Towards Better Understanding of Software Quality Evolution Through Commit-Impact Analysis

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Commit-Impact Analysis

Software Repository (e.g., Git and SVN)
  - Evolution History

Commit
  - Fine-grained incremental changes
  - Contains Information:
    - Code changes
      - Author, message, time, etc.
  - Each commit → a new revision

Impact
  - Difference between revisions before and after a commit
Not all changes are interesting!
- Docs Change \( \Rightarrow \) Performance Change

Main module
- The module under analysis
- Usually contains most of the codes
  - core, src/main, framework
- Excl. tests, docs, plugins, etc.

Impactful commit
- Changes source files in the main module
- Introduces a new revision of the main module
Two steps
- Extracting a **model** from each revision
- Defining **distance metrics** to compare those models

Models → Programming Analysis Techniques
- **Static**
  - PMD, FindBugs, SonarQube → absolute values (numbers/vectors)
  - Architecture recovery techniques (ARC, ACDC, etc.) → graphs/sets
- **Dynamic**
  - Rendering HTML files

Distance Metrics
- Subtracting two numbers/vectors
- Comparing two graphs/sets
Example: Absolute Values
Example: Commit-Impact
Research Questions:

- To what extent do developers commit impactful changes?
- To what extent and how do impactful commits break the compilability of the project?
- To what extent do impactful commits affect software quality attributes?
- Should developers rely on a single software quality metric as a change indicator?
Data Collection

ATLAS

- Large Scale Evolutionary Analysis on Software Systems

System selection process:

- Fetched all apache projects’ metadata using GitHub api
  - Name, #commits, repo url, PL, and latest update
- Only Java Projects
- At least one update in 2017
- Less than 3K commits
- The main module exists (manual check)
- No nontrivial prerequisite for compilation (manual check)
- At least 100 compilable impactful revisions

19580 fully analyzed impactful revisions of 38 systems
The centrality of the main module
- 48% of commits are impactful
- 69% of developers commit impactful changes

What may significantly impact the ratios of impactful commits and impactful developers?
- Architecture of the system
- The level of its integration with other systems
- Distribution of tasks during the development
98% of commits are compilable.

Interesting Observations:

- Relying on snapshot versions of dependencies may cause compilation error.
- Compiling the project in a new environment from scratch may reveal missing dependencies.
- After a file is added, compiling the project in a new environment may reveal compilation error.
- When contributing to the system alone, do compile the system in a new environment once in a while.
- Committing too early may result in an error commit.
- Committing too often may introduce error commits.
- Large refactoring may introduce error commits.
- Maintenance and code cleanups may introduce error commits.
To What Extent do Impactful Commits Affect Software Quality Attributes?

Difference between library systems and others
- Heavily documented (JavaDocs) → Lower LC
- More stable API → Lower FN/LC
- More stable architecture → Lower CS/FN

Importance of running tests
- Complexity (CX) change: 53%

Consider maintenance
- Code smell (SM) change: 46%

Importance of running integrated tools
- 64% of subject systems contain PMD plugin
  - Still 60% of impactful commits change PD
  - Only 0.2% commit messages mention using PMD

Importance of using multiple techniques to find potential security holes

| TABLE 4. The percentage of impactful commits that change a quality metric to all impactful commits |
|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
|                | Basic | Code Quality | Security      |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |         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Should Developers Rely on a Single Software Quality Metric as a Change Indicator?

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<th>Security</th>
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Tool Demonstration

(Web Application Prototype)

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**JIRA**

- **Project:** CSSE ATLAS
- **Version:** 0.1

**Git**

- **Repository:** CSSE ATLAS
- **Branch:** master
- **Commit:** 00b43a21e75db34d530265d6d675030b

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Backup Slides
Motivation

- The main question
  - How does software evolve?

- Version Level Analysis
  - Versions → the major milestones
    - Too coarse grained
    - The impact of each developer is omitted
    - The size of the system drastically increases ⇒ Other attributes increase