Toward Better Understanding and Documentation of Rationale for Code Changes

Khadijah Al Safwan
Dissertation Defense

PhD Committee
Francisco Servant (Chair)
Eli Tilevich, Na Meng, Muhammad Gulzar, and Thomas D Latoza
Toward Better Understanding and Documentation of Rationale for Code Changes

- Software development is driven by decisions

- Information-needs studies establish a strong demand for rationale behind decisions (in general)
  - (2010) Fritz and Murphy
  - (2012) Roehm et al.
  - (2018) Ram et al.
  - (2010) LaToza and Myers
  - (2014) Maalej et al.
Toward Better Understanding and Documentation of Rationale for Code Changes

- Rationale is the most **common** and **important** information need to understand from code-change history

  (2012) Tao et al.
What is the rationale behind these code changes?
Toward Better Understanding and Documentation of Rationale for Code Changes

- Why where [these changes] introduced? (2010) Fritz & Murphy
- Why the code is this way? (2015) Codoban et al.
- What is the purpose of this code? (2007) Ko et al.
- Why was this code implemented this way? (2010) LaToza and Myers
Toward Better Understanding and Documentation of Rationale for Code Changes

(Problem) What do software developers mean by rationale for code changes?

• It can be quite difficult to find an answer for rationale behind code changes

**Toward** Better Understanding and Documentation of Rationale for Code Changes

(Problem) What do software developers mean by rationale for code changes?

(Problem) How difficult is it for software developers to find rationale of code changes?
Toward Better Understanding and Documentation of Rationale for Code Changes

(Problem) What do software developers mean by rationale for code changes?

(Problem) How difficult is it for software developers to find rationale of code changes?

(Problem) How to help software developers document rationale of code changes?
Toward Better Understanding and Documentation of Rationale for Code Changes

**(Thesis)** The rationale of code changes

- **(H1)** can be needed in many software development tasks and involve many components
- **(H2)** can often be hard to find
- **(H3)** An automatic classification could be utilized to assist developers in documenting rationale
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(H2) can often be hard to find

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I) Understanding software developers’ need for rationale of code changes

(Study II) Surveying developers’ experiences with rationale

(Experiment) Predicting the documentation of rationale components in PR templates
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(H2) can often be hard to find

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I)

(Study II)

(Experiment)

(Contribution) A common understanding of developers need
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

- (H1) can be needed in many software development tasks and involve many components
- (H2) can often be hard to find
- (H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I) (Contribution) A common understanding of developers need

(Study II) (Contribution) An awareness of developers' efforts and issues

(Experiment)
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(H2) can often be hard to find

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I) (Contribution) A common understanding of developers' need

(Study II) (Contribution) An awareness of developers' efforts and issues

(Experiment) (Contribution) An ML approach to assist rationale documentation
Toward Better Understanding and Documentation of Rationale for Code Changes

(Research Studies)
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(Study I)

Understanding software developers’ need for rationale of code changes

H2) can often be hard to find

(Study II)

Surveying developers’ experiences with rationale

H3) An automatic classification could be utilized to assist developers in documenting rationale

(Experiment)

Predicting the documentation of rationale components in PR templates
Understanding Developers’ Need for Rationale of Code Changes

Publications: FSE 2019 & JSS 2022
Understanding Developers’ Need for Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results

What is the rationale behind these code changes?

Why where [these changes] introduced? (2010) Fritz & Murphy

Why the code is this way? (2015) Codoban et al.

Why was this code implemented this way? (2010) LaToza and Myers

What is the purpose of this code? (2007) Ko et al.
Understanding Developers’ Need for Rationale of Code Changes

• Motivation
• **Research Questions**
• Approach
• Summary of Results

• What are the *tasks* for which rationale for code commits are needed?
• What are the *components* of rationale for code commits?
Understanding Developers’ Need for Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results

One-to-One Interview

Recruitment

Public Channels
Referrals
Screening Questions
Understanding Developers’ Need for Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results
Understanding Developers’ Need for Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

One-to-One Interview

Public Channels
Referrals
Screening Questions

Design
- Pilot Interviews
- Situations of Rationale Need
- Decomposition of Rationale
- Initial decomposition
- Proposed decomposition

Analysis
- Manual Coding
- Card Sorting
Understanding Developers’ Need for Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results
Understanding Developers’ Need for Rationale of Code Changes

What are the tasks for which rationale for code commits are needed?

