Attributing Open-Source Contributions is Critical but Difficult: A Systematic Analysis of GitHub Practices and Their Impact on Software Supply Chain Security

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[§]North Carolina State University, USA

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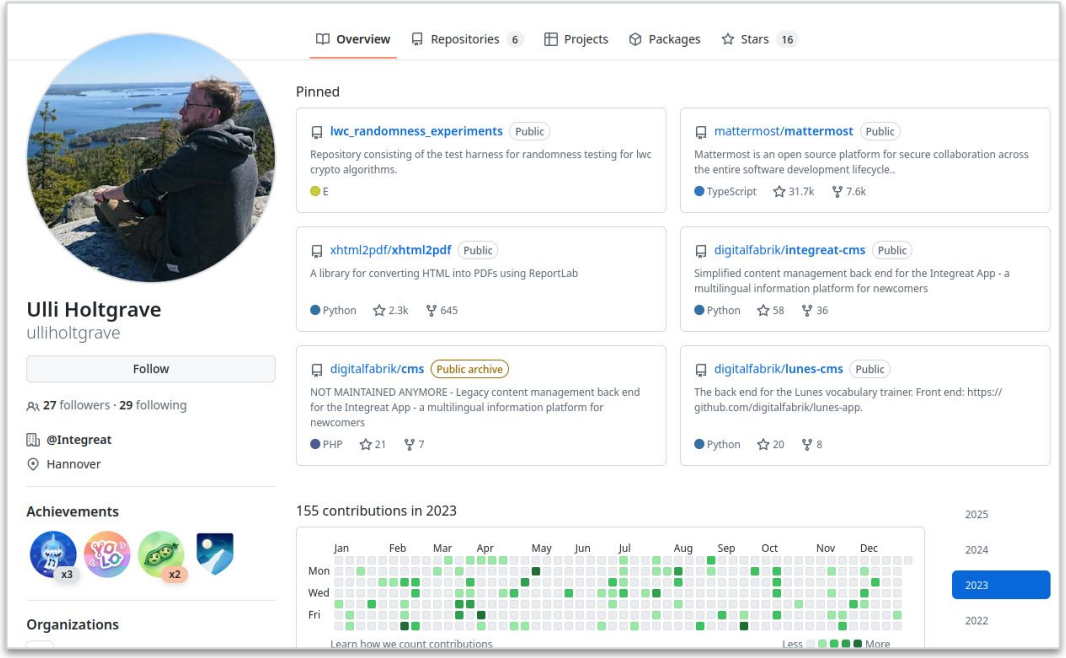
GitHub: A pillar of the OSS Supply Chain

- Most popular git hosting platform
- "Social Network" for open-source developers
- Lets you…
  - Host own software projects
  - Interact with other open-source projects via PRs or Issues
  - Follow the activities of other contributors
  - Investigate projects activities and contribution histories



