



# Characterization of Testing Techniques and Challenges of Non-Functional Requirements Testing on Mobile Applications

Conduction Protocol of Systematic Mapping Study

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Janeiro/2020

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This Systematic Mapping Study (SMS) aims to perform a characterization of the current state of the art involving the types of Non-Functional Requirements (NFR) testing approaches applied on mobile applications. This study allows to characterize NFR testing approaches under different points of views. We intend to identify also frameworks and tools proposed to implement such approaches. Finally, we aim at investigating how the NFR testing techniques are evaluated in practice.

The current SMS will be conducting following the guidelines proposed by Petersen et al. (2015). The following investigation steps illustrate the research protocol.

## 1 Definitions

The definitions regarding the basic concepts of Non Functional requirements come from ISO/IEC 25010 – Software Quality Characteristics, Software Architecture in Practice (3rd Edition); ISO/IEC/IEEE 29148:2011;

Other specific terms are defined as follows:

## 2 Research Questions

This section presents the goal and the research questions (RQs) of the SMS. Moreover, it is reported, for each RQ, the rationale that explains its purpose.

The main goal of this study *is to understand how the topic of NFR testing for mobile apps has been addressed in literature.*

### 2.1 Research Questions:

- **RQ1: What are the characteristics of NFR testing approaches used in mobile applications?**

**Rationale:** in RQ1, we will characterize the NFR testing approaches identified relating the NFR with each NFR testing approach.

**Data extracted:** approach, goal, methodology, NFRs associated with the approach, faults associated with each NFR, SO (Android, iOS), maturity level of the approach (TRL) and source (academy, industry, collaboration).

**Result:** association between approach, NFR, and faults (figure in a tree format).

- **RQ2: What is the level of automation and tool support of the approaches for NFRs testing in mobile applications?**

**Rationale:** in RQ2, we will extend the characterization performed in RQ1. Therefore, we will establish a relationship between NFR, the NFR testing approach and the automation level of the approach.

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**Data extracted:** automation level (automated? manual? hybrid?), tool/framework, NFRs, faults, approach, SO (Android, iOS), maturity level of the approach (TRL) and Source (academy, industry, collaboration).

**Result:** correlation between approach, automation level, and NFRs (figure in a tree format).

- **RQ3: How these techniques have been evaluated in practice?**

**Rationale:** in RQ3, we will evaluate how identified approaches are evaluated in the context of mobile applications.

**Data extracted:** automation level (automated? manual? hybrid?), tool/framework, NFRs, faults, approach, SO (Android, iOS), maturity level of the approach (TRL) and Source (academy, industry, collaboration).

**Result:** we can classify the evaluation methods as: application example, experiment, empirical evaluation (survey, case study, ..), toy example, evaluation with stakeholders, benchmarking, simulation.

### 3 Search String

The search string supporting this SMS was built using the PICOC with five levels of filtering:

- **Population:** mobile applications.  
Synonyms: "Mobile software", "Mobile Systems", "Android", "iOS")
- **Intervention:** approaches.  
Synonyms: techniques, methods, strategies, "activities", "methodologies", "tools", "frameworks".
- **Comparison:** - not applicable.
- **Outcome:** Non functional requirements.  
Synonyms: "Non-functional property", "Quality attribute", "non-functional", "Suitability", "Performance", "Efficiency", "Compatibility", "Usability", "Reliability", "Security", "Maintainability", "Portability", "Modifiability", "Testability", "Survivability", "Flexibility", "Reusability", "Safety", "Energy consumption"
- **Context:** testing.  
Synonyms: "test", "Validation", "Verification"

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### 3.1 Base Search String

("Mobile app" OR "Mobile application" OR "Mobile software" OR "Mobile System" OR "Android" OR "iOS") AND ("technique" OR "method" OR "strategy" OR "approach" OR "activity" OR "methodology" OR "tool" OR "framework") AND ("Non-functional property" OR "Quality attribute" OR "non-functional" OR "Suitability" OR "Performance" OR "Efficiency" OR "Compatibility" OR "Usability" OR "Reliability" OR "Security" OR "Maintainability" OR "Portability" OR "Modifiability" OR "Testability" OR "Survivability" OR "Flexibility" OR "Reusability" OR "Safety" OR "Energy consumption") AND ("testing" OR "test" OR "Validation" OR "Verification")

## 4 Studies Selection

Nesta seção são apresentados e discutidos aspectos relacionados as sources definidas para execução da string de busca e os critérios de inclusão e exclusão.

### 4.1 Sources

The sources were selected based on previous studies. Additional sources may be included during the snowballing process. Table 1 shows the sources selected to this systematic mapping:

Table 1: Sources used on systematic mapping.

| Source              | Url   |
|---------------------|---|
| ACM Digital Library | <a href="http://dl.acm.org/">http://dl.acm.org/</a>                           |
| IEEE Xplore         | <a href="http://ieeexplore.ieee.org/">http://ieeexplore.ieee.org/</a>         |
| Web of Science      | <a href="https://www.webofknowledge.com/">https://www.webofknowledge.com/</a> |
| Scopus              | <a href="http://www.scopus.com/">http://www.scopus.com/</a>                   |
| ScienceDirect       | <a href="https://www.sciencedirect.com/">https://www.sciencedirect.com/</a>   |

### 4.2 Selection Criteria

The studies will be included if they contain all inclusion criterion. Otherwise, the study will be excluded if contain at least one exclusion criterion.