<table>
<thead>
<tr>
<th>Task</th>
<th>Subtask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming</td>
<td>Reading, Writing, Proofreading, Code Review</td>
</tr>
<tr>
<td>Working on Bugs</td>
<td>Reproduction, Reporting, Triage, Debugging, Analysis</td>
</tr>
<tr>
<td>Communication</td>
<td>Learning, Coordination, Mentoring</td>
</tr>
<tr>
<td>Tools</td>
<td>Discovering, Installing, Using, Building</td>
</tr>
<tr>
<td>Documentation</td>
<td>Search, Writing, Reading</td>
</tr>
<tr>
<td>Project Management</td>
<td>Check out, Revert, Deploy</td>
</tr>
<tr>
<td>Testing</td>
<td>Writing, Running</td>
</tr>
<tr>
<td>Specifications</td>
<td>Writing</td>
</tr>
</tbody>
</table>
Understanding Developers’ Need for Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

What are the components of rationale for code commits?

<table>
<thead>
<tr>
<th>Theme</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change Objective</td>
<td>Goal</td>
</tr>
<tr>
<td></td>
<td>Need</td>
</tr>
<tr>
<td></td>
<td>Benefits</td>
</tr>
<tr>
<td>Change Design</td>
<td>Constraints</td>
</tr>
<tr>
<td>(pre-implementation assessment)</td>
<td>Alternatives</td>
</tr>
<tr>
<td></td>
<td>Selected Alternatives</td>
</tr>
<tr>
<td></td>
<td>Dependency</td>
</tr>
<tr>
<td>Change Execution</td>
<td>Committer</td>
</tr>
<tr>
<td></td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td>Location</td>
</tr>
<tr>
<td></td>
<td>Modifications</td>
</tr>
<tr>
<td></td>
<td>Explanation of Modifications</td>
</tr>
<tr>
<td>Change Evaluation</td>
<td>Validation</td>
</tr>
<tr>
<td>(post-implementation assessment)</td>
<td>Maturity Stage</td>
</tr>
<tr>
<td></td>
<td>Side Effects</td>
</tr>
</tbody>
</table>
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(H2) can often be hard to find

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I) (Study II) (Experiment)

(Contribution) Developers need rationale during 8 different tasks and decompose it into 15 components

Surveying developers’ experiences with rationale

Predicting the documentation of rationale components in PR templates
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(Study I)

(H2) can often be hard to find

(Study II)

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Experiment)

(Contribution) Developers need rationale during 8 different tasks and decompose it into 15 components

Surveying developers’ experiences with rationale

Predicting the documentation of rationale components in PR templates
Surveying Software Developers’ Experiences with Rationale of Code Changes

Publications: FSE 2019 & JSS 2022
Surveying Software Developers’ Experiences with Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

- What are software developers' experiences with rationale for code commits and its individual components?

- What makes software developers give up their search for rationale of code commits?
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

Online survey

Recruitment
- Public Channels
- Referrals
- Screening Questions
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

Online survey

Recruitment
- Public Channels
- Referrals
- Screening Questions

Design
- Pilot Surveys
- Quantitative Questions
- Factors Leading to Give up

Need
Finding
Recording
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

Online survey

Public Channels
Referrals
Screening Questions

Pilot Surveys
Quantitative Questions
Factors Leading to Give up

Give Up Factors
Experience with Rationale
Manual Coding
Responses Distribution
Scott-Knott Clustering Algorithm
Surveying Software Developers’ Experiences with Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results

What are software developers' experiences with rationale for code commits and its individual components?

Most components are not too frequently needed, but when they are needed they are really hard to find.
Surveying Software Developers’ Experiences with Rationale of Code Changes

- **Motivation**
- **Research Questions**
- **Approach**
- **Summary of Results**

What are software developers' experiences with rationale for code commits and its individual components?

Most needed components are almost always or often recorded.