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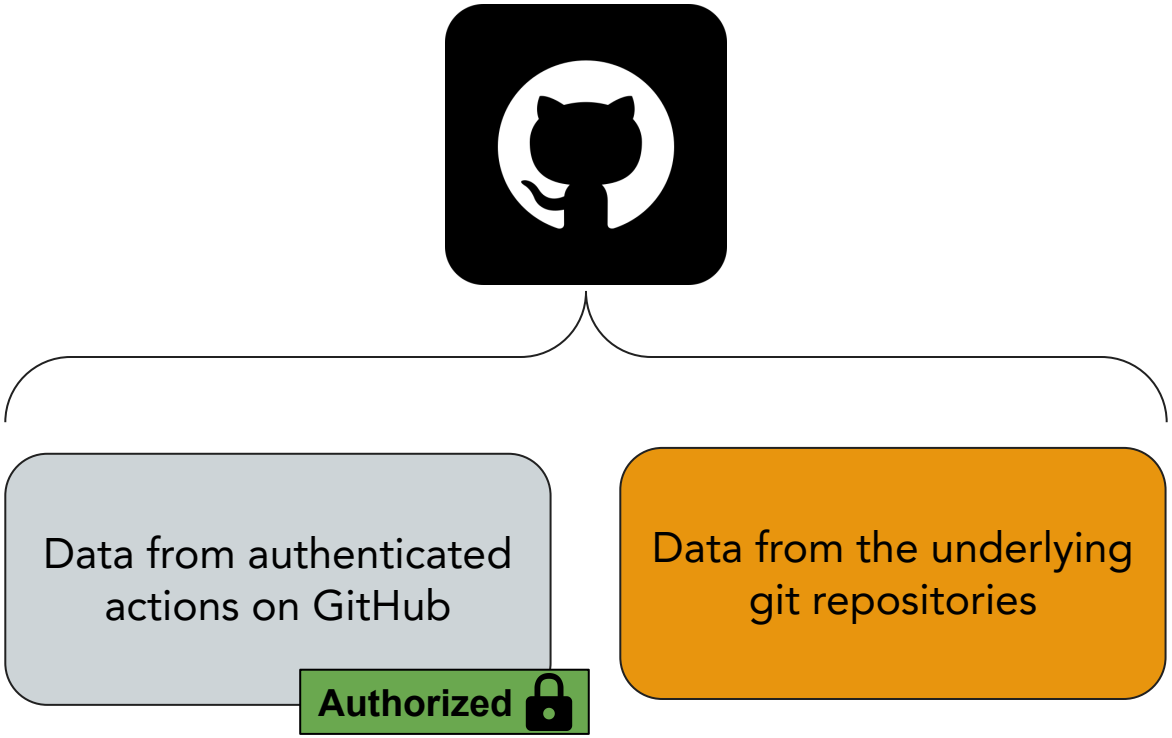
Problem: GitHub displays unverified data



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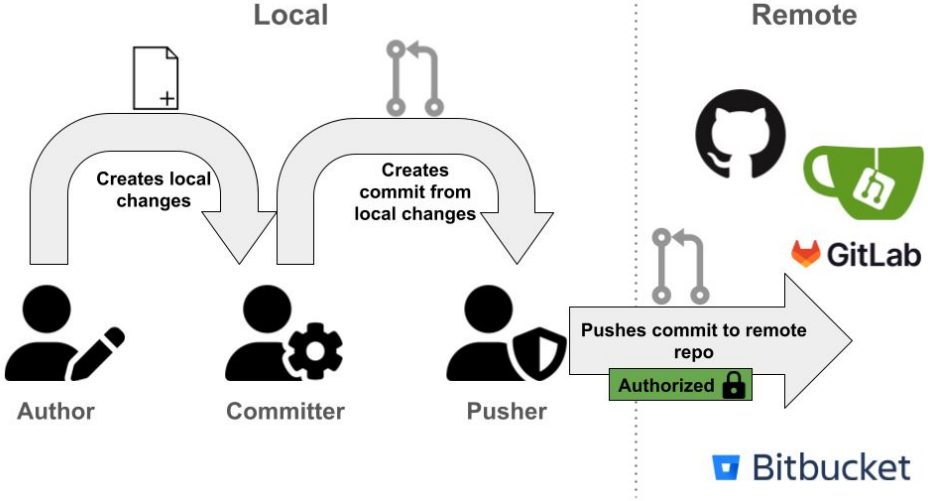
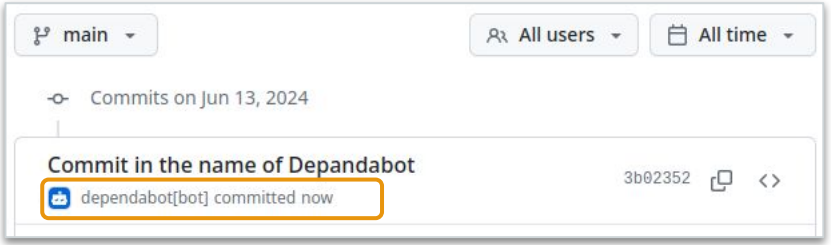
The git workflow




```
[user]
        email = dependabot[bot]@users.noreply.github.com
        name = dependatbot[bot]
```

```
tree fdd32538015c00a5eb392b9e11bf03516289887d
parent 01e9e8d1bf599b6296669053ecbfba014fcc7440
author dependabot[bot] <dependabot[bot]@users.noreply.github.com> 1718359303 +0200
committer dependabot[bot] <dependabot[bot]@users.noreply.github.com> 1718359303 +0200

Another commit in the name of Depandabot
```



