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

Conduction Protocol of Systematic Literature Review

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This Systematic Literature Review (SLR) 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, allowing as well identify the challenges involved on apply those approaches. Also, we intend to identify frameworks and tools proposed to implement such approaches. Finally, we intend to identify gaps among NFRs software testing and mobile applications, revealing research opportunities.

The current SLR will be conducting following the guidelines proposed by Kitchenham (2004) and Keele (2007). The following investigation steps illustrate the research protocol.

1 Questions Formulation

1.1 Question Focus (Objectives)

Identify NFR software testing approaches applied on mobile applications. Also, characterize the challenges that are faced during the NFR testing activity, as well as the types of non-functional faults that can be found during such activity.

1.2 Question Quality and Amplitude

Research Questions:

- **RQ1.0: How can the proposed NFR testing techniques be characterized?**

  Some specific research questions were proposed to investigate other directions:

  - **RQ1.1: Which types of non-functional requirements are taken into account?**

    Rationale: this rq aims at investigating which kinds of non-functional requirements are more addressed in literature. This may help at understanding which are the fields that worth investigating.

  - **RQ1.2: Which are the mobile operating systems/mobile platforms considered?**

    Rationale: this rq aims at investigating which are the mobile operating systems that are more exploited than others.

  - **RQ1.3: What is the level of automation of the proposed NFR testing techniques?**

    Rationale: this rq aims at investigating how much the proposed NFR testing techniques are automated or not. We may have fully automated, fully manual and hybrid.

- **RQ1.4: Which kinds of artifacts are involved in the NFR testing techniques?**

  Rationale: this rq aims at characterizing the artifacts that the testing technique relies on, e.g. requirements, models, source code, executable app.

- **RQ1.5: How the NFR testing techniques are supported by tools?**

  Rationale: this rq aims at understanding what is the support of free, open source tools for supporting NFR testing techniques.

- **RQ2.0: How the experimental evaluation of proposed NFR testing techniques can be characterized?**

  Some specific research questions were proposed to investigate other directions:

  - **RQ2.1: Which kinds of experiments are performed in the context of NFR testing techniques for mobile apps?**

    Rationale: this rq aims at understanding how the proposed NFR testing techniques are validated. E.g. by means of case studies, experiments, or home made running examples.

  - **RQ2.2: How much the evaluation is replicable?**

    Rationale: this rq aims at understanding whether the study could be replicated or not (it can be a common future work). In the inclusion criteria I will explain how much an experimentation can be replicated or not.

- **RQ3.0: How the selected articles can be characterized?**

  Some specific research questions were proposed to investigate other directions:

  - **RQ3.1: What is the annual articles count?**
  - **RQ3.2: What is the article count by venue type?**
  - **RQ3.3: What are the venues with highest articles count?**
  - **RQ3.4: What are the most influential articles in terms of citation count?**
  - **RQ3.5: Who are the authors with the highest number of articles?**
  - **RQ3.6: Which countries have the greatest impact of research related to NFR testing techniques applied on mobile applications?**
  - **RQ3.7: There is collaboration between Industry and Academia in developing NFRs test strategies for mobile?**

- **RQ4.0: How the limitations of NFR testing techniques can be characterized?**

  Some specific research questions were proposed to investigate other directions:

  - **RQ4.1: What is the level of testing automation for each kind of NFR.**

    Rationale: this rq has the aim of understanding whether there are kinds of non functional requirements that can be easily automatically tested than others. As an example, for specific non functional requirements it is more easy to design an automated testing technique.

  - **RQ4.2: What is the article count by venue type?**

    Rationale: this rq has the aim of understanding whether there are tools for the testing of specific kinds of non functional requirements. As an example, for specific non functional requirements it is more easy to implement testing tool.

  - **RQ4.3: What is the scalability of each kind of NFR testing technique?**

    Rationale: this rq has the aim of understanding whether techniques for specific kinds of non functional requirements may not scale for large experiments.

Keywords and Synonyms:

The String was defined from the documents specific to each domain. Also, we performed tests of each term inserted in the String. Then, the defined terms of each domain are presented and the documents used as the basis for such terms are quoted.

- **Testing technique, tool or framework**:

  Source: indication of software testing specialists involved in the work.

  "testing technique*" OR "testing method*" OR "testing strategy*" OR "testing approach*" OR "testing activit*" OR "testing methodology*" OR "Validation" OR "Verification" OR "testing tool" OR "testing Framework"

  We don't include terms such as "testing" or "test". These terms are very generic and resulted in articles not related to our purpose. Therefore, we inserted more specific terms and that return articles directly related to the purpose of the SLR.

