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PROTOCOL FOR A SYSTEMATIC MAPPING STUDY ON

Architectural Technical Debt Identification: the Research Landscape

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ABSTRACT

This document describes the review protocol of a systematic mapping study on identification of architectural technical debt.

KEYWORDS

Systematic Mapping Study, Architecture, Technical Debt.

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1 Background and rationale

Technical debt (TD) is a term first coined in 1992 by Cunningham [1] to indicate immature portions of code that, while potentially working fine, might be unmanageable when they grow in quantity. From its original description, i.e. "not quite right code which we postpone making it right" [1], various people have adopted the TD metaphor to describe different types of debt and shortcomings of software development processes. To date, several types of TD can be identified in the literature [2]. A particularly interesting one results to be Architectural Technical Debt (ATD), which encompasses various types of TD that have an impact on the architecture of software-centric systems. As described by Van Vliet [3], between 50% and 70% of resources of a software project are allocated to maintenance processes. If such processes are neglected or not correctly carried out, software-intensive systems tend to slowly deteriorate through time, potentially leading to a obsolete or even failing system. During the development phases, software architecture plays a crucial role in the implementation of software systems [4]. Hence it can also potentially lead to the introduction of TDIs that have a high impact on the overall TD of a software-centric system.

In general terms, ATD is referred to sub-optimal decision taken at the architectural level, which usually result in the conceivement of immature software architectural artifacts [5]. Such ill-suited architectural decisions can be of different types, e.g. they can be implicit or explicit [6], and can be made consciously or unconsciously [7]. Generally, instances of Architectural Technical Debt (ATDI) occur when a design or construction choice is taken at architectural level as an expedient in the short term, but results to create a technical context that increases complexity and cost of the development processes in the long term [8]. While ATD is not a new problem, many questions remain to date unanswered, starting from the definition of ATD. In fact, in the literature, the term ATD encompasses many different aspects of software systems: from non maintainable architecture design to incorrect management of developer teams. From the inspection of the ATD body of literature, one important takeaway message emerges: many crucial aspects of ATD remain to date unexplored. In this study we aim to provide researchers and practitioners with a comprehensive overview of the existing ATD identification approaches and report their most prominent characteristics.

1.1 Existing systematic studies on the topic

From the inspection of the TD body of literature only few secondary studies can be found on the subject. In particular, to the best of our knowledge, six secondary studies focusing on TD can be found in the literature to date. In the vast majority of such studies, general aspects of TD are considered. In the study of Li et al. [2] an eagle-eye view of the state of the art of TD research is presented. In a similar research carried out by Alves et al. [9], the TD related literature was inspected in order to characterize the types of TD, their indicators, management strategies and possible visualization techniques. In an earlier secondary study of Tom et al. [10], the TD body of literature was inspected in order to identify the nature of technical debt and its impact on software development activities. A more detailed overview on a specific topic, namely the economical implications of TD, is considered in the systematic literature review of Ampatzoglou et al. [11]. In their work, Ampatzoglou et al., inspected the literature in order to understand the financial aspects of TD and how these relate to the underlying software engineering concepts.

Finally, in the study of Besker et al. [5] a more refined level of granularity w.r.t. the research topic is considered. In fact in their study Besker et al. exclusively consider researches related to ATD. More specificaly, the authors inspect the literature in order to conceive a descriptive model aimed to provide a comprehensive interpretation of the ATD phenomenon. In particular, through their model, the researchers aim to identify the main characteristics of ATD and unveil their corresponding relations. Such study was further extended in a later publication by the same authors [12]. While a more comprehensive investigation of the literature was adopted in such more recent study, the goal of the research remained the same: Model a comprehensive interpretation of the ATD phenomenon. An overview of the secondary studies on technical debt is provided inn

Table 1.

1.2 The need for an SLR on ATD identification

From a study of the available literature, it becomes clear that a research focusing on comprehensively reporting the characteristics of approaches aimed at identification of ATD Items (ATDIs) is still missing in the ATD research landscape. With this systematic mapping study we aim to characterize the existing research on approaches aimed to identify ATDIs in software-centric systems. Our study will help researchers and practitioners in identifying the focus, limitations and trends of existing research on approaches conceived for ATDI identification. Also, we will assess the potential of research on analyses methodologies related to ATDIs with a focus on how its results can be transferred and adopted in industrial projects. By knowing the potential of approaches for ATDI identification, researchers and practitioners will have a reference framework for better understanding and possibly adopting ATDI related approaches, respectively.

2 Research Process

This research will be carried out by following the process shown in Figure 1; it can be divided into three main phases, which are well-established when it comes to systematic literature studies [13, 14]: planning, conducting, and documenting.