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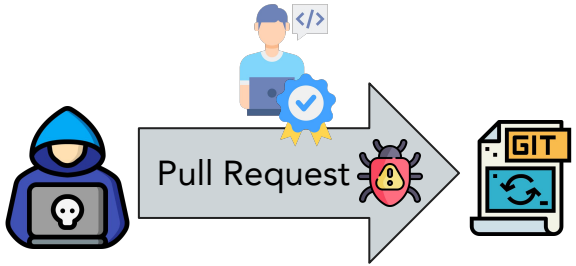

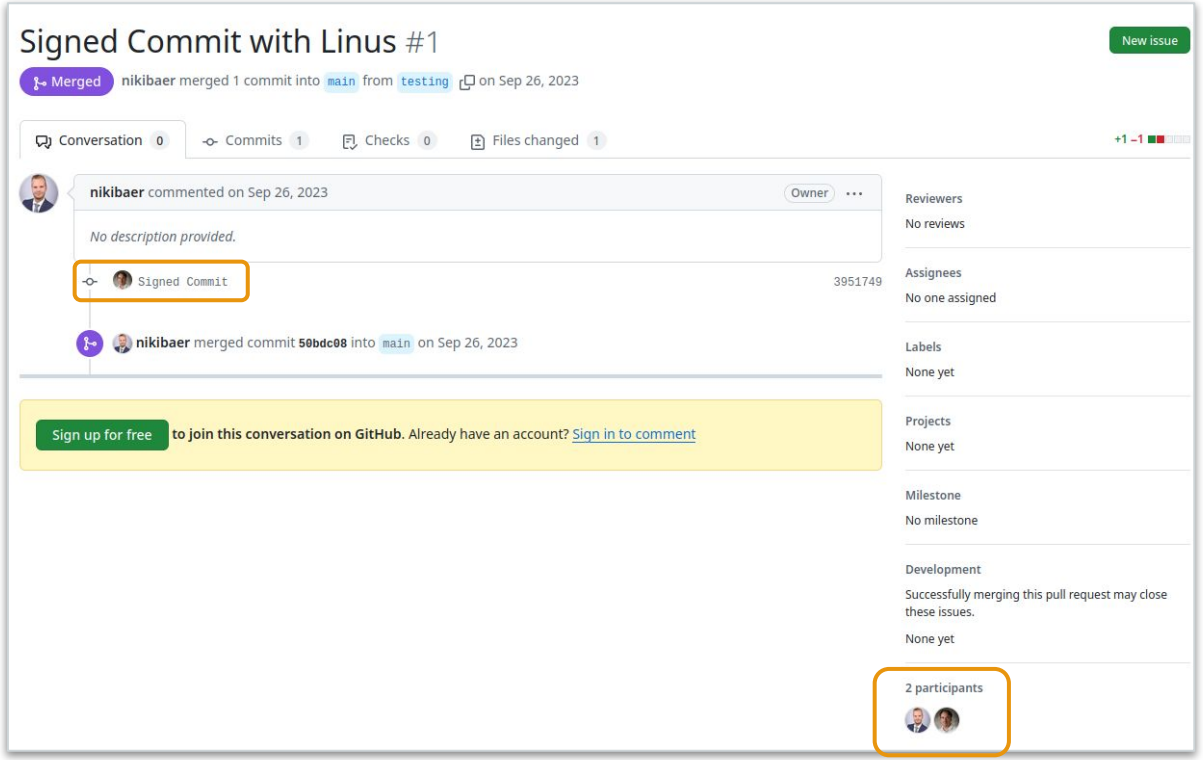

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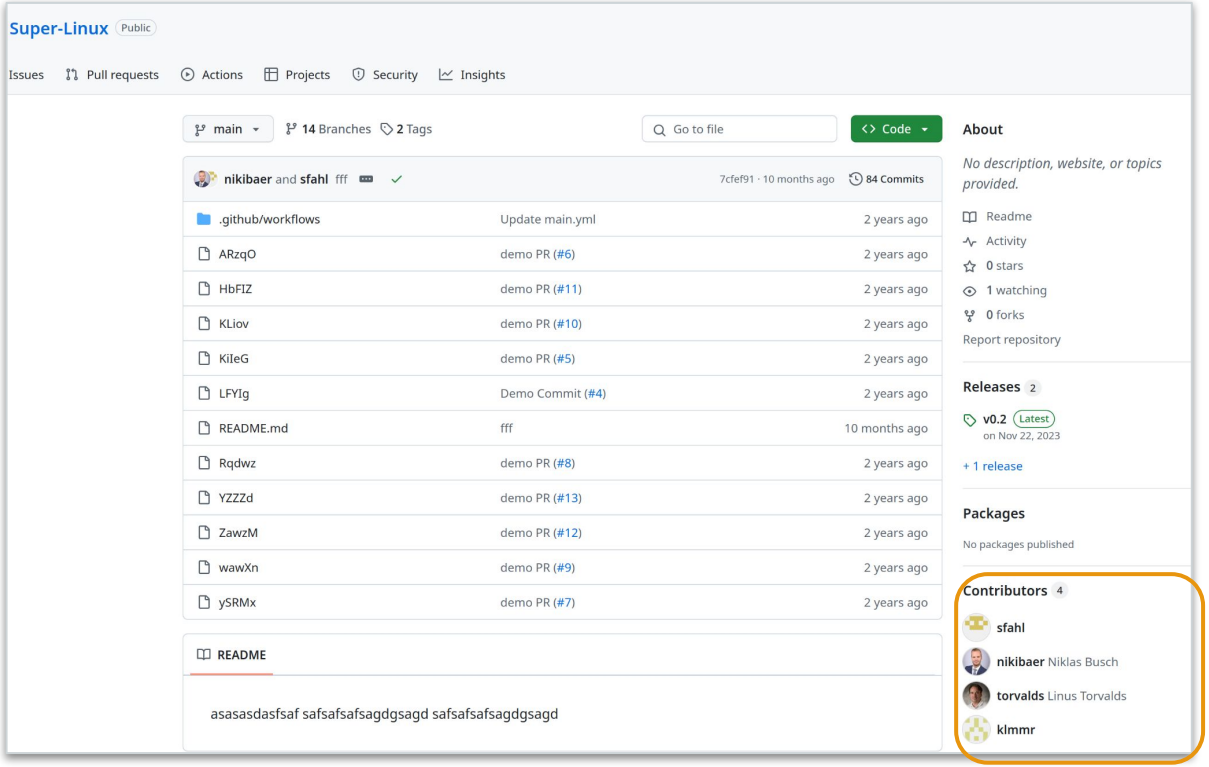
Goal: Increase reputation of a project, e.g., for repository confusion attacks.



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Attackers can hijack unlinked commits

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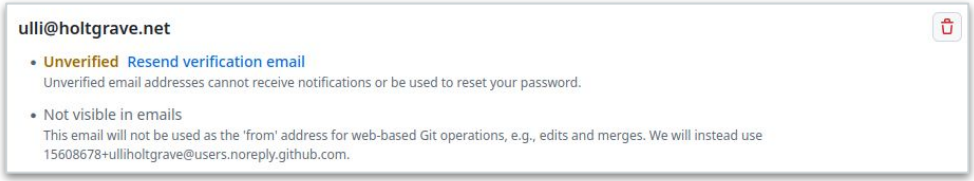
Claim unassigned commits in large OSS projects by adding the email to your account. Use Domain Hijacking for full attribution. Goal: Create fake legend, e.g., for infiltrating other OSS projects (see XZ-utils).



