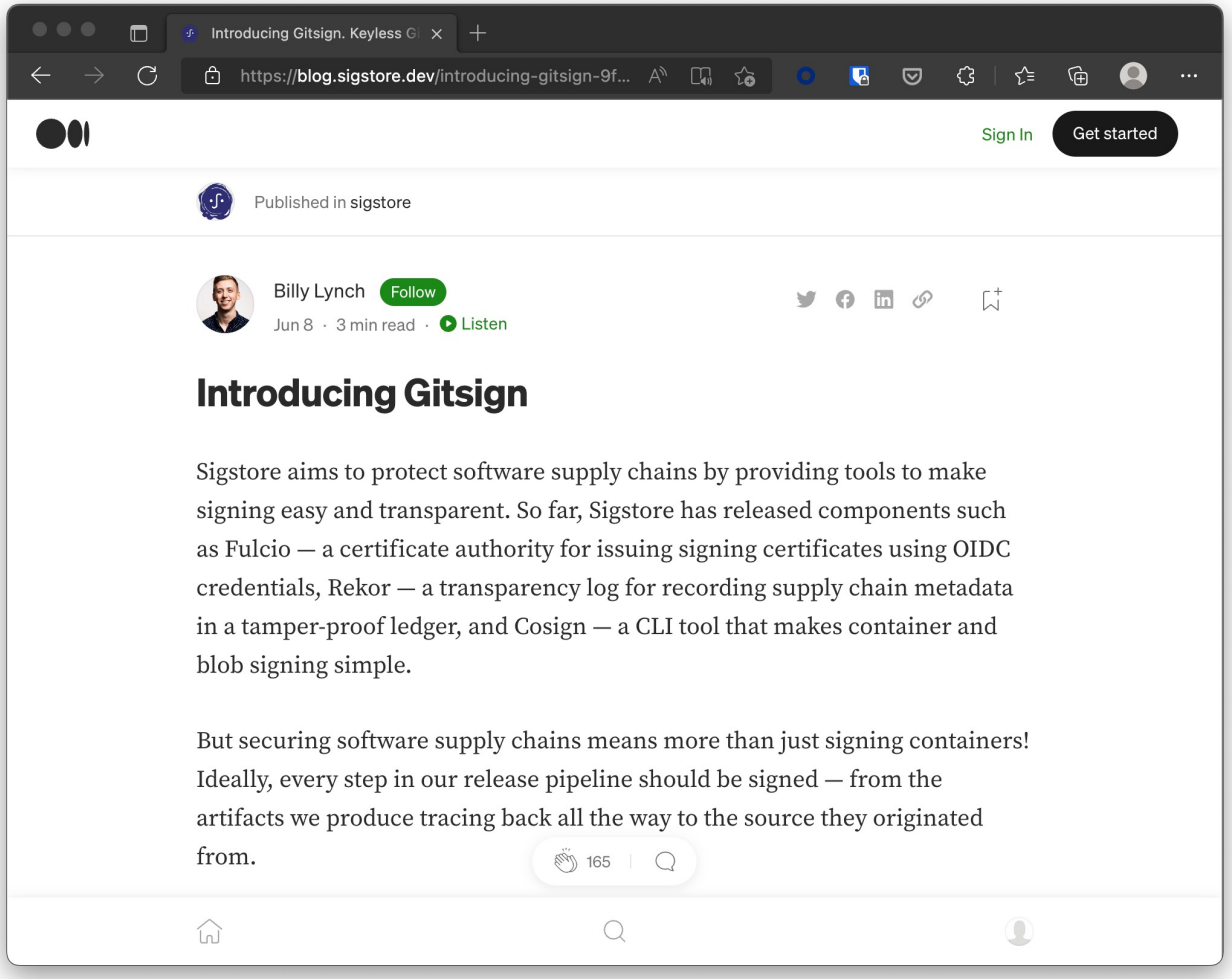


Signing artifacts

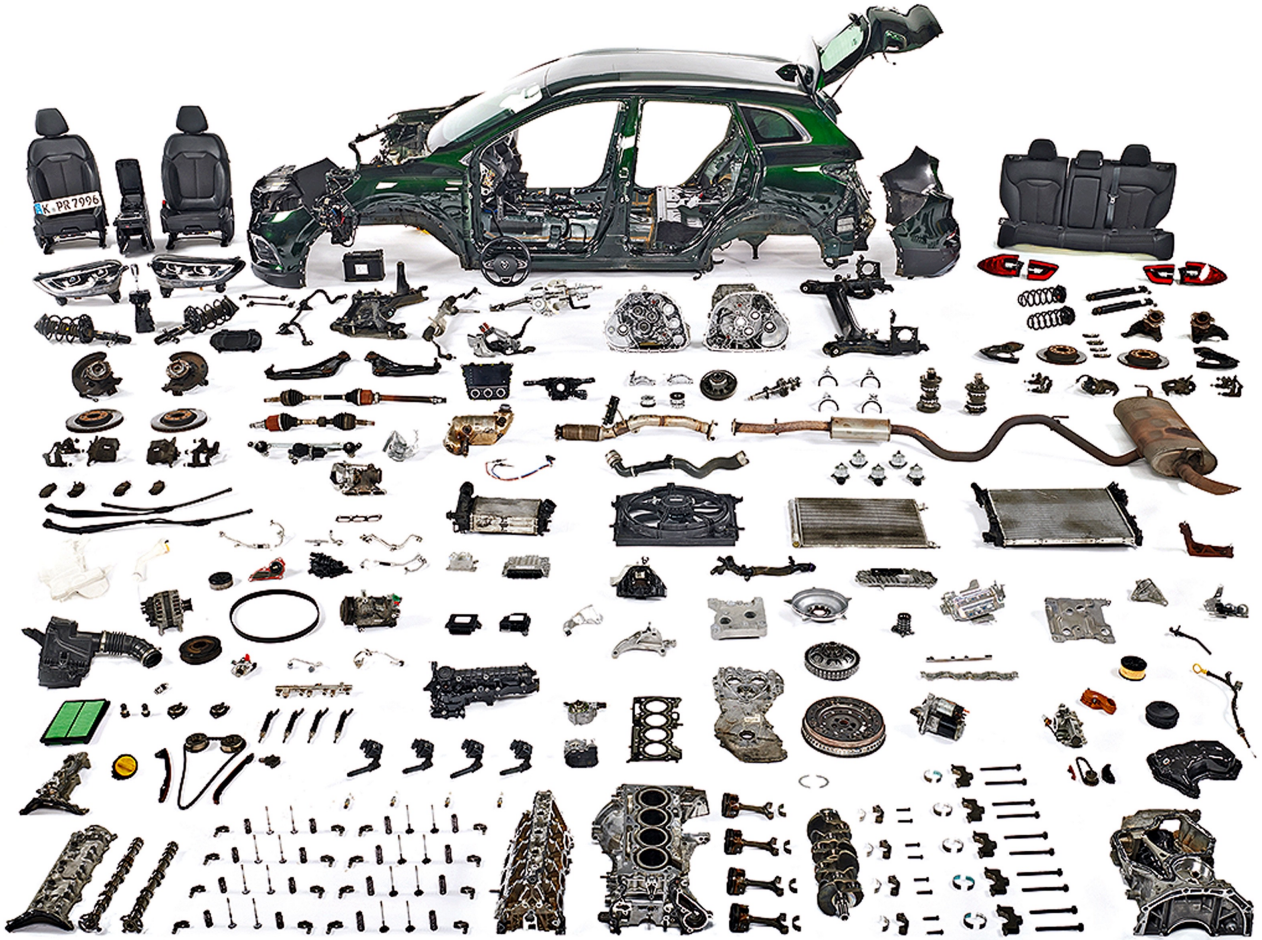
- Cosign can be used for signing files like binaries, packages and Docker images
- It can do keyless signing based on OpenID Connect
- GitHub Actions have released OpenID Connect support since end 2021

