Dependable software engineering
Can we increase trust in our components?

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IFIP Working Group 10.4
Dependable Computing and Fault Tolerance

87th meeting – Praia do Forte, Bahia, Brazil – 6-10 Feb 2025

How much we can trust in current software distributions?

- Let’s say we want to deploy a web server
  - Example: nginx, latest version: 1.27
- Easy today
  - `apt install nginx`
  - `docker run nginx`
  - `kubectl apply` *`(your manifest here)`*
- **Is it safe?**
- Existing tools:
  - GitHub Dependabot, OWASP dependency check
  - npm/pi/cargo audit, Snyk, Trivy
  - SCAs Black Duck, JFrog Xray, Sonatype Nexus

What is the fundamental problem?

- Software can be hacked (old story)

- All software is the result of compositions
  - Including numerous dependencies (and sub-dependencies)
  - Composition is done at different levels (compilation, packaging, etc)

- **It is hard to figure out what we are actually executing**
  - It is hard to ensure trust in software supply chains (traceability)
  - Can any of my components be hacked?
- The composition (supply) chains can be hacked
  1. Malicious additions to genuine source code
  2. Abuses in the distribution (malicious replacements, homonyms, etc)

Remember
- SolarWinds
- Log4j?

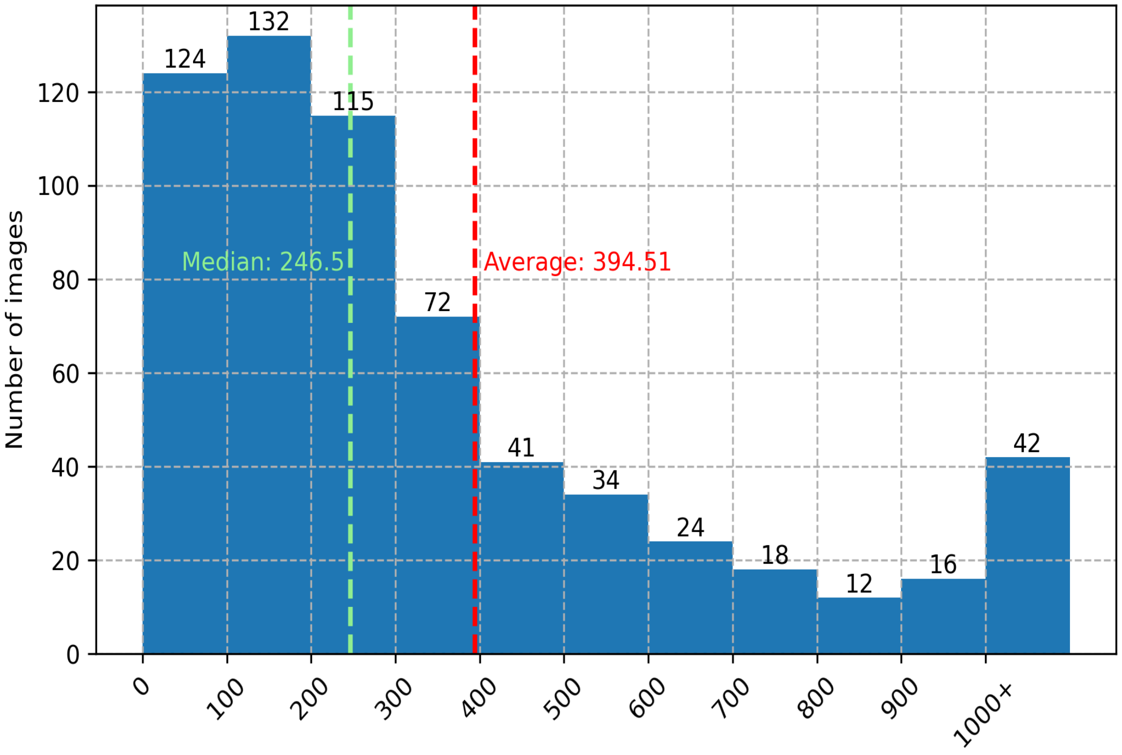
How bad is this problem?

How much we can trust in existing software dependencies?