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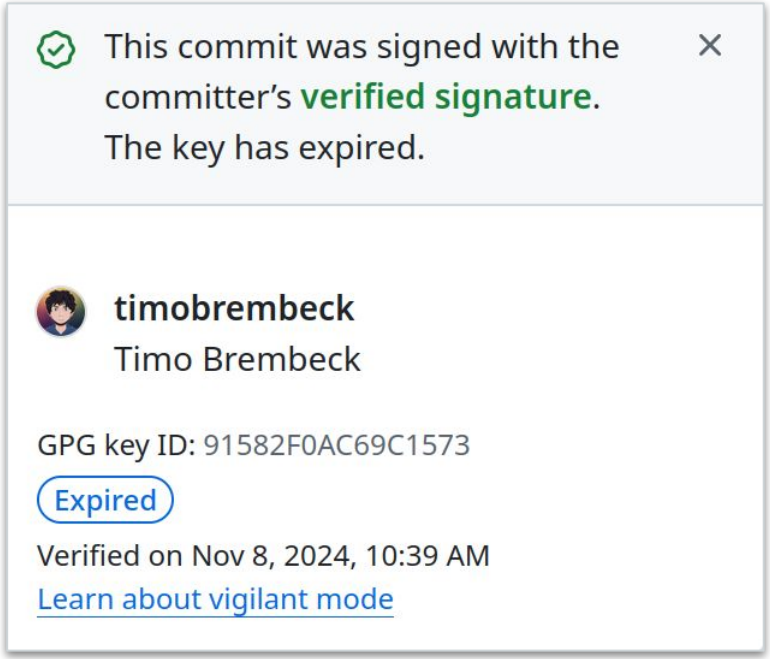
Signing commits adds cryptographic proof

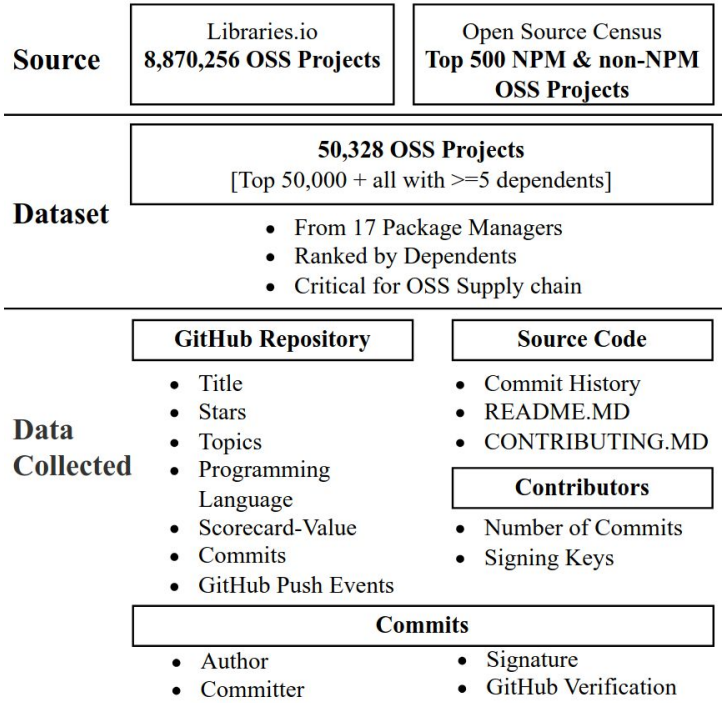
- Git offers committer signatures for commits and adds a layer of authenticity to commit objects
- GitHub supports PGP, SSH, and S/MIME and awards it with a “verified” badge



Measuring the attack surface for OSS

Methodology

- Top 50,328 open-source packages by dependent count hosted on GitHub
- 26,170,564 commits
- We investigated:
  - Disparity of git roles within a commit
  - Prevalence of claimable commits
  - Prevalence of commit signing on GitHub and signature validation status



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Scenarios are feasible and difficult to detect

Contributor Spoofing & Reputation Hijacking

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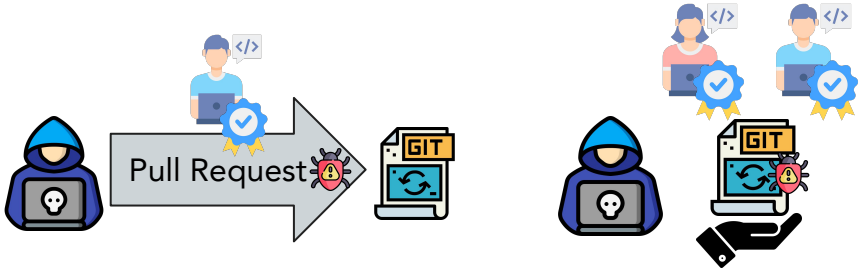
- 2,368 repositories contain no commit with parity (e.g., mirrors)