Cosign Keyless Signing

Git Commit Signing Sigstore GitSign



Automotive Industry



Car Supply Chain

Tata Steel Factory

- Iron Ore from Sweden
- ISO 6892-1 Tested/Certified
- Batch #1234

Bosch Factory

- Steel Batch #1234 Tata
- ECE-R90 Tested/Certified
- Serie #45678
- Used by Ford, Volkswagen and Renault

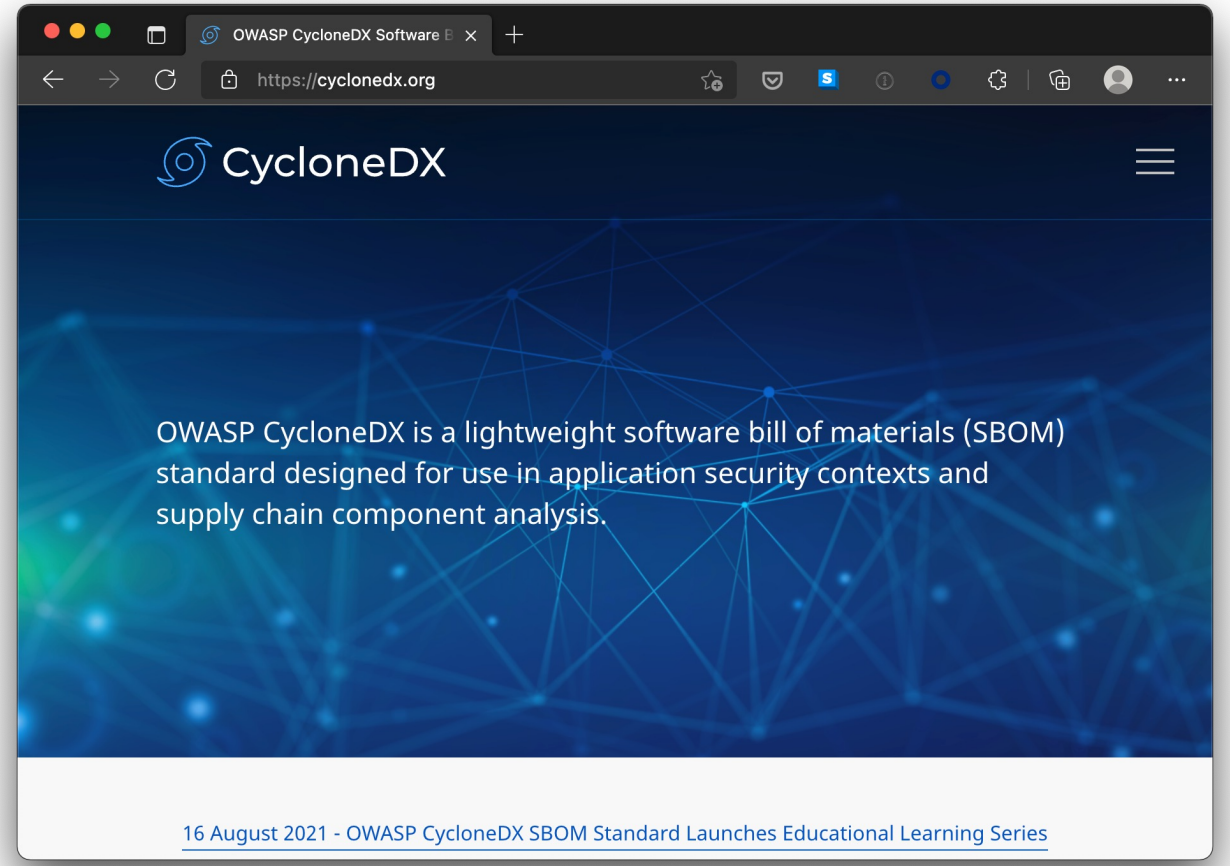
Renault Manufacturing

- Bosch Disk #45678
- Bosal Exhaust #RE9876
- Goodyear Tires #GY8877
- Kadjar VIN 1234567890

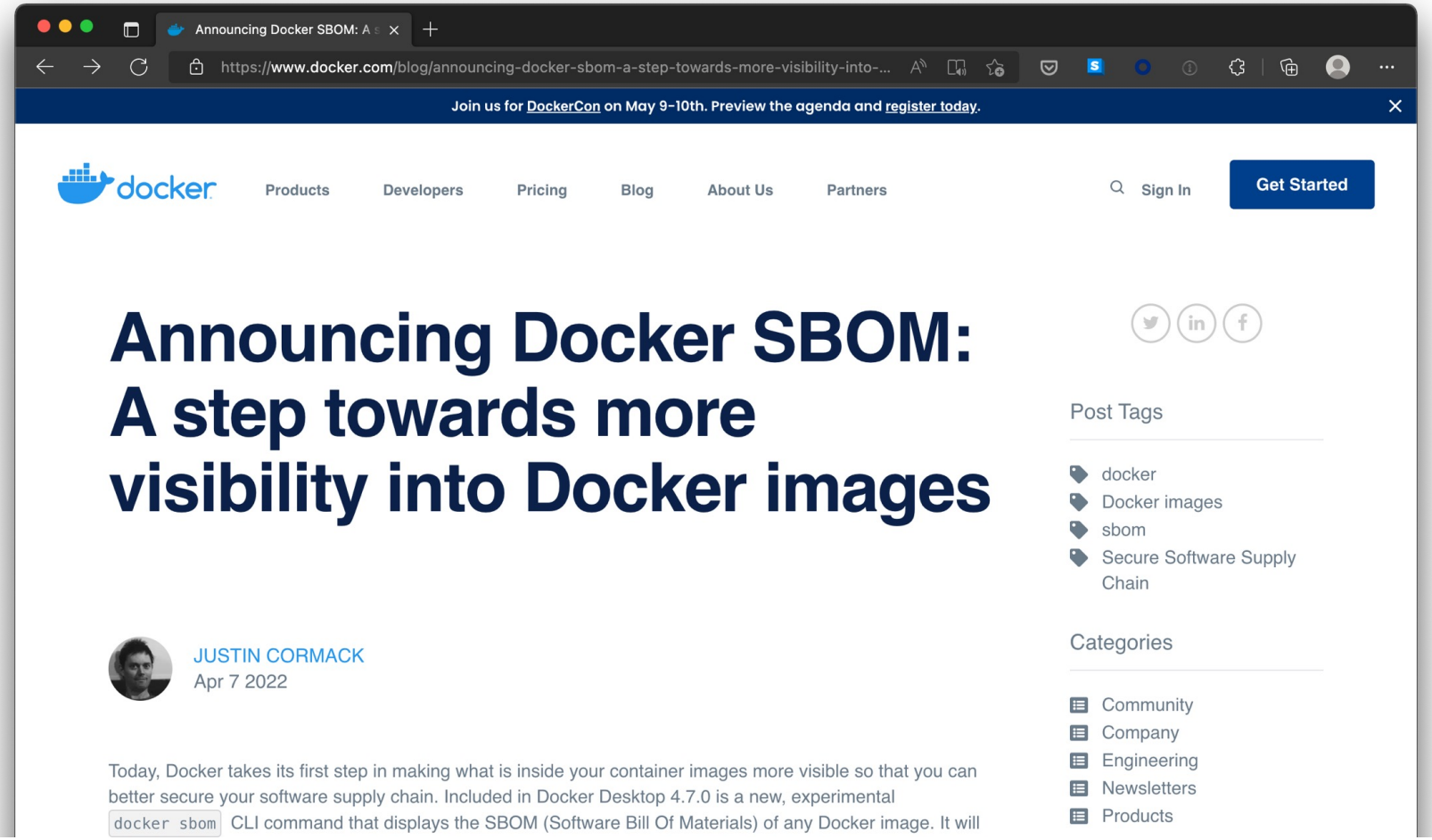
Software Bill of Materials (SBOM)