Frequency of Need

Frequency of Recording

- Almost Always
- Often
- Sometimes
- Rarely
- Almost Never

Frequency of Recording

- Committer
- Location
- Goal
- Modifications

Frequency of Need

- Time
- Need
- Validation
- Side Effects
- Benefits
- Maturity Stage
- Selected Alternative

- Explanation of Modifications
- Dependency
- Alternatives
- Constraints

- A few times per year
- Multiple times per year
- Multiple times per month
- Multiple times per week
- Multiple times per day
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

What are software developers' experiences with rationale for code commits and its individual components?

Participants struggle most to find the side effects, alternatives, and constrains.
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- **Summary of Results**

What makes software developers **give up** their **search** for rationale of code commits?

<table>
<thead>
<tr>
<th>Factor Category</th>
<th>Give Up Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-centric Factors</td>
<td>Codebase state</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
</tr>
<tr>
<td>Human-centric Factors</td>
<td>Effort management</td>
</tr>
<tr>
<td></td>
<td>Developer knowledge</td>
</tr>
<tr>
<td></td>
<td>Interpersonal (Emotions)</td>
</tr>
<tr>
<td>Team-centric Factors</td>
<td>Impact on productivity</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
</tr>
<tr>
<td></td>
<td>Time management</td>
</tr>
</tbody>
</table>

“Usually, there are certain scenarios where I give up finding rationale, if I cannot run the code, or the code base is too big…”
Surveying Software Developers’ Experiences with Rationale of Code Changes

- Motivation
- Research Questions
- Approach
- Summary of Results

What makes software developers give up their search for rationale of code commits?

<table>
<thead>
<tr>
<th>Factor Category</th>
<th>Give Up Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-centric Factors</td>
<td>Codebase state</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
</tr>
<tr>
<td>Human-centric Factors</td>
<td>Effort management</td>
</tr>
<tr>
<td></td>
<td>Developer knowledge</td>
</tr>
<tr>
<td></td>
<td>Interpersonal (Emotions)</td>
</tr>
<tr>
<td>Team-centric Factors</td>
<td>Impact on productivity</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
</tr>
<tr>
<td></td>
<td>Time management</td>
</tr>
</tbody>
</table>

“If it takes half an hour, it is not worth spending more time [on the search]. Then, I will ask others and interrupt their work”
Surveying Software Developers’ Experiences with Rationale of Code Changes

• Motivation
• Research Questions
• Approach
• Summary of Results

What makes software developers give up their search for rationale of code commits?

<table>
<thead>
<tr>
<th>Factor Category</th>
<th>Give Up Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-centric Factors</td>
<td>Codebase state</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
</tr>
<tr>
<td>Human-centric Factors</td>
<td>Effort management</td>
</tr>
<tr>
<td></td>
<td>Developer knowledge</td>
</tr>
<tr>
<td></td>
<td>Interpersonal (Emotions)</td>
</tr>
<tr>
<td>Team-centric Factors</td>
<td>Impact on productivity</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
</tr>
<tr>
<td></td>
<td>Time management</td>
</tr>
</tbody>
</table>

“The decision made by a previous project manager. We do not understand the reason, but we make a new decision from this point.”
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in many software development tasks and involve many components

(H2) can often be hard to find

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Study I) Developers need rationale during 8 different tasks and decompose it into 15 components

(Study II) Eight factors leading developers to giving up the search for rationale

(Contribution) Developers need rationale during 8 different tasks and decompose it into 15 components

(Experiment) Predicting the documentation of rationale components in PR templates
Toward Better Understanding and Documentation of Rationale for Code Changes

(Thesis) The rationale of code changes

(H1) can be needed in **many** software development **tasks** and involve **many components**

(Study I)

(H2) can often be **hard to find**

(Study II)

(H3) An automatic classification could be utilized to assist developers in documenting rationale

(Experiment)

(Contribution) Developers need rationale during **8 different tasks** and decompose it into **15 components**

(Contribution) **Eight factors** leading developers to **giving up the search** for rationale

Predicting the documentation of rationale components in PR templates
Predicting the Documentation of Rationale Components in Pull Request Templates

In preparation for publications
Predicting the Documentation of Rationale Components in Pull Request Templates

- Motivation
- Research Questions
- Approach
- Summary of Results
Predicting the Documentation of Rationale Components in Pull Request Templates

- **Motivation**
- **Research Questions**
- **Approach**
- **Summary of Results**

