Securing the Supply Chain in a Company

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What is a software supply chain?

- It is anything that goes into your code or anything that affects your code from development to production
- What all is included in the software supply chain?
  - Code
  - Binaries
  - Open-source software (from repositories, package managers, etc)
  - Internal packages
  - Build scripts
  - Packaging scripts
  - The infrastructure the software runs on
- Also:
  - Who wrote the software, who reviewed it, software licensing, supported versions, when it was contributed
  - The software that checks for known security issues

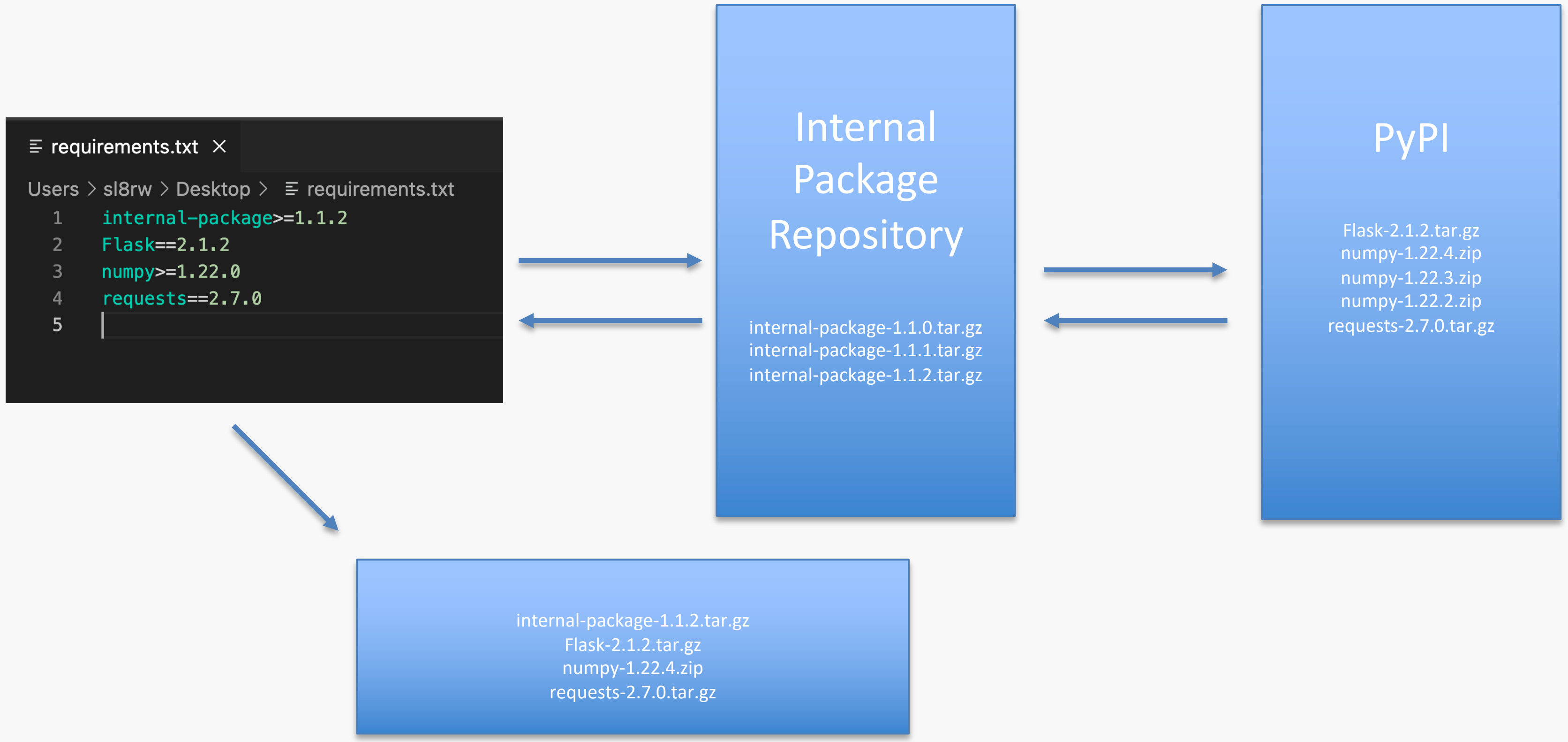
Where to attack?

