## Modern code reviews - Preliminary results of a systematic mapping study

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## ABSTRACT

Reviewing source code is a common practice in a modern and collaborative coding environment. In the past few years, the research on modern code reviews has gained interest among practitioners and researchers. The objective of our investigation is to observe the evolution of research related to modern code reviews, identify research gaps and serve as a basis for future research. We use a systematic mapping approach to identify and classify 177 research papers. As preliminary result of our investigation, we present in this paper a classification scheme of the main contributions of modern code review research between 2005 and 2018.

## **CCS CONCEPTS**

• Software and its engineering  $\rightarrow$  Software design techniques;

## **KEYWORDS**

Modern code reviews, Source code review, Contemporary code review

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## **1** INTRODUCTION

Code reviews have evolved from being rigorous and intensive to lightweight and collaborative. Modern code reviews are conducted to examine the changes made to a software system and to evaluate its quality. In an open source or inner source project, people other than the core team can make contributions to a software product. Hence, reviewing the code before it is accepted and merged is crucial; not necessarily to identify faults, but rather to improve solutions, share knowledge and code ownership [2].

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Although modern code review has become a prevalent practice in the software industry, there is no study that aggregates existing associated literature and identifies gaps in the body of knowledge. Therefore, the aim of our investigation is to conduct a mapping study to aggregate existing literature in this area and identifying gaps. In this paper, we present the preliminary results of our investigation. We followed the guidelines by Petersen et al. [57] to conduct a systematic mapping study. The contributions of our mapping study are to provide a classification scheme of modern code review research, evolution of research topics and identify research gaps and potential future research areas.

The structure of the paper is as follows: Related work is described in Section 2. The research design used to conduct systematic mapping study is described in Section 3. The preliminary results are presented in Section 4. Finally, our conclusions and next steps in our investigation are presented in Section 5.

## 2 RELATED WORK

Nargis et. al [19] have published a systematic literature review protocol, designed at identifying challenges and benefits of modern code reviews. Our study has a broader scope, i.e. we intend to map all research on modern code reviews without limitation on outcome. Earlier reviews target traditional code inspections [73] or peer assessment outside the software engineering domain [28]. To the best of our knowledge, no systematic investigation on what we know about modern code reviews has yet been conducted.

## **3 RESEARCH DESIGN**

The guidelines by Petersen et al. [57] include the following steps: (1) definition of review questions; (2) conduct search for primary papers; (3) screening relevant papers; (4) keywording of abstracts; (5) Data extraction and mapping of studies.

#### 3.1 Goal and review questions

**Goal**: The main goal of this review is to provide an overview of the existing research on modern code reviews. The overview consists of the contributions of the different research articles and the research approach used in the papers. The purpose of the review is to map the frequencies of research published in the area of modern code reviews to observe the evolution of the research topic. Based on the goal of the review, we have formulated the following review questions:

R1 What aspects/topics of modern code reviews are investigated?

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EASE '19, April 15–17, 2019, Copenhagen, Denmark Table 1: Search results from each database

Database	Papers
Scopus	866
IEEE Explore	335
ACM Digital Library - Title	99
ACM Digital Library - Abstract	243
Total	1543
Total after removing duplicates	873

R1.1 How have the aspects/topic changed over time?

R1.2 How many articles cover the different aspects of modern code reviews?

R2 How were the aspects in R1 investigated?

Note that the preliminary results presented in this paper only address RQ1.

#### 3.2 Search strategy

We employed the following search strategy:

**Databases included**: After defining the review questions, the next step is to select databases to find the relevant papers. The following databases were selected based on their coverage of papers: Scopus, IEEE Explore, and ACM Digital Library.

**Search string**: In order to search for relevant papers in the three databases, we used the following keywords: Code review, Modern code review, Contemporary code review, Patch accept, Commit review, Pull request, Modern code inspect. We used the keywords in the search engines using the "OR" operator between each keyword and the keywords were suffixed with a wildcard - "\*". The result of applying the search strings on the three databases is presented in Table 1.