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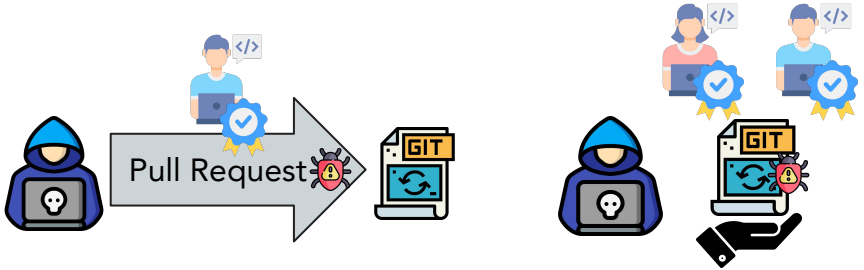

Contribution Hijacking

- 3,013,817 unlinked commits
- 573,043 contained valid email addresses
- We found 4,107 available domains that can be taken over via *Domain Hijacking*

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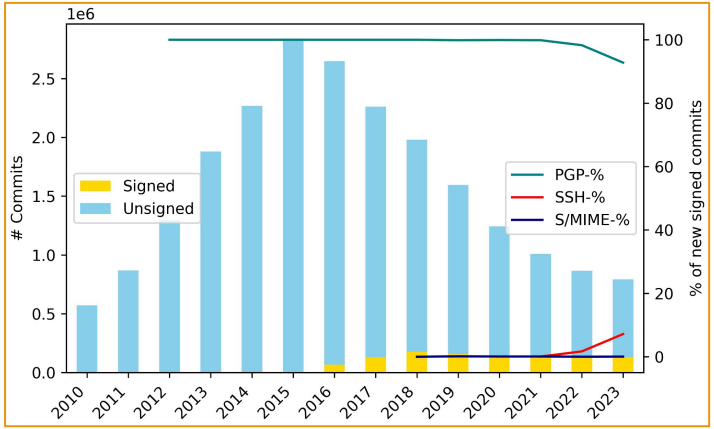
Only 5% of commits are signed

- Recent trend towards more SSH signing



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Valid	890,171	82%	10,660	90%	2	0%	2,960,651	100%
Unknown key	104,760	10%	810	7%	–	–	1	0%
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Bad email	19,918	2%	–	–	0	0%	0	0%
Unverified email	19,690	2%	273	2%	0	0%	0	0%
Invalid	212	0%	2	0%	1	0%	941	0%
GPG error	384	0%	–	–	–	–	111	0%
Bad certificate†	–	–	–	–	363	67%	–	–
No signing key	162	0%	–	–	–	–	0	0%
OCSP revoked*	–	–	–	–	15	3%	–	–

We also found 5 instances of unknown signature types we could not process.
* Entry in the certificate chain was revoked. † Certificate could not be verified.

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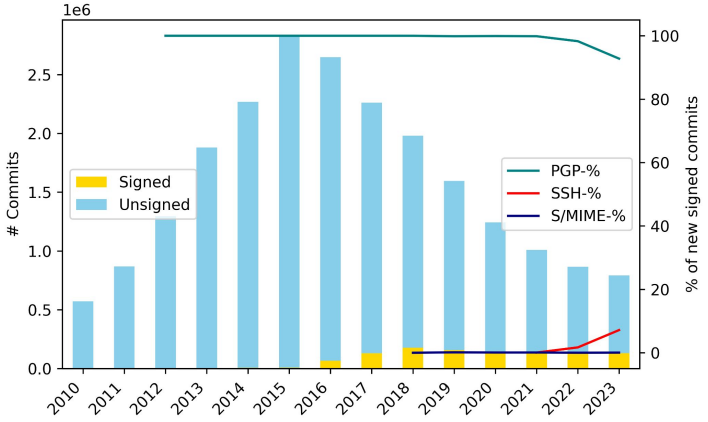