- Two main areas where the supply chain can be attacked
  - Components under the company’s control
  - External components not under the company’s control
- Types of attacks:
  - Dependency confusion targeting open-source components or internal packages
  - Typosquatting
  - Developer accidents
  - Compromising an employee’s accounts or otherwise injecting code into the company’s private repository
  - Stealing code-signing certificates
  - Attacking the build environment

Recent newsworthy attacks

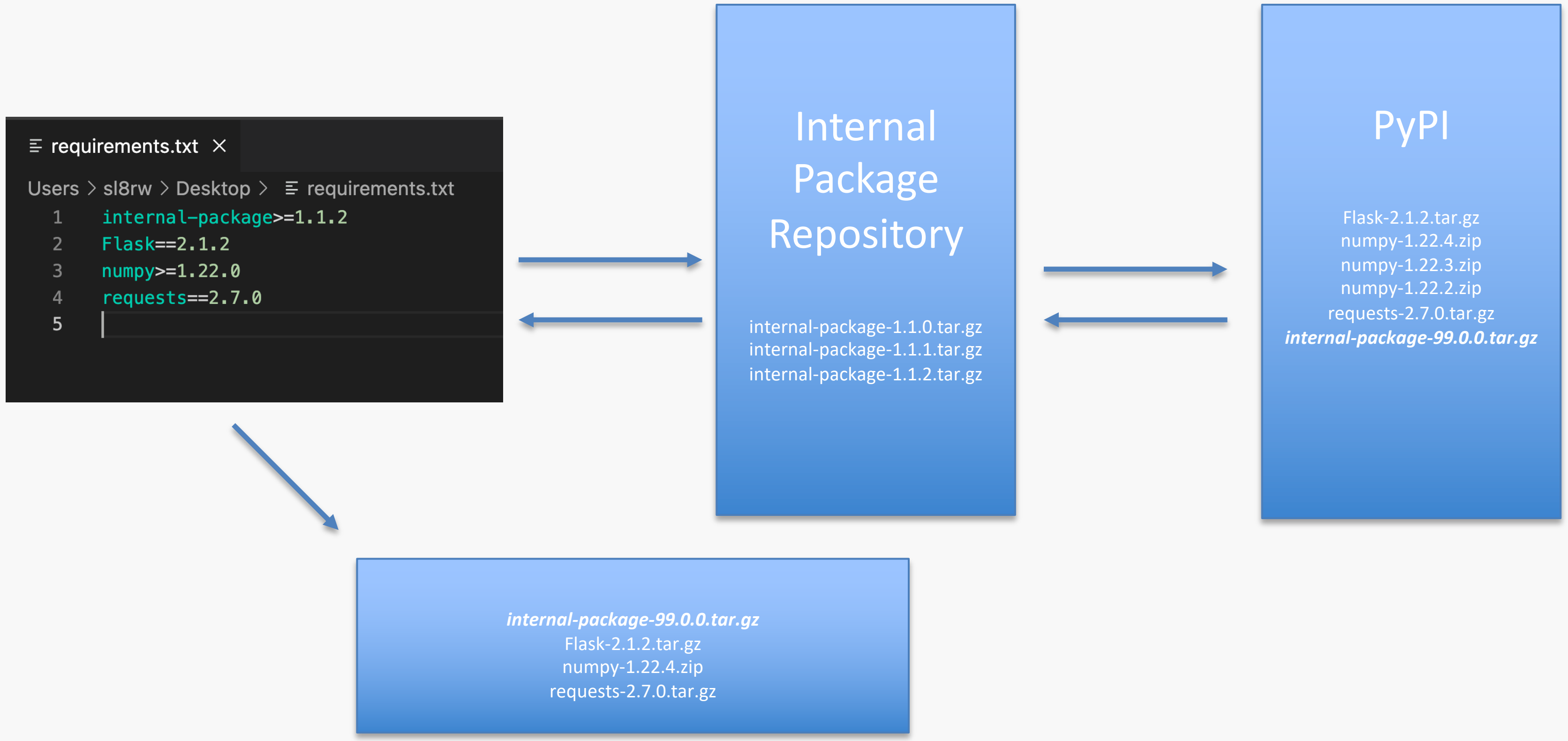
- Trojan Source
  - Hiding malicious code with Unicode characters resulting in it getting missed during a routine code review
  - Early return example
- SolarWinds
  - Targeted Orion, an IT performance monitoring system
    - This software had privileged access and was widely deployed
  - SolarWinds network was infiltrated, build system was targeted, and code injection vectors were tested
  - Code was eventually signed and deployed to the 30K+ customers
- XcodeSpy
  - Trojan Xcode project based on TabBarInteraction, a legitimate Xcode project which adds animation to the tab bar for an iOS application
  - Runs malicious code that downloads the EggShell backdoor from a remote server
  - Acts as a first step in a supply chain attack
- ua-parser-js
  - Took over developer's account (https://github.com/faisalman/ua-parser-js/issues/536#issuecomment-949742904) with the probable help of an email bomb
  - After installation, the script detects the OS and downloads the respective binary, which then downloads a cryptominer to mine cryptocurrency