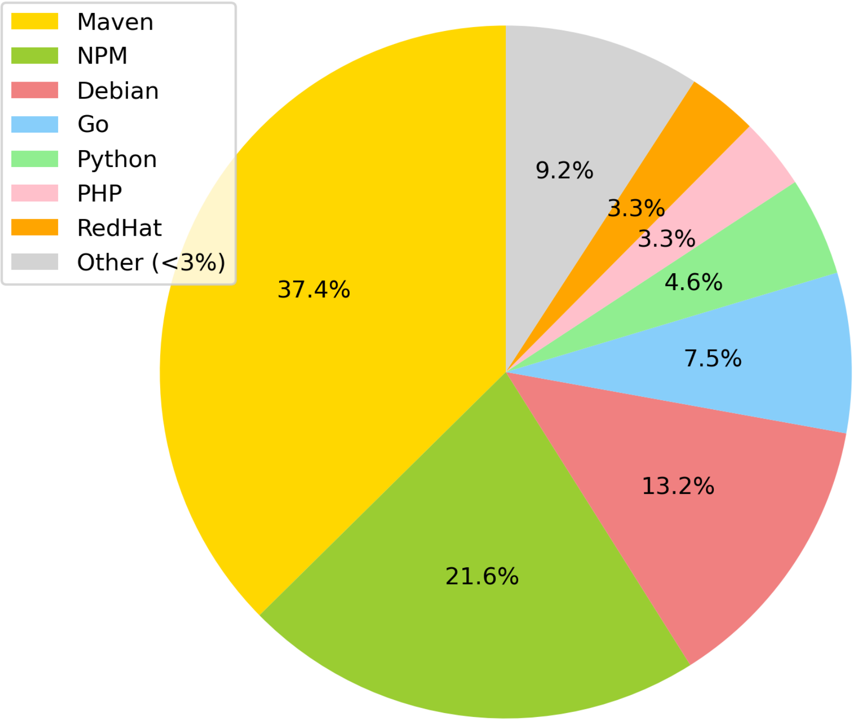
- Analysed Docker Hub's 1000 Top Repositories
- Safe to assume they are widely deployed, maybe even in critical systems