- Industry standard of describing the software
  - Producer Identity – Who Created it?
  - Product Identity – What's the product?
  - Integrity – Is the project unaltered?
  - Licensing – How can the project be used?
  - Creation – How was the product created? Process meets requirements?
  - Materials - How was the product created? Materials/Source used?

Software Bill of Materials (SBOM)



Docker SBOM


Announcing Docker SBOM: A
https://www.docker.com/blog/announcing-docker-sbom-a-step-towards-more-visibility-into-...
Join us for DockerCon on May 9-10th. Preview the agenda and register today.
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Announcing Docker SBOM: A step towards more visibility into Docker images
JUSTIN CORMACK
Apr 7 2022
Today, Docker takes its first step in making what is inside your container images more visible so that you can better secure your software supply chain. Included in Docker Desktop 4.7.0 is a new, experimental
docker sbom
CLI command that displays the SBOM (Software Bill Of Materials) of any Docker image. It will
Post Tags
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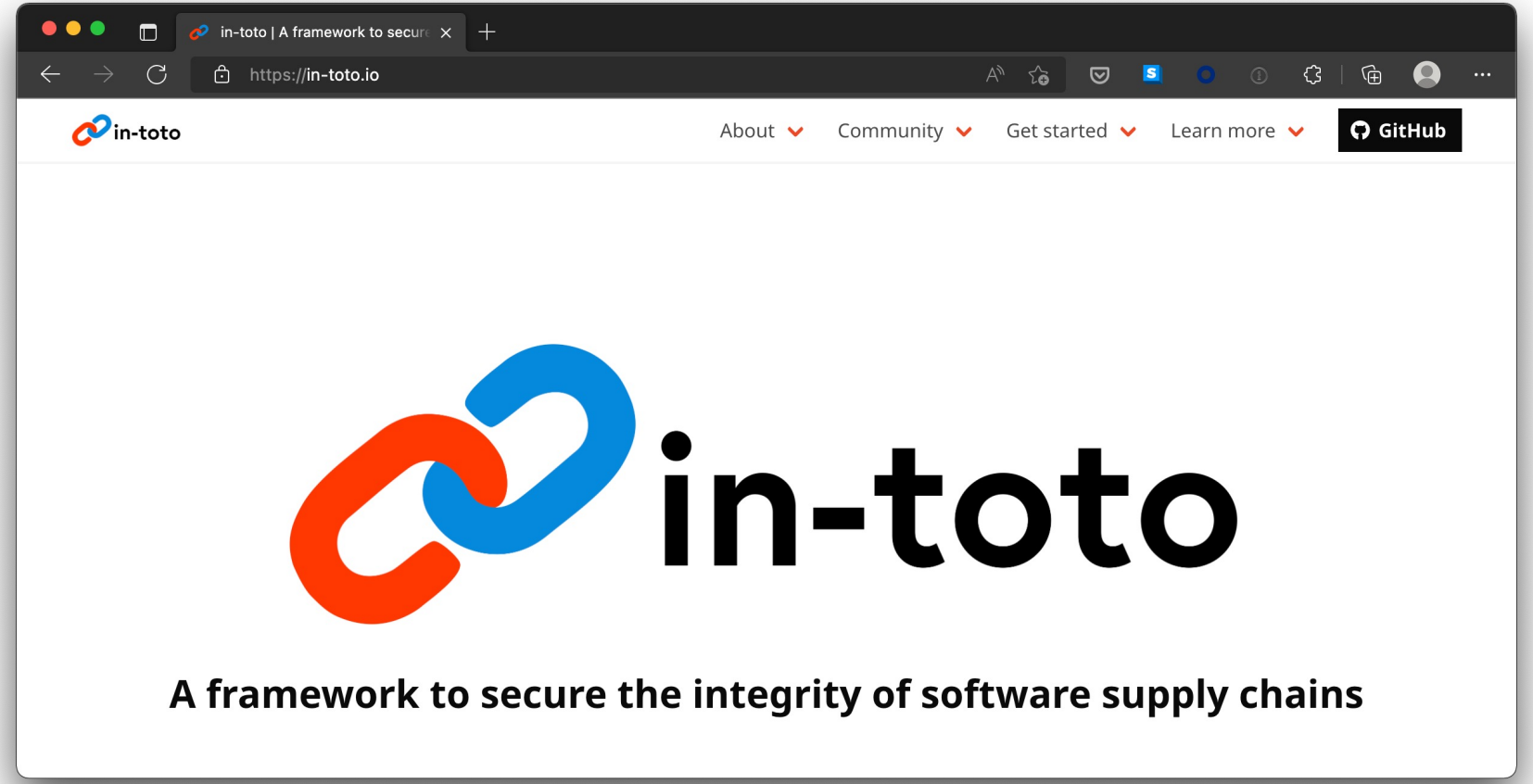
In-toto


in-toto | A framework to secure
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A framework to secure the integrity of software supply chains