An Example – Dependency Confusion



```
requirements.txt
Users > sl8rw > Desktop > requirements.txt
internal-package>=1.1.2
Flask==2.1.2
numpy>=1.22.0
requests==2.7.0
```

An Example – Dependency Confusion



requirements.txt

Users > sl8rw > Desktop > requirements.txt

```
internal-package>=1.1.2
Flask==2.1.2
numpy>=1.22.0
requests==2.7.0

```

Internal Package Repository
internal-package-1.1.0.tar.gz
internal-package-1.1.1.tar.gz
internal-package-1.1.2.tar.gz
PyPI
Flask-2.1.2.tar.gz
numpy-1.22.4.zip
numpy-1.22.3.zip
numpy-1.22.2.zip
requests-2.7.0.tar.gz
internal-package-99.0.0.tar.gz
internal-package-99.0.0.tar.gz
Flask-2.1.2.tar.gz
numpy-1.22.4.zip
requests-2.7.0.tar.gz

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But you need the internal package names…

- You can get these by scraping GitHub
- Searching the JavaScript on the website of interest for calls such as:
  - require()
  - Search for paths that are prepended with the company’s name
- Stack Overflow
- Guessing

Has this happened?

- Yes, a proof-of-concept was demonstrated in early 2021
- https://www.npmjs.com/package/yelp-bunsen-logger-js
- https://www.npmjs.com/package/yelp-js-infra
- https://www.npmjs.com/package/yelp_sitrep

This seems easy… Why?

- A lot of times it’s due to assumptions or confusion
- For example, in Python:
  - Developers using --extra-index-url, which does the same type of check as previously described, instead of --index-url.
  - Using Artifactory, which is used in many corporations, mixes internal and public libraries into its own type of library. Therefore, it shares the same type of vulnerability

Other derivatives - Typosquatting

- Typosquatting, which has been known about since 2016
- Let’s say I want to install requests, I do: pip install requests
- As the name typosquatting implies, an attacker takes advantage of common typos, such as:
  - requets
  - reqeusts
  - requsts
- This can lead to arbitrary code execution among other issues