- Used information from images' BOMs
  - 63% of images contained a BOM

Docker Hub dependencies

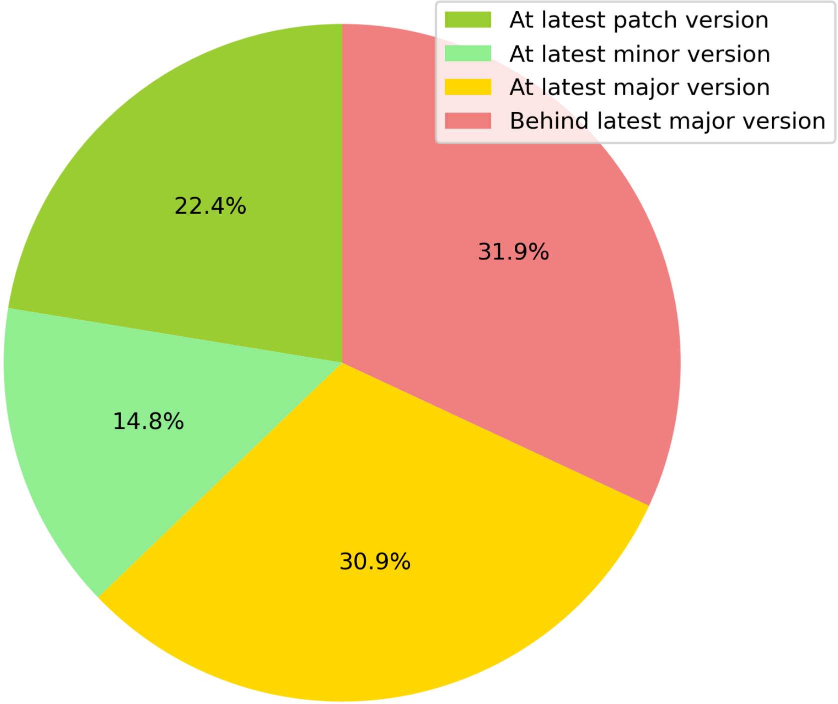


Number of dependencies

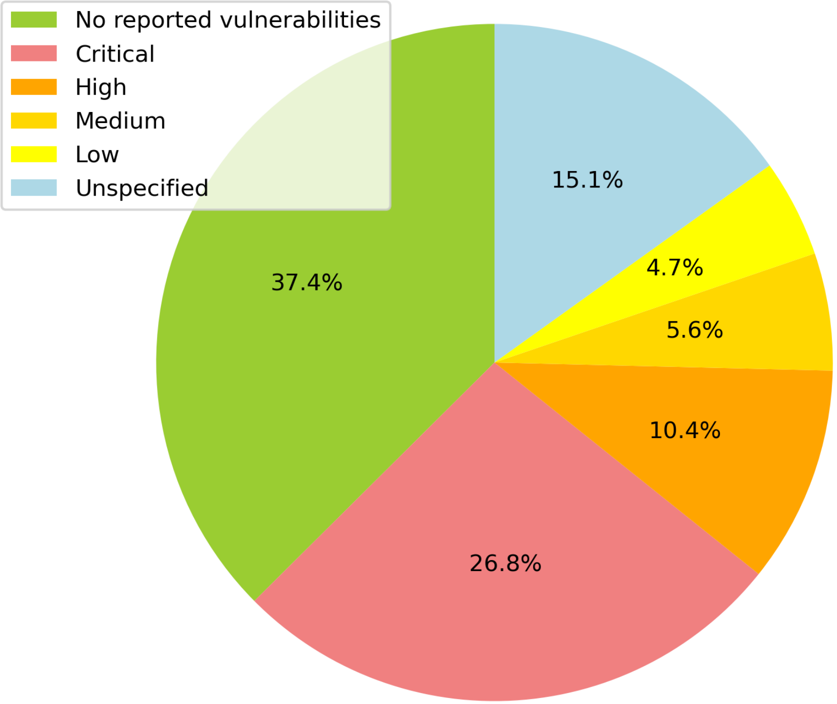


Dependencies sources

Docker Hub dependencies



Dependencies versions’ upkeep



Known CVE vulnerabilities

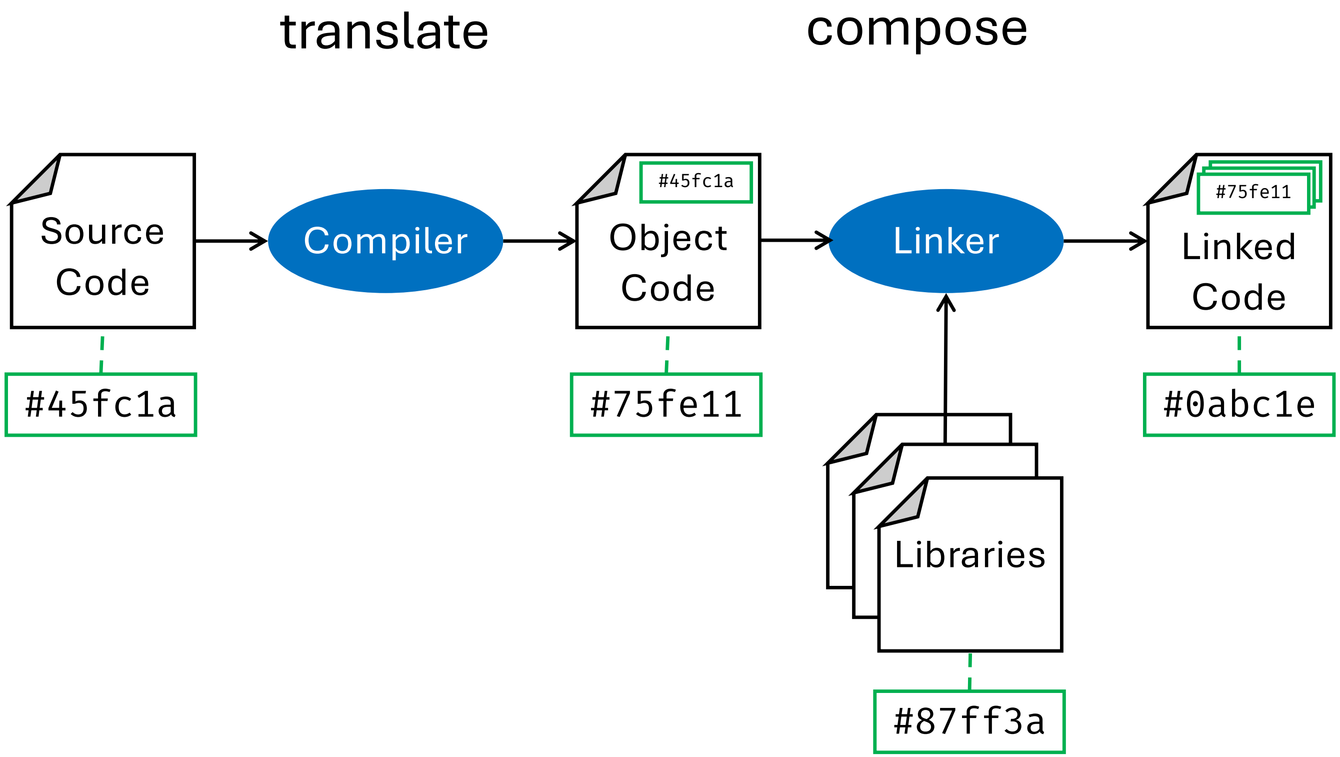
How can we add trust?

