Towards Reliable Dependency Management

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What's the problem with dependency management?

Developers rely on dependency managers to resolve dependency sets but they are not guaranteed to be **up-to-date**, **compatible**, nor **secure**.

- Keeping dependencies **up-to-date** is crucial to receive bug fixes and security patches
- Open version ranges automate updates but risk **breaking changes** [1]
- Low Semantic Versioning compliance encourages update aversion among developers [2-3]
- Pinned versions risk version conflicts, and propagate stale and **vulnerable** dependencies [4]

Dependency managers *cannot* ***reason*** *about all these properties so ensuring them is often a labor-intensive task left to the developer…* ***But what if they could?***

A new approach to dependency management

How can we provide and maintain dependencies that are ***up-to-date***, ***compatible***, *and* ***secure****?*

- A **dependency metadata store** to better inform constraints for the resolution process
  - Enable reasoning over compatibility, vulnerabilities, network resources, performance requirements, …
- A **constraint-based resolver** that can extract useful constraints and optimize the resolution result

Proof-of-concept: Compatible Version Ranges in Maven with MaRCo

Paper under submission: Reliable Dependency Resolution Using Client-Agnostic Compatibility Detection

~73% of projects at risk of future dependency-related issues

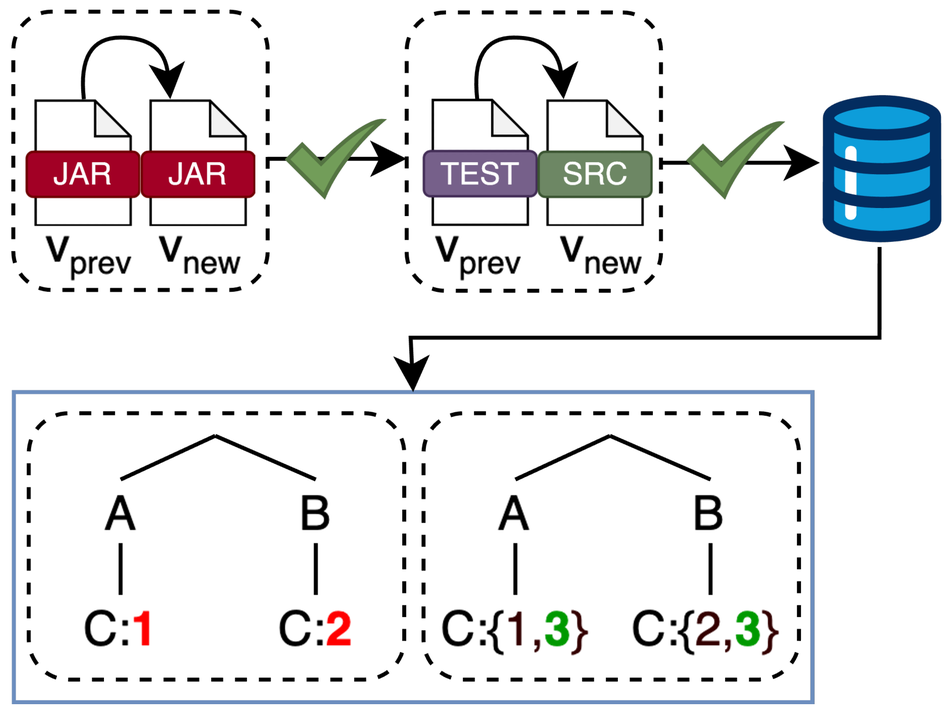
- 73% use transitive dependencies directly
- 66% have conflicting pinned versions
  - 67% resolve conflicts manually

We built MaRCo to mitigate these issues

- Injects missing direct dependencies in 91% of projects
- Replaces pinned versions with compatible ranges in 79% of projects
  - Replaces 13% of dependencies on average

Client-agnostic compatibility allows reuse across clients

- Stable but strict ranges (0.99 breaking vs 0.75 non-breaking recall)
- Limitation: Inability to find runnable test suites for many libraries



MaRCo *serves as a* ***proof-of-concept*** *showcasing how we can* ***extract better constraints*** *from pre-computed data to* ***ensure compatible dependency resolution*** *in a* ***scalable*** *way.*

Future work

- **Fine-grained** compatibility data via **test generation**
- **Filtering** of constraints on **client usage**
- Feasibility of **constraint-based resolver** with **different constraint types**

References

- [1] Dietrich et al. "Dependency versioning in the wild." *MSR, 2019.*
- [2] Raemaekers et al. "Semantic versioning and impact of breaking changes in the Maven repository," Journal of Systems and Software, 2017.
- [3] Pashchenko et al. "A qualitative study of dependency management and its security implications," CCS, 2020.
- [4] Zhang et al. "Mitigating persistence of open-source vulnerabilities in Maven ecosystem," ASE, 2023.