## 3.3 Inclusion-exclusion criteria

The 873 identified papers were reviewed based on a defined set of inclusion and exclusion criteria. Before we started the review process, we conducted a pilot study<sup>1</sup> on 20 papers to ensure that all the authors have the same interpretation of the criteria. After the pilot study, the initial criteria were updated and new criteria were added. We conducted a second pilot study on 20 additional papers using the revised criteria. As a result, we achieved higher consensus in our decision. The final formulation of the criteria is as follows:

#### Inclusion criteria.

 Papers discussing source code (including test code) review which is done on regular basis (modern code review done on every pull request to either accept/reject them). Deepika Badampudi, Ricardo Britto, and Michael Unterkalmsteiner

- (2) Papers discussing aspects such as reviewer selection, what code to review, etc. that support modern code review process.
- (3) Papers discussing reviewer and/or developer perspective.
- (4) Papers (peer reviewed and grey literature) related to modern code reviews.
- (5) Papers including modern code reviews from different aspects. Examples - Benefits, outcomes, challenges, motivations, quality, usefulness and so on.
- (6) Papers proposing solutions for modern code review.

#### Exclusion criteria.

- Papers not discussing modern code reviews or the subject of investigation is not the modern code review process.
- (2) Papers that do not discuss the implications of a solution on modern code review process.
- (3) Papers that discuss modern code review in education.
- (4) Papers not in English and those that do not have full text available.

## 3.4 Keywording of abstracts and meta-data

During the screening process, we looked at the abstracts to find keywords and concepts that represent the contribution of the papers. We collected the following data from the selected papers:

- Overview of the main contribution The contribution could be related to the different aspects of modern code review, solutions for modern code review improvement or discussion of modern code review process from reviewer/developer perspective.
- Author The authors of the papers.
- Publication type Conference, journal or book.
- Year Year of publication.

#### 3.5 Data extraction

In addition to the data extracted during the keywording process, we will extract research facet based on Wieringa's [89] classification. We will extract the information needed to evaluate the rigor and relevance of the papers. Moreover, the data extracted through the keywording process will be refined (if necessary) based on full-text reading.

#### 3.6 Validity threats

It is important to address the validity threats relevant to a mapping study which are as follows:

*Researcher bias in inclusion/exclusion* - All three authors were included in the screening process. We conducted two pilot studies to ensure that all authors had the same interpretation of the inclusion/ exclusion criteria. In case of doubts, we discussed the papers together and revised the criteria to make them more explicit (see Section 3.3).

*Exclusion of relevant papers* - We adopted an inclusive approach; whenever we were in doubt regarding a paper, we included it for further reading. We marked all excluded papers with the applicable exclusion criteria to ensure transparency and traceability.

<sup>&</sup>lt;sup>1</sup>In our first pilot study, we noticed a paper on test case review, we refined our inclusion criteria 1 to add test code review as well. Some papers discussed approaches to support the modern code review process to make it more efficient, for example, by selecting a relevant reviewer. Therefore, we added inclusion criteria 2. We decided to exclude papers that discuss modern code reviews in education. We modified exclusion criteria 1 to emphasize the subject of the investigation; we only include papers where the process of modern code review is under investigation. We also came across papers that discuss solutions that might benefit, among other things, the modern code reviews process, without discussing the implications of the approach on the code review process itself (e.g., defect prediction). As a result, we excluded such papers and added exclusion criteria 2.