- **Non-Functional requirements**:

  Source: ISO/IEC 25010 – Software Quality Characteristics; Software Architecture in Practice (3rd Edition); ISO/IEC/IEEE 29148:2011; and Authors involved in the SLR.

"Non*functional property" OR "Quality attribute" OR "non*functional testing" 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"

We consult standards documents related to quality properties and attributes and consult some requirements and software architecture experts. Therefore, we have chosen to include terms cited in the main standard documents and some generic terms such as "non-functional requirements", "quality attribute" and synonyms.

- **Mobile applications**:

  Source: indication of mobile specialists involved in the work.

  "Mobile app*" OR "Mobile application" OR "Mobile software" OR "Mobile System" OR "Android" OR "iOS"

  We evaluate more generic terms, such as Mobile. This term is very generic and returned articles related to Mobile networks, which is not associated with the objectives of our SLR.

Intervention: primary studies that apply or propose NFR testing approaches for mobile applications.
Effect (Results): a characterization of the current state of the art about approaches, challenges and testing tools to evaluate NFRs on mobile applications.
Outcome Measure: characteristics of testing approaches, challenges and testing tools.
Population: scientific literature about software testing and requirements engineering that address mobile application.
Application: researchers and developers that work with software testing on mobile applications.
Experimental Design: establishment of relationships between testing approaches, tools testing and challenges of NFR testing for mobile applications.

2 Sources Selection

2.1 Sources Selection Criteria Definition

The sources were selected based on previous studies. Additional sources may be included during the snowballing process.

Source List: ACM Digital Library[1]; IEEE Xplore[2]; Springer[3]; ScienceDirect[4]; Scopus[5].

2.2 Studies Languages

English

2.3 Sources Identification

Source Search Methods: the base search string must be customized to the targeted search engines. The customized strings will be applied and results will be stored for further analysis. The snowballing step will be performed manually, by analyzing lists of publications of particular authors of interest.

Base Search String

("testing technique*" OR "testing method*" OR "testing strategy*" OR "testing approach*" OR "testing activit*" OR "testing methodology*" OR "Validation" OR "Verification" OR "testing tool" OR "testing Framework")

AND

("Non*functional property" OR "Quality attribute" OR "non*functional testing" 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 ("Mobile app*" OR "Mobile application" OR "Mobile software" OR "Mobile System" OR "Android" OR "iOS")

3 Studies Selection

3.1 Studies Definition

Inclusion (I) and Exclusion (E) Criteria:

- (I-1) Addresses the topic of NFR software testing approach for mobile applications;
- (I-2) Studies that propose or present an NFRs testing tool or framework applied on mobile applications;

[1]http://dl.acm.org/
[2]http://ieeexplore.ieee.org/
[3]https://link.springer.com/
[4]https://www.sciencedirect.com/
[5]https://www.scopus.com/

- (I-3) Studies that propose an experimental evaluation of the proposed testing approach;
- (E-1) Studies that do not fulfill any inclusion criteria;
- (E-2) Not written in English;
- (E-3) The full study is not available;
- (E-4) The study is a editorial, lecture, poster or panel.

Types of Studies: methodological; experimental; characterization study.
Procedures for Study Selection: the preliminary selection consists of the reading of the Title of each study in order to check whether it should be or not selected to read the Abstract. Then, the author's will read the Abstract each study in order to check whether it should be or not selected for full reading. In the final selection step, the researchers will fully read each primary study and make the final decision regarding selecting or discarding it, using the inclusion and exclusion criteria presented earlier. The data of interest will be extracted and stored in customized forms.

4 Additional Information

4.1 Extraction form

The extraction form of the selected studies will be available for each author involved in the SLR. Therefore, each author will be responsible for a certain number of articles and will have to record the extracted data in the extraction form. Finally, a merge of the extracted data will be performed in a single extraction form and such data will be reported.

4.2 Selection toll

The authors will use the JabRef[6] tool as support in the studies selection. 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;
- the remaining papers will be labelled as doubt and they will be selected by abstract.

[6]http://www.jabref.org/

References

Keele, S. Guidelines for performing systematic literature reviews in software engineering. In: *Proceedings of the Technical report*, 2007.

Kitchenham, B. Procedures for performing systematic reviews. *Keele University*, p. 1–26, 2004.