Full traceability can help solving the problem

- Consider software composition as a tree
  - Executable is the root, sources are leaves
  - Composition points are edges
  - Intermediary files are nodes in the tree

- Simple steps
  - Annotate all nodes in the tree
  - Certify source code at all leaves
  - Add traceability throughout the tree
    - Annotate node with children's hashes (its sources)
  - Attest the executable code (the root) before executing

Basic traceable software supply chain



Certification

- Expert code review
  - Actual visual code review
  - Formal analysis
  - Pen tests
  - IA can help in all steps, some can be automated
- Not flawless, but many decent techniques exist

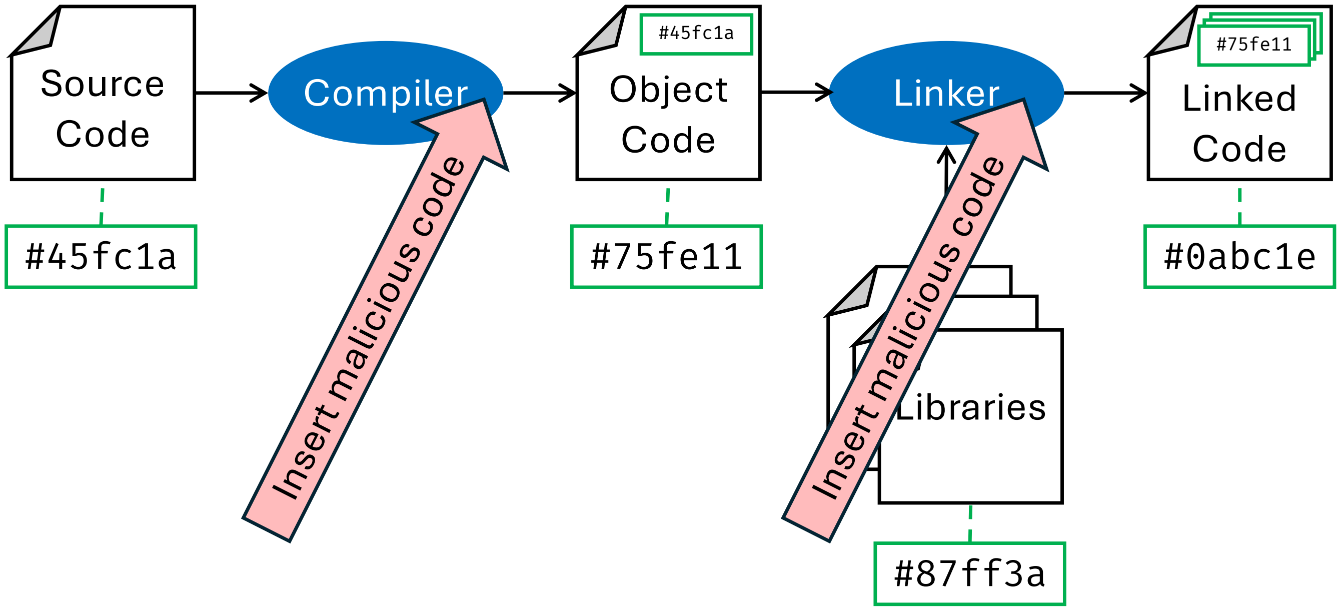
- If pass, a certificate is issued and signed
  - All source files must carry a certificate

Is the "flawless fault detector" a thing?