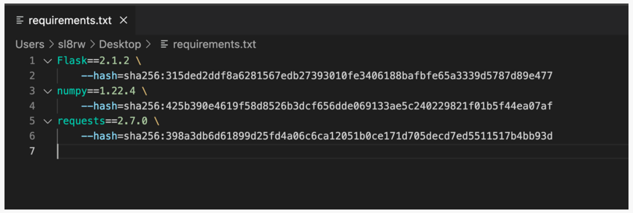
CrateDepression - Rust

- This attack targeted rust_decimal by uploading a malicious crate called rustdecimal
- Once the machine is infected, the environment variable GITLAB_CI is searched for
- The Poseidon payload (written in Go) is downloaded to the targeted Linux or macOS platform. Once downloaded, the binary is set as an executable and on macOS the quarantine bit is removed
- C2 communication is set up

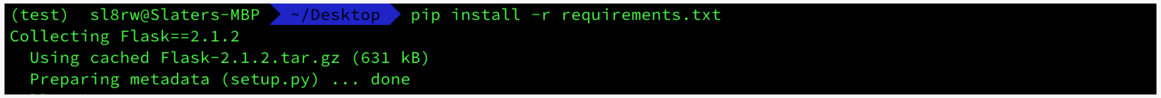
How do you mitigate these types of attacks?

- To mitigate against dependency confusion in Python:
  - Avoid using --extra-index-url
  - Use version pinning
  - If possible, use version hashing (pip install --hash)

Hash match for Flask version:

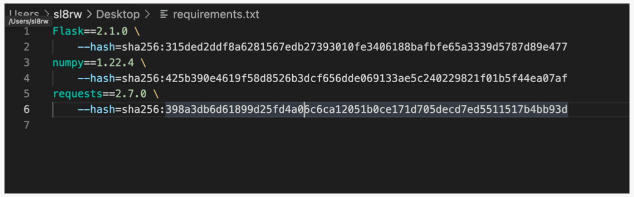


```
requirements.txt ×
Users > sl8rw > Desktop > requirements.txt
Flask==2.1.2 \
    --hash=sha256:315ded2ddf8a6281567edb27393010fe3406188bafbfe65a3339d5787d89e477
numpy==1.22.4 \
    --hash=sha256:425b390e4619f58d8526b3dcf656dde069133ae5c240229821f01b5f44ea07af
requests==2.7.0 \
    --hash=sha256:398a3db6d61899d25fd4a06c6ca12051b0ce171d705decd7ed5511517b4bb93d
```

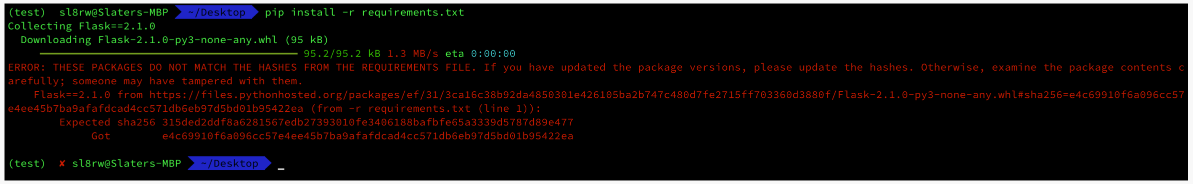


```
(test)  sl8rw@Slaters-MBP  ~/Desktop  pip install -r requirements.txt
Collecting Flask==2.1.2
  Using cached Flask-2.1.2.tar.gz (631 kB)
  Preparing metadata (setup.py) ... done
```