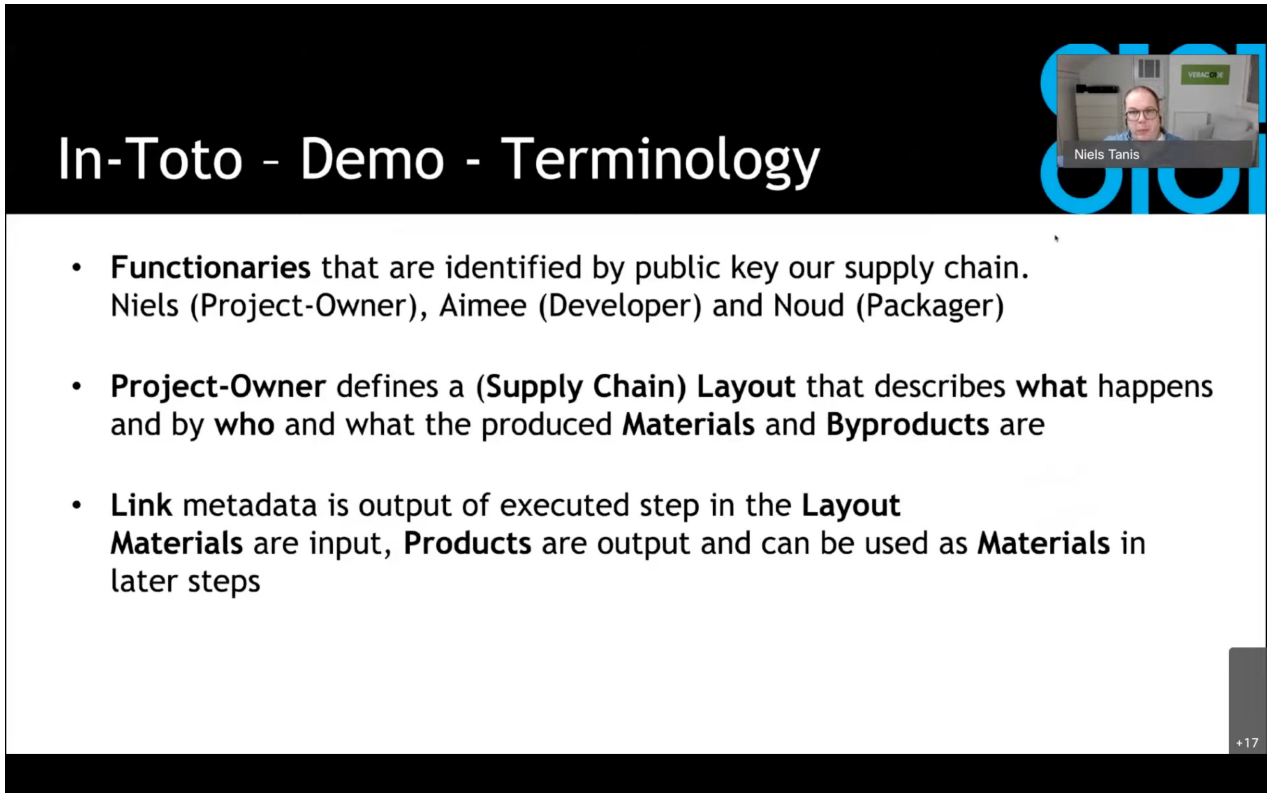
In-Toto - Terminology

- **Functionaries** that are identified by public key our supply chain.
  For example, the Project-Owner, Developer, and Release Manager

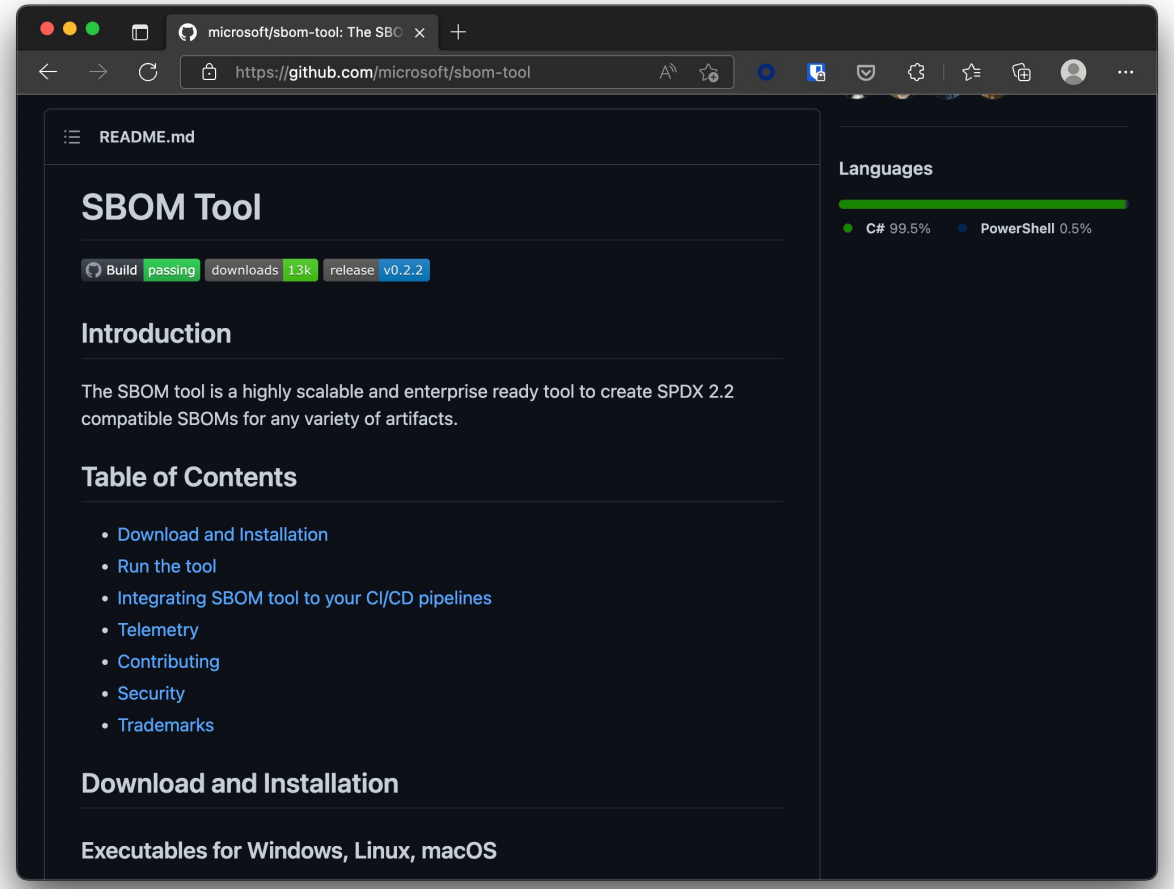
- **Project-Owner** defines a (**Supply Chain) Layout** that describes **what** happens and by **who** and what the produced **Materials** and **Byproducts** are.

- **Link** metadata is output of executed step in the **Layout**
  Materials are input, **Products** are output and can be used as **Materials** in later steps