Traceability

- Start with certified/signed sources
- Hashes are combined at every composition (ex. linking)
  - E.g. Merkle trees
- Annotations must be implemented at all stages
  - Compilation, linking, composition, layering, etc.
- There are not many popular standards
  - How to annotate
  - How to represent the trace tree
  - Current BOMs / manifests could be extended with annotations

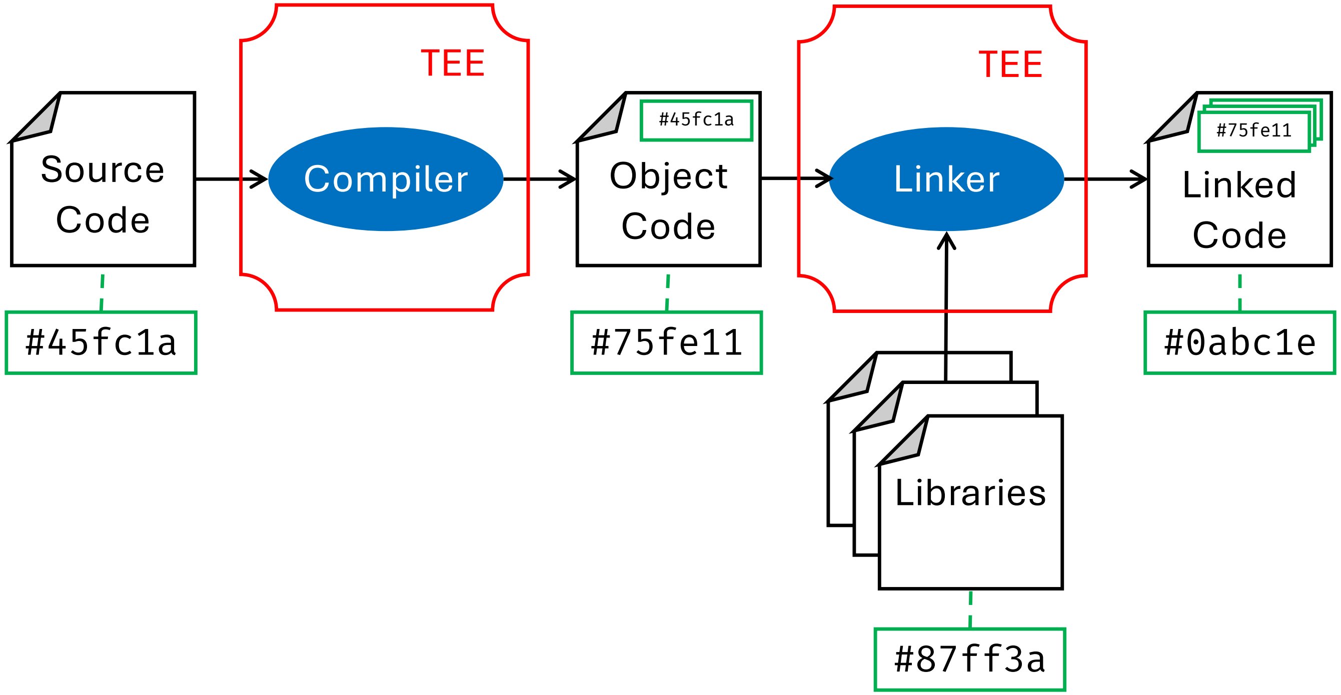
Attacks to the supply chain



Trusted computing

- Need to trust all tools used in the path from source to binary
  - Make sure only genuine tools are running
- Implemented with trusted execution environment (TEE)
  - Intel SGX & TDX, AMD SEV, Arm TrustZone & CCA, RISC-V CoVE
- Changes to running software can be detected
  - Trusted hardware provide remote attestation
- Annotations can be signed inside TEE, increasing trust in the chain

Trusted traceable software supply chain



Prototype implementation

- Development chain for Rust into WebAssembly
  - Implemented in cooperation with SCS https://www.scs.ch/
  - Relies on previous work with UNINE

- Wasmsign
  - Embed metadata in WebAssembly binaries
- Wasmshield
  - Integrated with Rust DK
    - Custom workflows to produce, bundle, and verify proofs
      - Component integrity
      - SBOM vulnerability assessment

Wrap-up

- Fully trusted traceability is rather easy to implement
- Need modifications in the tools for code transformation
- Great help from trusted execution environments

Thank you for your time !

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