Hash mismatch for Flask version:



```
Users > sl8rw > Desktop > requirements.txt
/Users/sl8rw
Flask==2.1.0 \
    --hash=sha256:315ded2ddf8a6281567edb27393010fe3406188bafbfe65a3339d5787d89e477
numpy==1.22.4 \
    --hash=sha256:425b390e4619f58d8526b3dcf656dde069133ae5c240229821f01b5f44ea07af
requests==2.7.0 \
    --hash=sha256:398a3db6d61899d25fd4a06c6ca12051b0ce171d705decd7ed5511517b4bb93d
```



```
(test)  sl8rw@Slaters-MBP  ~/Desktop  pip install -r requirements.txt
Collecting Flask==2.1.0
  Downloading Flask-2.1.0-py3-none-any.whl (95 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 95.2/95.2 kB 1.3 MB/s eta 0:00:00
ERROR: THESE PACKAGES DO NOT MATCH THE HASHES FROM THE REQUIREMENTS FILE. If you have updated the package versions, please update the hashes. Otherwise, examine the package contents c
arefully; someone may have tampered with them.
    Flask==2.1.0 from https://files.pythonhosted.org/packages/ef/31/3ca16c38b92da4850301e426105ba2b747c480d7fe2715ff703360d3880f/Flask-2.1.0-py3-none-any.whl#sha256=e4c69910f6a096cc57
e4ee45b7ba9afafdcad4cc571db6eb97d5bd01b95422ea (from -r requirements.txt (line 1)):
        Expected sha256 315ded2ddf8a6281567edb27393010fe3406188bafbfe65a3339d5787d89e477
             Got        e4c69910f6a096cc57e4ee45b7ba9afafdcad4cc571db6eb97d5bd01b95422ea

(test)  ✘ sl8rw@Slaters-MBP  ~/Desktop  _
```

Event-Stream - Dependencies of dependencies attack

- A JavaScript library known as Event-Stream is downloaded approximately 2 million times a week
- The original author gave another developer/maintainer access to the repository (Right9ctrl)
- The new developer added a dependency to Flatmap-Stream(which was an injection attack) and bumped the minor version of Event-Stream
- A few days, that developer removed Flatmap-Stream and bumped the major version of Event-Stream
- Millions of users were affected as it’s downloaded so often
- Ultimately, the malware targeted Copay. If wallet is found, it executes and attempts to steal your bitcoin wallet
- https://github.com/dominictarr/event-stream/issues/116

Secure SDLC

- Having clear security requirements defined up front and distributed to developers
- Perform threat modeling
- Establish design requirements and use appropriate cryptographic standards
- Keeping an inventory of all 3rd-party components that are used and performing dependency analysis/SCA
- Using approved tools/versions and using appropriate compiler flags
- Performing static analysis against source code before compiling
- Perform dynamic analysis of the compiled software
- Pen testing

Threat Modeling

- The 5 major steps are:
  - Define the security requirements of the application
  - Diagram the application
  - Identity the potential threats and security boundaries
  - Apply mitigations
  - Validate that the threats have been mitigated
- Having to make a significant change to an application costs a huge amount of money, causes delays, optics, etc

Establish design requirements/Crypto standards

- Many features are susceptible to vulnerabilities just based on complexity
  - Authentication
  - Role-based access controls
  - Logging
  - Cryptographic protocols
- Examples
  - Two-factor authentication
  - Password complexity
  - Collision resistant hashing algorithms

Dependency Analysis/Software Composition Analysis (SCA)

- Identification of vulnerabilities in open-source code used by companies
- Many tools exist including:
  - Snyk.io
  - Synopsys Black Duck
  - npm-audit or yarn audit
  - Manual review of the package manifests
- Each of these tools have various strengths and weaknesses.
- What if these tools identify a huge number (I have seen 20K+ findings in the past)
  - This does not mean the application is vulnerable. It is possible that the application does the not leverage a vulnerable component in a vulnerable way.
  - It is important to ensure that each of the findings though are reviewed to determine if a vulnerability exists.
- A lot of the findings can be fixed by updating to the latest point release. Think back to Event-Stream, if you updated to the major release a few days later, you would no longer be vulnerable.