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Table 2: Studied aspects of modern code reviews

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Aspects	Sub-Aspects	No.
	Benefits of modern code review	3
Modern	Causes - acceptance/ rejection/ partial ac-	6
code	ceptance/ integration delays of pull requests	
review	Motivations, expectations, challenges and/	4
process	or best practices	
	Characteristics / principles of modern code review processes	8
	Effectiveness and/or efficiency of modern	3
	code review	
	Impact/outcome	35
Contributor	Perception on modern code review	3
Contributor /Reviewer	Characteristics such as skills, behaviour	15
/Reviewei	and/or participation	
	Reviewer selection	23
Solution	Tool support	39
Source	Code characteristics	5
code	Identification of code to review	15
Poviow	Classification of comments	3
	Assessment of comments	3
comments	Usefulness of the comments	5
Other		7
Review comments	Classification of comments Assessment of comments	3 3 5

## **4 REVIEW RESULTS**

In this section, we present our preliminary results, i.e. answers to R1. In total, we have included 177 papers after screening the abstracts<sup>2</sup>.

Table 2 presents the aspects (R1) and the number of papers that cover the different aspects of modern code reviews (R1.2). The most investigated topics are "solutions", "impact/outcome", and "reviewer identification". We elaborate on these topics in Sections 4.1, 4.2 and 4.3 respectively. To investigate how the research topics evolved over time (R1.1), we first split all the papers by the year in which they were published. Figure 1 shows the number of papers published per year (2005-2018). In the last five years, the number of papers has increased drastically compared to previous years.

# 4.1 Papers proposing solution to improve modern code review process

We have identified 39 solution papers in our mapping study. A few papers proposed solution for the same purpose: support for collaborative modern code review [27, 47, 58, 67], identifying behavior-modifying changes [1, 22], motivation enhancement [85, 86], use of static analysis to reduce modern code review effort [3, 68], and the information needs of modern code review [55]. Table 3 provides a list of solutions addressing different purposes.

## 4.2 Impact and/or outcome

The impact of modern code reviews is one of the frequently investigated topics. The topics investigated are impact on software

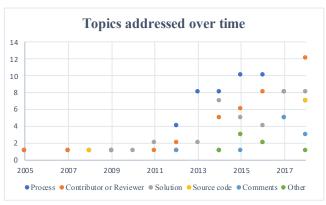


Figure 1: Number of papers published per year Table 3: Proposed solutions

<b>I</b>	
Purpose	Ref.
Improve the skills of newcomer developers	[50]
Measure the performance of modern code review and a	[34]
method to study linux-style reviews	
Address challenges in modern code review process when	[32]
conducted by third-part organization	
Allow developers to explain their code using voice and video	[26]
Remove stagnation from modern code review	[87]
Analyse how code changes affect test code	[52]
Assist mining modern code review data by enabling better	[75]
understand of dataset context and identifying abnormalities	
Automatically identify factors that confuse reviewers	[18]
Automatically partition composite changes and then facili-	[72]
tate modern code reviews	
Cleaner modern code review	[41]
Modern code review driven by software quality concerns	[81]
Collect modern code review data, generate metrics and	[10]
provide ways to access the metrics and data	[00]
Community-based modern code review	[98]
Determine how code changes should be ordered to facilitate	[6]
modern code reviews (increase cognitive support)	[45]
Estimate modern code review effort based on patch size and	[45]
complexity	[4]
Explore the need for a new generation tool of modern code review tools	[4]
Focus on design quality concerns	[60]
Choose pre- or post-commit modern code reviews	[82] [5]
Identify problems with modern code review processes	[24]
Identify problems with modern code review processes	[24] [14]
Improve modern code review process within organization	[15]
Peer modern code review	[31]
Retrieve modern code review data	[23]
Summarize similar changes and detect missing or inconsis-	[97]
tent edits	[,,]
Support the modern code review of visual programming	[60]
languages	[]
Track modern code review performance	[33]
Use of mobile to review source code	[21]
Use of social networks for frequent modern code reviews	[17]
	-

 $<sup>^2</sup>$ We did not include the 21 papers selected in the pilot study and 46 tentatively accepted papers in this paper due to the space constraints. We will include them in our extended paper

EASE '19, April 15–17, 2019, Copenhagen, Denmark Table 4: Relationship between different factors investigated