#### **Inclusion (I) and Exclusion (E) Criteria:**

- (I-1) studies describing a novel NFR software testing approach for mobile applications;

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- (I-2) studies exploiting existing NFR software testing approach for mobile applications in empirical evaluation;
    - (I-2-A) Studies that addressed the testing of energy consumption. We considered it as performance testing.
  - (E-1) studies that appear in duplicate;
  - (E-2) studies that are not written in English;
  - (E-3) studies that report a summary, a conference calls, or patents;
  - (E-4) studies that are not available in electronic digital libraries;
  - (E-5) studies that are lecture notes, posters, panels, or conference short papers (i.e., papers having less than 6 pages);
  - (E-6) studies that do not present an evaluation, such as: case study, controlled experiment, proof of concept, empirical study, etc;
  - (E-7) studies that do not explicitly claim that they address the problem of NFR testing for mobile apps. More precisely we did not consider:
    - (E-7-A) studies presenting a technique aiming at finding crashes but do not specify whether a nonfunctional quality attribute is tested or not;
    - (E-7-B) studies presenting techniques in the field of digital forensics.

**Regarding E-7-A and E-7-B we could count the number of discarded papers. This can help us in an extra discussion and it can be used to mitigate a possible threat to validity.**

## 5 Additional Information

In this section, additional information on the number and specialty of the researchers involved, tool support for the selection process, extraction form and selection methodology are presented and discussed.

### 5.1 Researches

In conducting the mapping, three researchers are involved in the selection process and two researchers are involved in the supervision and validation of the selection process. Below are the researchers involved with their specialty:

- Misael Júnior (involved in selection process): PhD Student in Computer Science and Computational Mathematics by the Institute of Mathematical and Computer Sciences (ICMC) of the University of Sao Paulo (USP). Misael has experience in Software Engineering and in the following fields: software testing, test oracles, testing automation, and metamorphic testing;

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- Domenico Amalfitano (involved in selection process): Assistant Professor at the University of Naples Federico II, located in Naples-ITA. Domenico Amalfitano specializes in software testing in the contexts of web applications, mobile applications and GUIs;
  - Stevão Andrade (involved in selection process): PhD Student in Computer Science and Computational Mathematics by the Institute of Mathematical and Computer Sciences (ICMC) of the University of Sao Paulo (USP).
  - Lina Garcés (supervision the selection process): PhD in Computer Science from the University of Sao Paulo, Brazil and the Université de Bretagne-Sud, France. Her research focuses on Software Architecture and Software Quality, acting primarily in the fields of Telemedicine, e-Health, Ambient Assisted Living, Healthcare Supportive Home, and Critical Embedded Systems.
  - Márcio Delamaro (supervision the selection process): Titular Professor in Institute of Mathematical and Computer Sciences (ICMC) of the University of Sao Paulo (USP) with specific projects in automation and systematization of software testing.

## 5.2 Support Tool

The authors will use the JabRef<sup>1</sup> tool as support in the studies selection. In addition to JabRef, Excel will be used to facilitate the organization and sharing of the list of articles with all researchers involved in selection process.

## 5.3 Extraction Form

The extraction form will be done through the Google Forms tool<sup>2</sup>. The choice of tool is related to ease of sharing among all researchers. Therefore, each research will be responsible for a certain number of articles and will have to record the extracted data in the Google Forms. Finally, a merge of the extracted data will be performed in a single extraction form and such data will be reported.

## 5.4 Extraction Methodology

The selection process was defined according to the guidelines defined by Petersen et al. (2015). The studies selection will be performed by three researchers who will judge the studies with: Yes, Doubt or No. The results are compared and the studies are selected according to the following criteria:

- the papers having at least 2 yes will be selected;
- the papers having at least 2 no will be discarded;

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<sup>1</sup><http://www.jabref.org/>

<sup>2</sup><https://www.google.com/forms/>

- the remaining papers will be labelled as doubt and they will be selected by full read.

Therefore, three researchers performed the selection process from the following steps:

1. Selection by Title and Abstract: the three researchers involved in the selection process should read the title and abstract of all articles returned by String. Then, each researcher must define Yes, Doubt or No for the article under analysis should be included in the mapping. Finally, the answers of the three researchers are compared to define the selected articles;
2. Full reading selection: after the selection by title and abstract, the selected articles are full read and selected by the three researchers involved in the selection process. Finally, the answers of the three researchers are compared to define the selected articles.

It is important to mention that two researchers supervised and validated the selection process.

## References

Petersen, K.; Vakkalanka, S.; Kuzniarz, L. Guidelines for conducting systematic mapping studies in software engineering: An update. *Information and Software Technology*, p. 1–18, 2015.