Tool Use and SAST

- What IDEs are being used? Are appropriate plugins being used?
- In the build pipeline, what compiler/linker flags are being used?
  - For example (GCC): -Werror, -Wall, -Wextra, -fstack-protector, -Wsign-conversion, -Wconversion
- Is the source code free of secrets including in the history?
- Is the developer documentation free of secrets?
- What static analysis tools are being used?
  - For example, Semmle, PVS-Studio, Semgrep

Other areas to look at in the supply chain

- Build reproducibility
- Code review process
- Release process
- Build artifact storage and retention
- Access revocation
- Session longevity
- Automation of the build/scripting

Introducing SLSA: Supply-chain Levels for Software Artifacts

- Introduced by Google
- SLSA provides an easy framework to measure the security of a supply chain
- Consists of 4 levels where 4 is the most secured
  - Level 1: Automated build and build provenance
  - Level 2: The source and build are hosted and the provenance is signed
  - Level 3: Security controls are required on the host the provenance cannot be falsifiable
  - Level 4: Two-person reviews, hermetic build
- The 4 components of SLSA are:
  - Source Requirements
  - Build Requirements
  - Provenance Requirements
  - Common Requirements

SLSA Source Requirements

- In Level 1
  - Version control is not required but it is recommended
- In Level 2
  - Version control required (overrides Level 1 recommendation)
- In Level 3
  - Verified history (the committer must be strongly authenticated, a timestamp must be available, 2FA)
  - Source code and revision history must be retained at least 18 months and cannot be modifiable except by admins who have 2-party approval
- In Level 4
  - History retained indefinitely
  - Two-person review required for every change in the history, they must be different people, and each must be strongly authenticated

SLSA Build Requirements

- In Level 1
  - Scripted build
- In Level 2
  - Build is ran using a service (e.g., GitHub Actions)
- In Level 3
  - Build definition and configuration files are stored in VCS and the code is built using those by the build service
  - The build is performed in an ephemeral environment that is used only for the build
  - The build service must be isolated (it cannot be influenced by any other builds and it cannot influence any other build environments)

SLSA Build Requirements

- In Level 4
  - Scripted build
  - Build is ran using a service
  - Build definition and configuration files are stored in VCS and the code is built using those by the build service
  - The build is performed in an ephemeral environment that is used only for the build
  - The build service must be isolated (it cannot be influenced by any other builds and it cannot influence any other build environments)
  - **The build must be parameterless (the build is fully defined by the build script and required no additional parameters)**
  - **The build must be hermetic.**
    - **Build script: All dependencies must be declared using immutable references**
    - **Build service: All artifacts must come from a trusted control plane and the integrity of each artifact needs to be verified.**
  - **The build should be reproducible**

SLSA Provenance Requirements

- In Level 1
  - Must be made available to consumers in a format the customer agrees to
- In Level 2
  - The authenticity and integrity must be verifiable by the consumer
  - The data must come from the build service
- In Level 3
  - Must be non-falsifiable. The signing key needs to be stored in a secure manner that can only be accessed by the build system. It must be generated in a trusted control plane.
- In Level 4
  - Must contain information about all dependencies that were available while the build was running including the initial state of the build machine

SLSA Provenance Content Requirements

- In Level 1
  - Cryptographically identifies the output artifact using a modern hashing algorithm (e.g. SHA-256)
  - Identifies who performed the build and created the provenance
  - Identities the high-level build instructions
- In Level 2
  - Identifies the origins of the source code (not the dependencies)
- In Level 3
  - Identifies the entry point of the build definition
  - Identifies all build parameters that can be controlled by a user
  - Example provenance: https://github.com/slsa-framework/slsa-github-generator-go?ref=golangexample.com
- In Level 4
  - All transitive dependencies must be included
  - Indicate if the build is or is not reproducible

SLSA Common Requirements

- In Level 4
  - Security: All systems included in the supply chain must be routinely patched, undergo vulnerability scanning, secure boot enabled, appropriate transport security, etc
  - Access: Any physical or remote access should be rare, logged, and require multi-party approval
  - Superusers: There should be small number of admins. Any modification which would override a guarantee requires two-admin approval

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Thank You

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