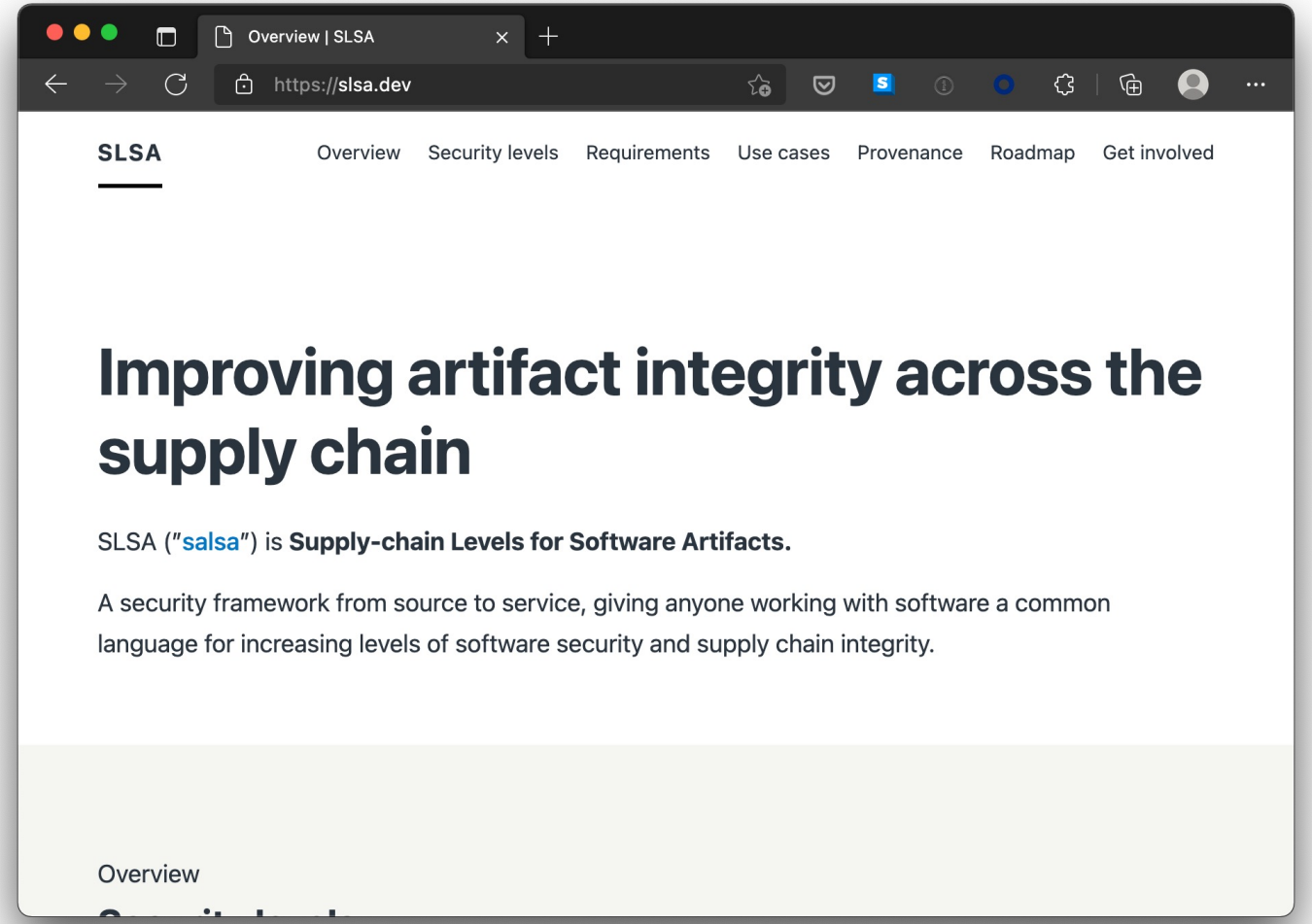
In-Toto - Demo


In-Toto - Demo - Terminology
Niels Tanis
• Functionaries that are identified by public key our supply chain. Niels (Project-Owner), Aimee (Developer) and Noud (Packager)
• Project-Owner defines a (Supply Chain) Layout that describes what happens and by who and what the produced Materials and Byproducts are
• Link metadata is output of executed step in the Layout Materials are input, Products are output and can be used as Materials in later steps
+17

Microsoft SBOM Tool



Google SLSA


Overview | SLSA
https://slsa.dev
SLSA
Overview
Security levels
Requirements
Use cases
Provenance
Roadmap
Get involved
Improving artifact integrity across the supply chain
SLSA ("salsa") is Supply-chain Levels for Software Artifacts.
A security framework from source to service, giving anyone working with software a common language for increasing levels of software security and supply chain integrity.
Overview

Google SLSA Levels

Level	Description	Example
1	Documentation of the build process	Unsigned provenance
2	Tamper resistance of the build service	Hosted source/build, signed provenance
3	Extra resistance to specific threats	Security controls on host, non-falsifiable provenance
4	Highest levels of confidence and trust	Two-party review + hermetic builds

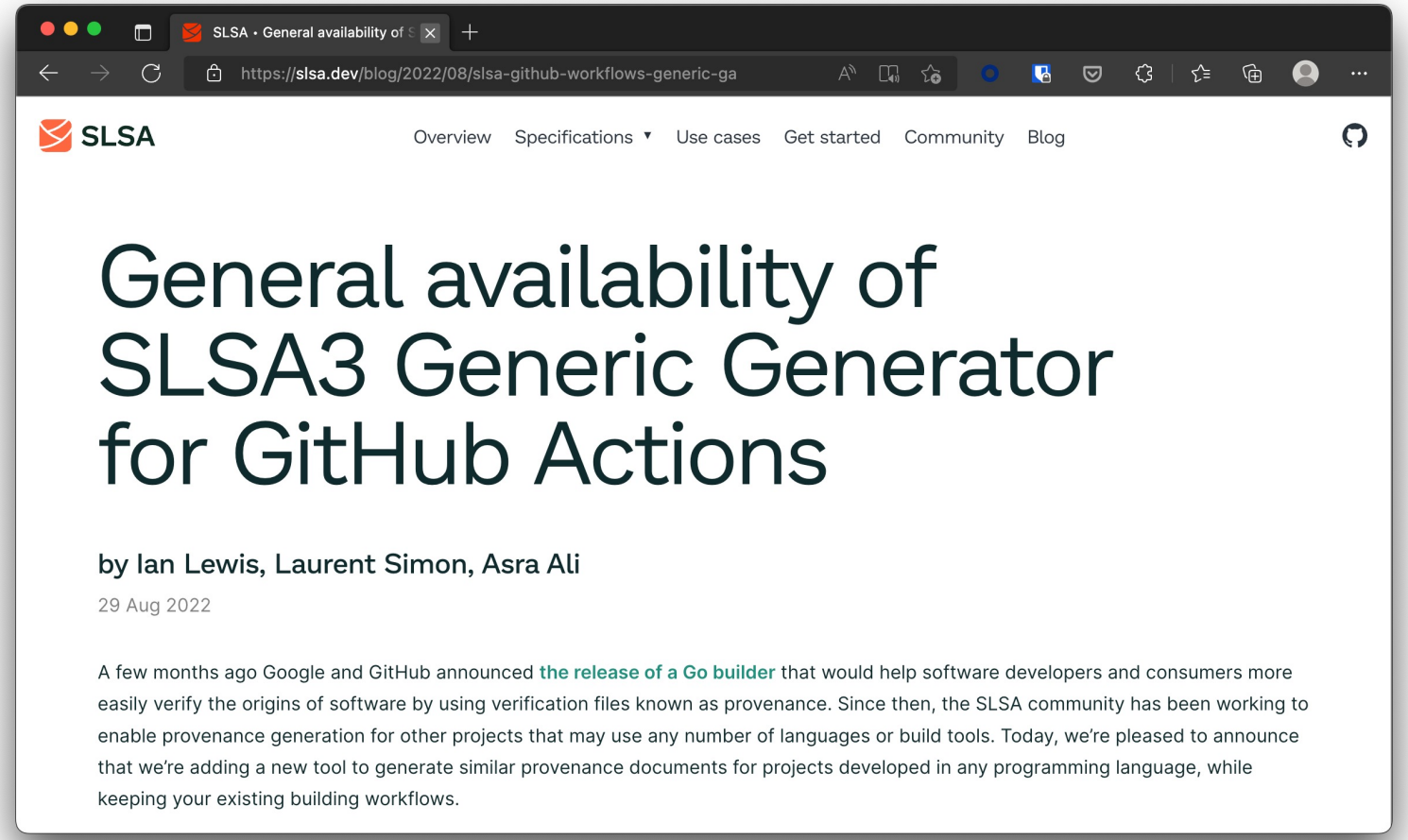
SLSA GitHub Action

- Released April 2022

- SLSA level 2 provenance generator in GitHub Action
- SLSA level 3+ provenance generator for Go binaries