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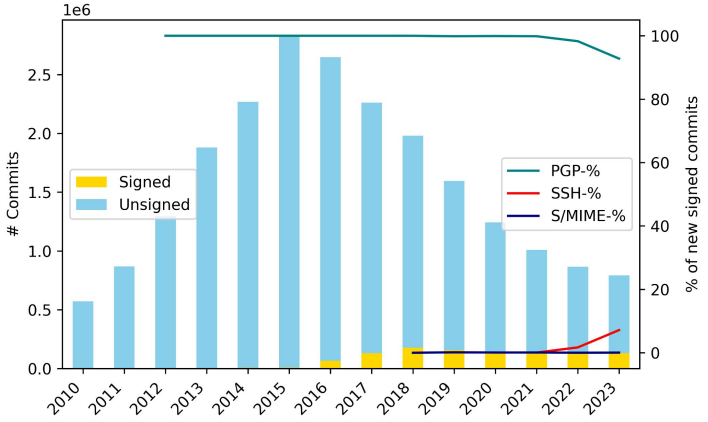

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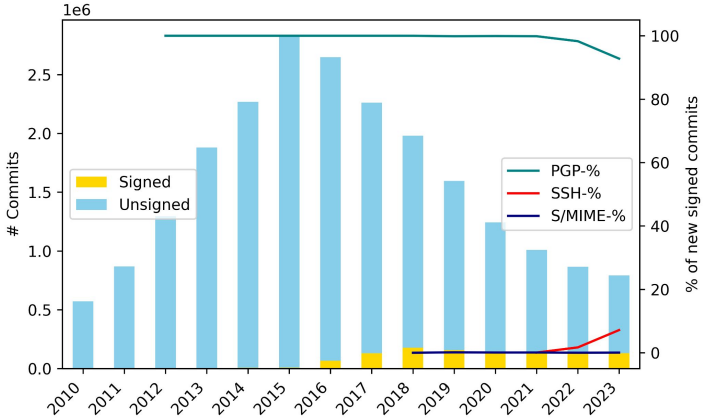

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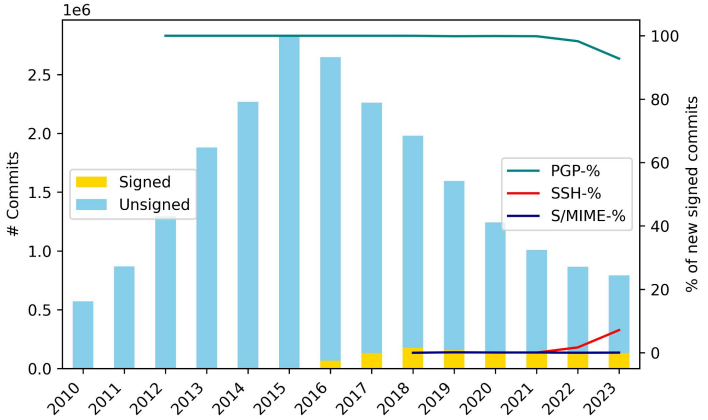

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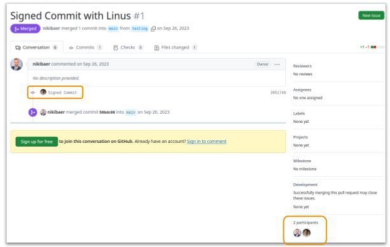

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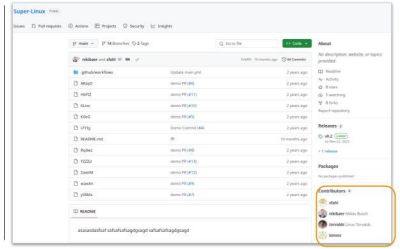

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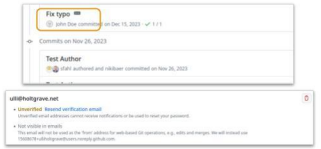

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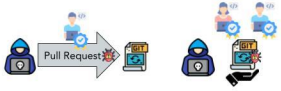

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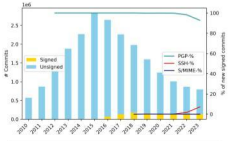

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