		0
Impact of	Impact on	Ref.
Code ownership and re- viewer expertise	Software quality	[78]
Reviewer age and efficiency	Software quality	[?]
Reviewers disagreement	Software quality	[30]
Modern code reviews feed-	Motivation to contribute in	[49]
back	OSS projects	
Continuous code review	Understandability and col-	[9]
process	lective ownership of the code base	
Reviewers' reviews and per- sonal and social factors	Review quality	[38]
Peer-Based Software Re- views	Team Performance	[65]
Socio-Technical modern	Identification of	[44]
code review metrics	bugs/warning/vulnerabilities	
Reviewers' path develop-	Identification of	[79]
ment experience	bugs/warning/vulnerabilities	
Feedback	Developers' sentiment	[64]
	-	

quality [7, 43, 46, 66, 76], human memory [39, 70], chances in inducing bug fixes [7], if-statements and change requests [59, 83, 84], and the identification of bugs/warning/vulnerabilities [12, 54].

While the impact of modern code reviews on several factors was investigated as mentioned above, the impact of several factors on modern code reviews has also been investigated: the impact of continuous integration [99], developer reputation [11], geographical location [62], pair programming [51], patch voting [29], and technical and non-technical factors [?] on modern code reviews.

The relationship between specific characteristics of modern code reviews and their respective impact on different aspects of software development has also been investigated (Table 4).

The impact of non-technical factors (different patch size, patch priority, component, reviewer load, reviewer activity, and patch writer experience) was investigated in [8]. The outcome of modern code reviews in terms on detection of code smells [48] and defects [13], ability to identify information on design decisions [88] and design rational [71] and ability to discover misunderstandings about object oriented principles [80] have also been investigated.

## 4.3 Reviewer identification

Papers proposing solutions to recommend modern code reviewers based on different selection criteria are presented in Table 5.

A solution recommending the role (managerial or technical) of the review was proposed in [92]. The motivation of invited reviewers was investigated and led to proposing guidelines for inviting reviewers [63]. The factors that influence reviewer assignment was investigated in [69]. The use of reviewer recommendation was investigated in [40] and [56].

The results indicate that, even though reviewer selection is perceived to be relevant and effort saving, it rarely adds additional value and creates an unbalanced work load.

### 5 CONCLUSIONS AND NEXT STEPS

In this paper we presented the preliminary results of a systematic mapping study on code reviews. We have included 177 papers and

Deepika Badampudi, Ricardo Britto, and Michael Unterkalmsteiner Table 5: Reviewer selection criteria

Reviewer selection criteria	Ref.
Previously reviewed file path	[74, 77]
Reviewers expertise/experience	[3, 25, 53, 61]
Reviewer comment networks	[95]
Modern code reviewer profiles	[20]
Participation in the core team	[16]
Reviewers' activeness	[36, 91]
Social network analysis	[94]
Text and file location	[90]
Topic modelling of historic source code	[37]
changes and reviews	
File change history, relationships between	[35]
contributors and activity	
Developer expertise, text similarity and so-	[93]
cial relations	
Code contributions	[96]
Collaborators	[42, 53]

extracted data from their abstracts to answer our RQ1 research question. We identified a steady upward trend regarding publications related to modern code review starting in 2011. Moreover, the main aspects addressed by existing research are related to: modern code review process, reviewer selection, tool support, identification of code to be reviewed, and analysis of the review comments.

The following are the next steps in our investigation: i) describe all the aspects of modern code review in Table 2 in detail (e.g., the techniques used to propose solutions). This will give an overview on how the solutions have been designed and what are the limitations, gaps, and potential future works; ii) measure the rigor and relevance of the included studies. Such analysis can determine the strength of the results; iii) extract additional data from the papers' full text (e.g., research facet) and verify the classification of the aspects that was extracted from the abstracts; iv) include a detailed discussion of the results.

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