<table>
<thead>
<tr>
<th>Pull Request Templates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Header</strong></td>
</tr>
<tr>
<td>Explaining project guidelines</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Summary</td>
</tr>
<tr>
<td>Related issues</td>
</tr>
<tr>
<td>Motivation</td>
</tr>
<tr>
<td>Side effect</td>
</tr>
<tr>
<td>Screenshot</td>
</tr>
<tr>
<td>Additional context</td>
</tr>
<tr>
<td>Configuration/Environment</td>
</tr>
<tr>
<td>Expected/Actual behavior</td>
</tr>
<tr>
<td>Log/debugging</td>
</tr>
<tr>
<td>List of main changes</td>
</tr>
<tr>
<td>Testing</td>
</tr>
<tr>
<td>Checklist</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>
Predicting the Documentation of Rationale Components in Pull Request Templates

• Motivation
• **Research Questions**
• Approach
• Summary of Results

• How are different pull request characteristics correlate with filling a pull request template rationale headers?

• To what extent can classification algorithms predict if a pull request’s template rationale headers will be filled?
Predicting the Documentation of Rationale Components in Pull Request Templates

• Motivation
• Research Questions
• Approach
• Summary of Results

<table>
<thead>
<tr>
<th>Pull Request Features</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patch Characteristics</td>
<td>Developer Characteristics</td>
</tr>
<tr>
<td>Template Characteristics</td>
<td>Repository Characteristics</td>
</tr>
</tbody>
</table>
Predicting the Documentation of Rationale Components in Pull Request Templates

- Motivation
- Research Questions
- Approach
- Summary of Results
Predicting the Documentation of Rationale Components in Pull Request Templates

- Motivation
- Research Questions
- Approach
- Summary of Results
Predicting the Documentation of Rationale Components in Pull Request Templates

• Motivation
• Research Questions
• Approach
• Summary of Results
Predicting the Documentation of Rationale Components in Pull Request Templates

• Motivation
• Research Questions
• Approach
• Summary of Results

How are different pull request characteristics correlate with filling a pull request template rationale headers?

<table>
<thead>
<tr>
<th>Pull Request Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patch Characteristics</td>
</tr>
<tr>
<td>Developer Characteristics</td>
</tr>
<tr>
<td>Template Characteristics</td>
</tr>
<tr>
<td>Repository Characteristics</td>
</tr>
</tbody>
</table>
Predicting the Documentation of Rationale Components in Pull Request Templates

• Motivation

• Research Questions

• Approach

• Summary of Results

How are different pull request characteristics correlate with filling a pull request template rationale headers?

<table>
<thead>
<tr>
<th>Pull Request Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patch Characteristics</td>
</tr>
<tr>
<td>Developer Characteristics</td>
</tr>
<tr>
<td>Template Characteristics</td>
</tr>
<tr>
<td>Repository Characteristics</td>
</tr>
</tbody>
</table>
Predicting the Documentation of Rationale Components in Pull Request Templates

- Motivation
- Research Questions
- Approach
- Summary of Results

To what extent can classification algorithms predict if a pull request’s template rationale headers will be filled?

All trained prediction algorithms perform better than the baseline predictions.
Predicting the Documentation of Rationale Components in Pull Request Templates

- Motivation
- Research Questions
- Approach
- Summary of Results

To what extent can classification algorithms predict if a pull request’s template rationale headers will be filled?

Overall, Random Forest predictor provide best performance with 79% precision and 85% recall.
Toward Better Understanding and Documentation of Rationale for Code Changes

- **(H1)** can be needed in many software development tasks and involve many components.
- **(H2)** can often be hard to find.
- **(H3)** An automatic classification could be utilized to assist developers in documenting rationale.

**Contribution**
- Developers need rationale during **8 different tasks** and decompose it into **15 components**.
- Eight factors leading developers to **giving up the search** for rationale.
- Predicting if PRT rationale header will not be filled with 79% precision and 85% recall.

**Study I**
- (H1) can be needed in many software development tasks and involve many components.

**Study II**
- (H2) can often be hard to find.

**Experiment**
- (H3) An automatic classification could be utilized to assist developers in documenting rationale.

Khadijah Al Safwan
Acknowledgments