- GitHub Hosted Runner
- Uses SigStore to do keyless signing with GitHub OIDC
- Verifier included

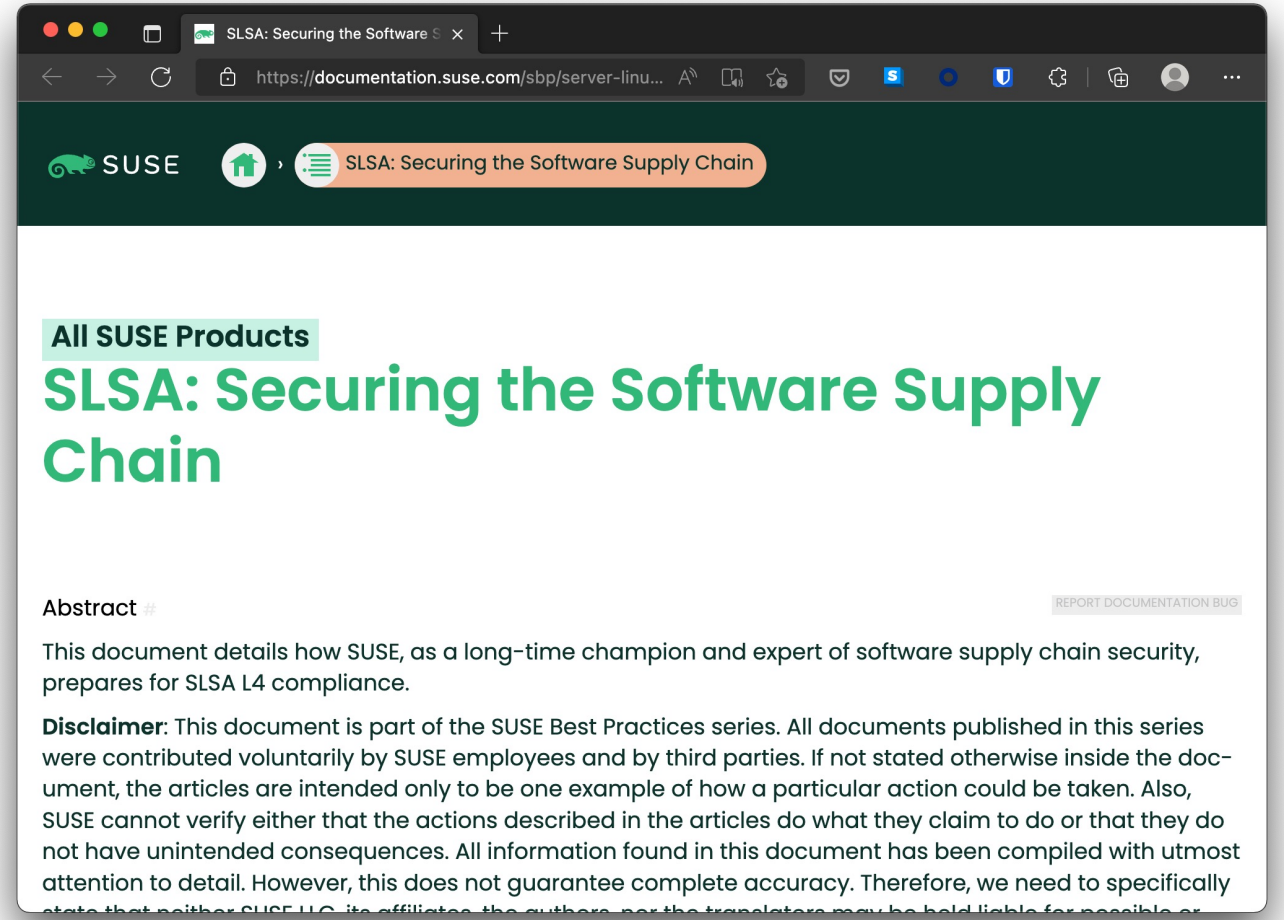
SLSA3 Generator GitHub Actions



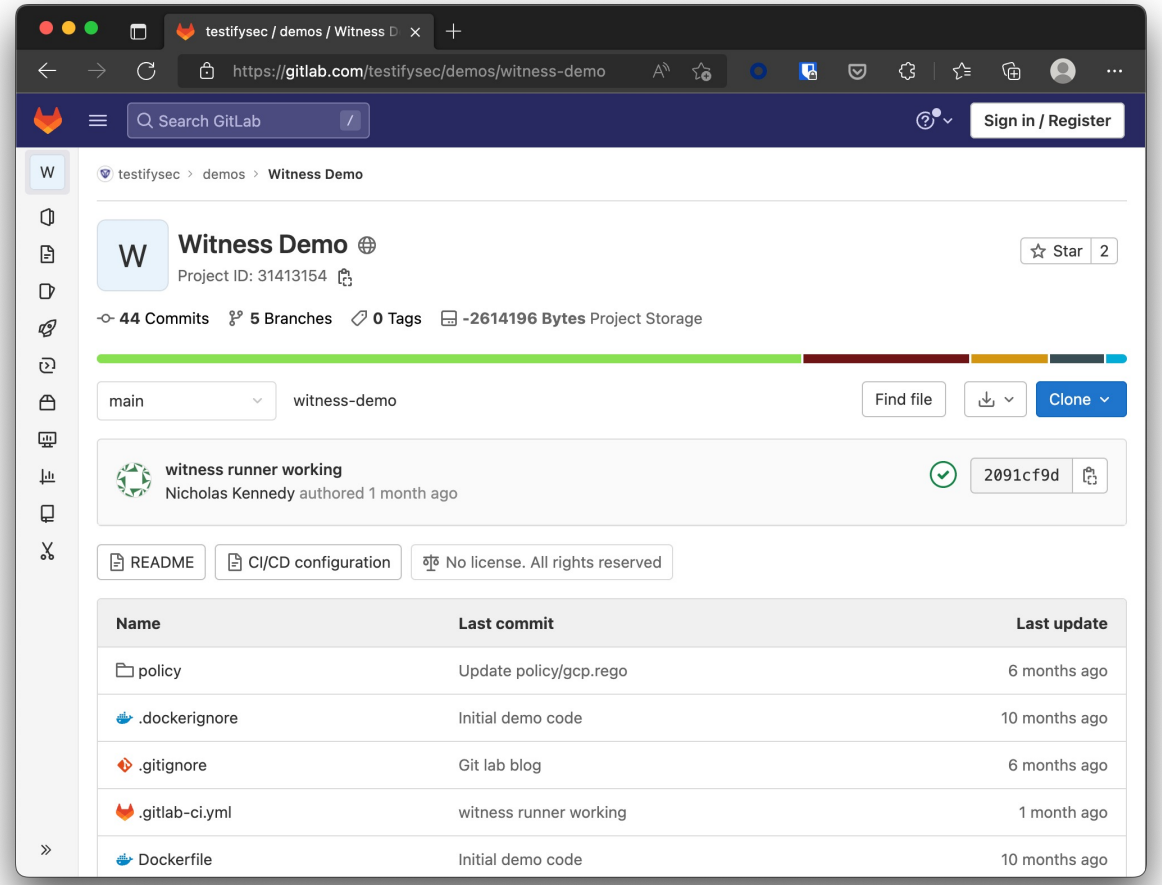
MyAwesomePDFComponent Demo

- A NuGet Package build in GitHub Actions
- CycloneDX SBOM
- Sigstore Keyless Signing
- SLSA Level 3 Provenance
- SBOM data, know what?

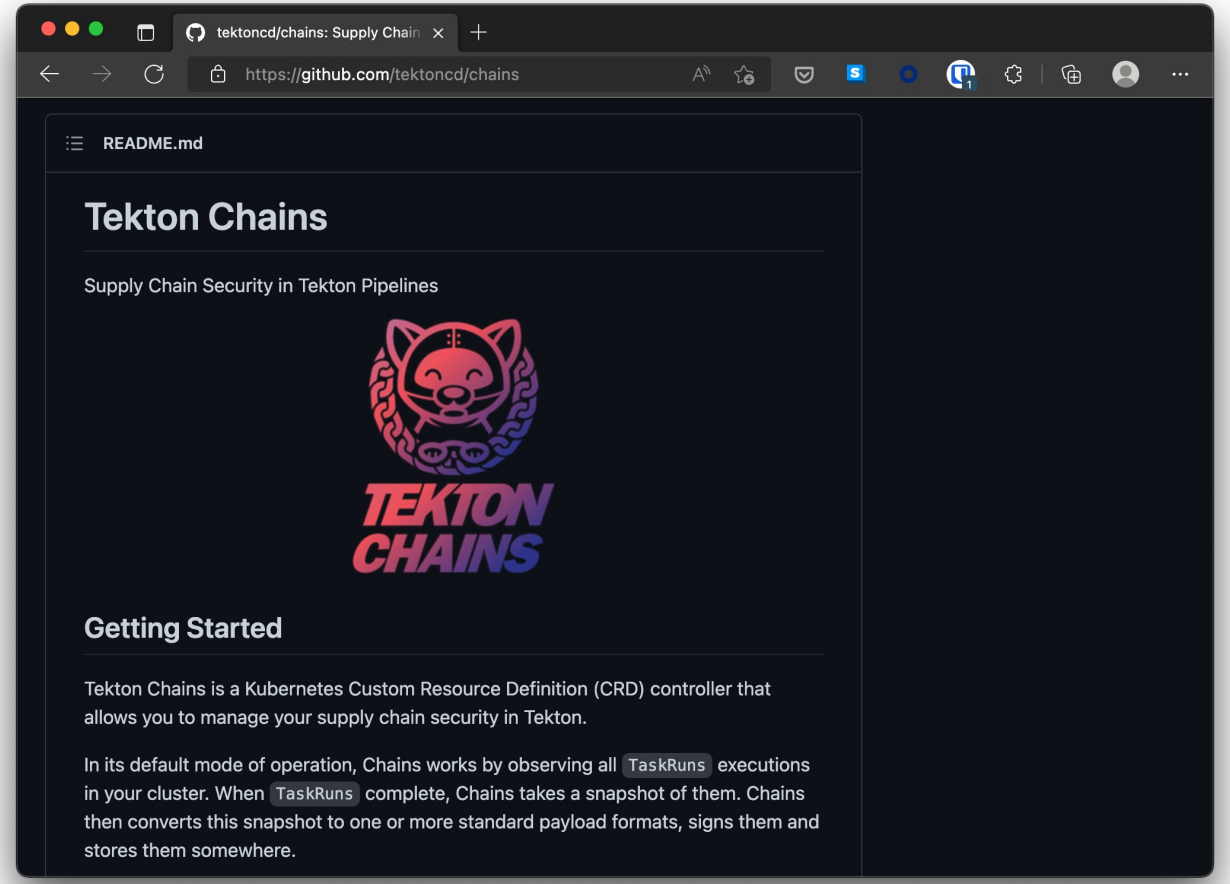
SUSE SLSA Level 4



Witness & GitLab Attestator

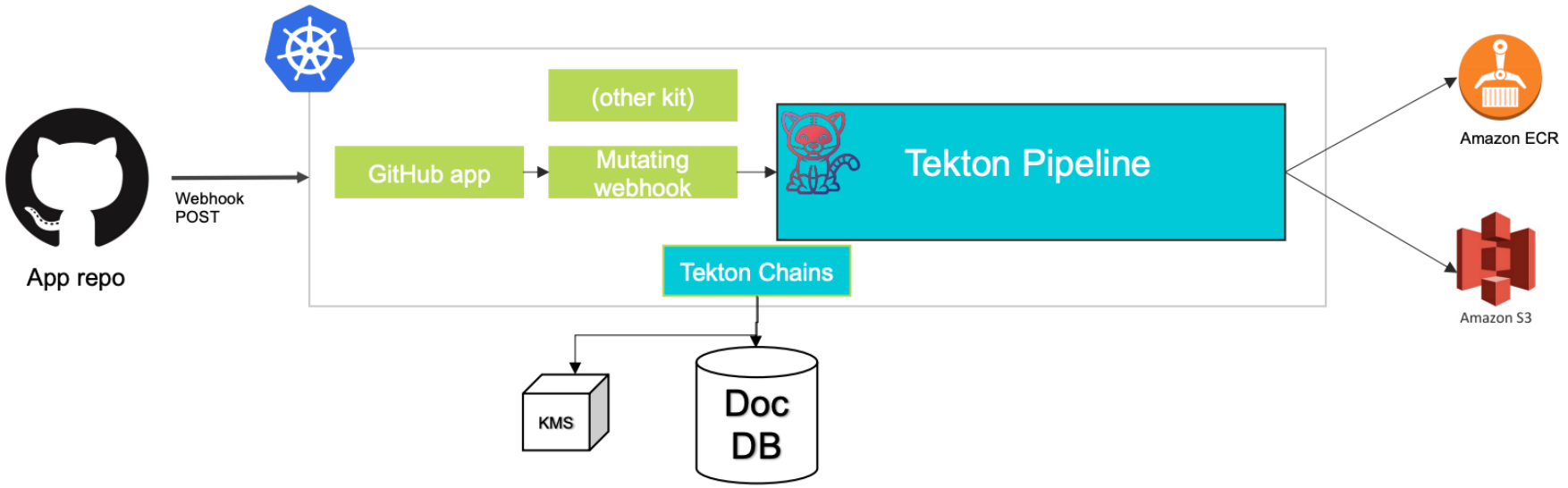


Open Shift - Tekton - Tekton Chains



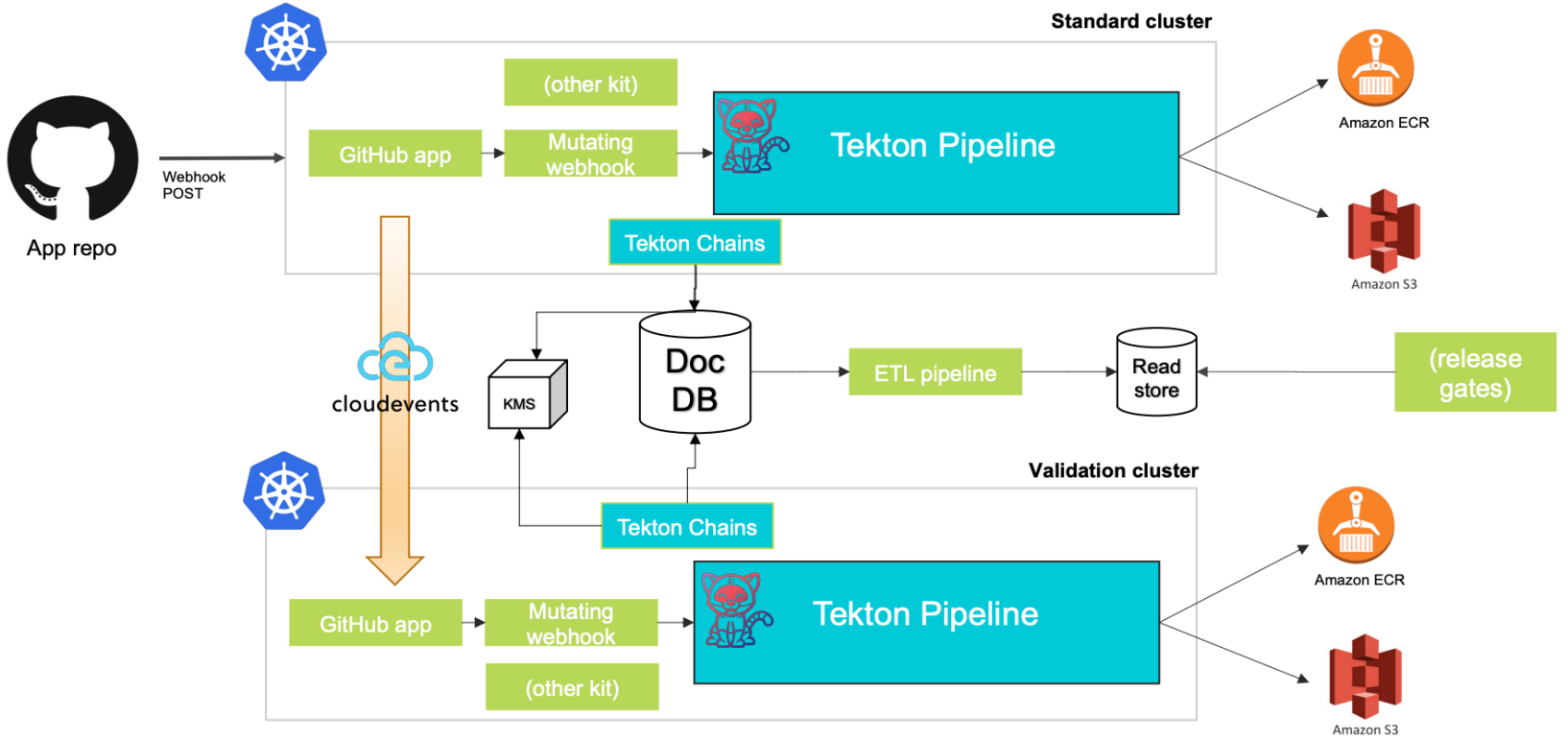
SolarWinds Project Trebuchet

Pipeline With Attestations



SolarWinds Project Trebuchet

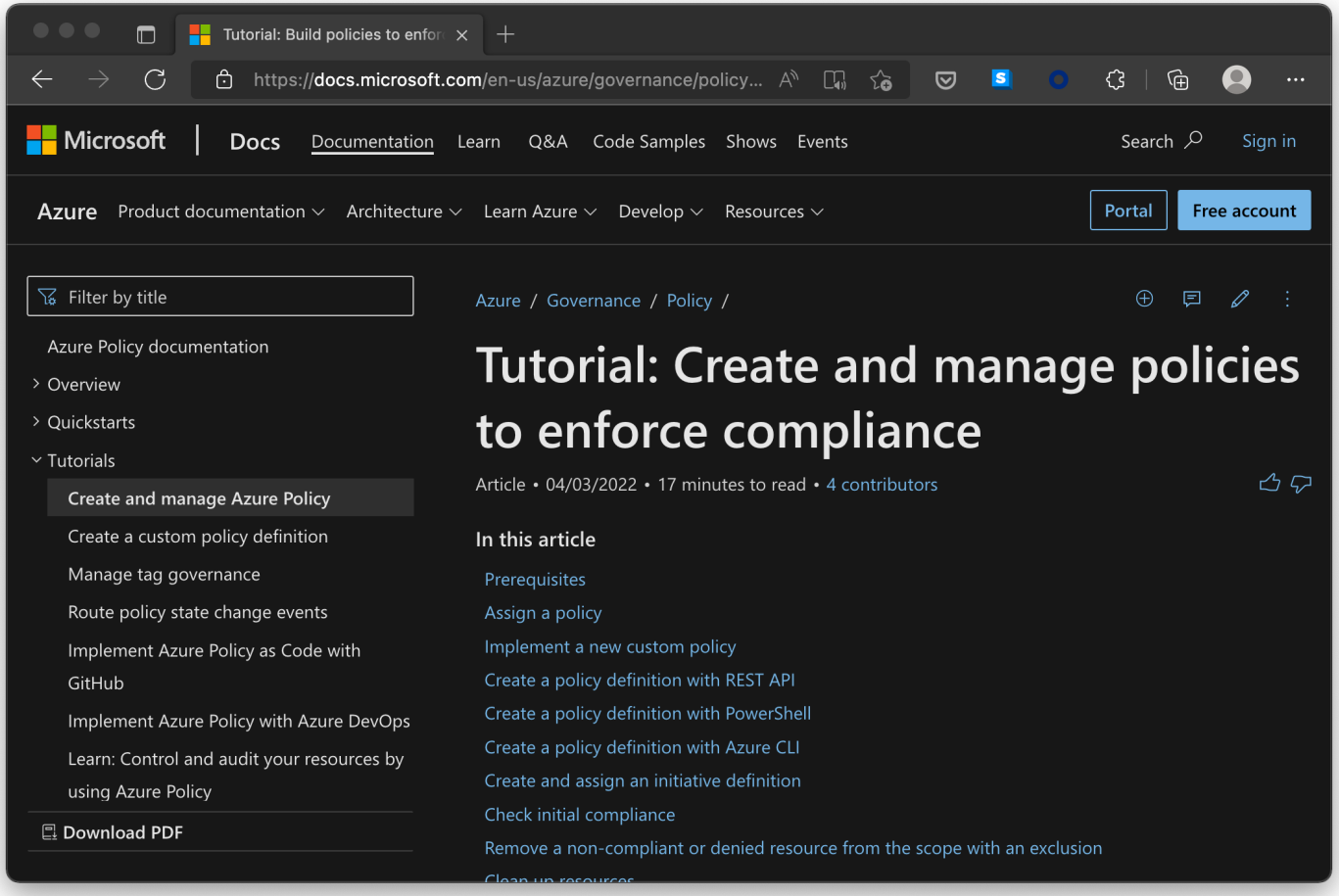
Reading Results



Grafeas and Kritis by Google

- Google released in 2019
- Grafeas – Component Metadata API
  - Container Analysis API on Google Cloud Platform
- Kritis – Deployment Authorization for Kubernetes Apps
  - Binary Authorization on Google Cloud Platform

Azure Policy



Conclusion

- It’s not how it’s more a matter of when!
- Be aware of your used software supply chain(s).
- Know what you’re using and pulling into projects.

Conclusion

- Integrate security into your software lifecycle.
- Start working on creating SBOM's and see how SLSA can fit into your process.
- Try to work with SBOM output and use it!

VERACODE

Thanks! Questions?

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ntanis at veracode.com
@nielstanis on Twitter