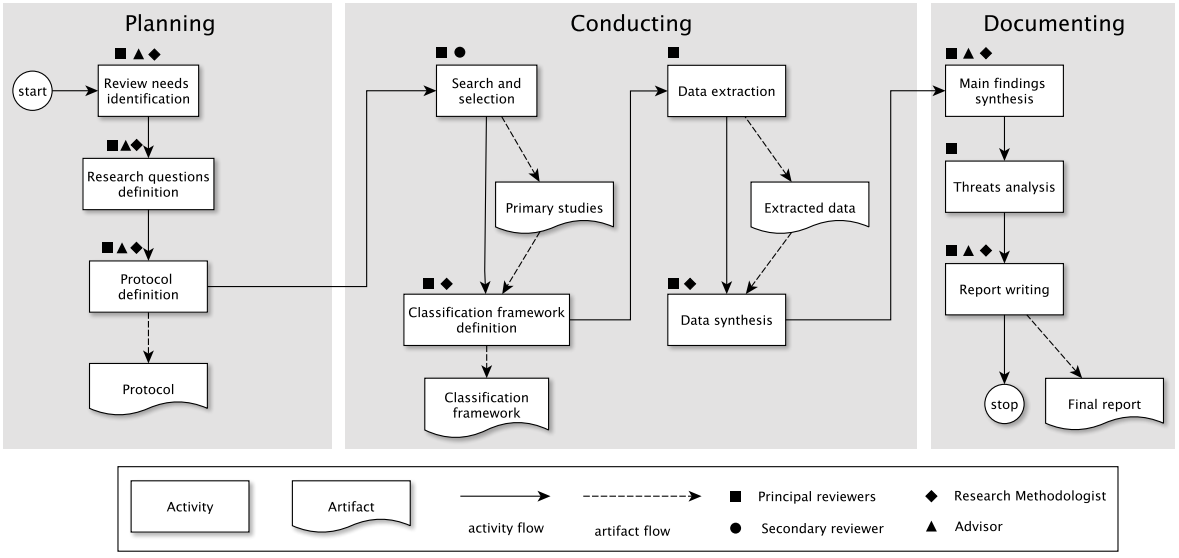

Figure 1: Overview of the whole review process

Each phase has a number of output artefacts, e.g., the planning phase produces the review protocol described in this document. In the following we will go through each phase of the process, highlighting main activities and produced artefacts. The grayed out elements, referred to as *prospect activities* (and related artifacts) consist of processes that will be carried out in a later stage by a subset of the initial team of researchers.

2.1 Planning

This phase aims at (i) establishing the need for performing a review on ATDI identification approaches (see Section 1.2), (ii) identifying the main research questions (see Section 3), and (iii) defining the protocol to be followed by the involved researchers. The output of the planning phase is a detailed protocol (i.e., this document).

Table 1: Overview of TD related secondary studies

Title	Publication year	Goal	Focus on architecture	Number of primary studies	Considered time frame
An exploration of technical debt [10]	2013	Provide an overview of the nature of TD and its impact on software development activities	No	35	Not specified
A systematic mapping study on technical debt and its management [2]	2015	Provide an overview of TD research and management	No	94	1992-2013
Identification and management of technical debt: A systematic mapping study [9]	2015	Provide an overview of TD characterization, indicators, management strategies, and visualization techniques	No	100	2006 - 2014
The financial aspect of managing technical debt: A systematic literature review [11]	2015	Understand the financial aspects of TD and how these relate to underlying software engineering concepts	No	69	2009-2013
A Systematic Literature Review and a Unified Model of ATD [5]	2016	Conceive a descriptive model aimed to provide a comprehensive interpretation of the ATD phenomenon	Yes	26	2012-2015
Managing architectural technical debt: A unified model and systematic literature review[12]	2017	Conceive a descriptive model aimed to provide a comprehensive interpretation of the ATD phenomenon	Yes	42	2011-2016

2.1.1 Conducting

In this phase we will perform the mapping study by following all the steps previously defined. More specifically, we will carry out the following activities:

- *Search and selection*: we will perform a combination of automatic search through a popular scholarly literature indexer and a backward and forward snowballing in order to identify the set of potentially relevant research articles on identification of ATDIs. The identified candidate entries will be filtered subsequently from the two processes according to a selection criteria in order to obtain the final list of primary studies to be considered in later activities of the review. Section 4 describes in details the search and selection process.
- *Classification framework definition*: in this activity we will define the set of parameters that will be used to compare primary studies.
- *Data extraction*: in this activity we will go into the details of each primary study, and we will fill a corresponding data extraction form. Filled forms will be collected and aggregated in order to be ready to be analyzed during the next activity. More details about this activity are presented in Section 5.
- *Data synthesis*: this activity will focus on a comprehensive analysis and summary of the data extracted in the previous activity. The main goal of this activity is to elaborate on the extracted data in order to answer each research question of the mapping study (see Section 3). This activity will involve both quantitative and qualitative analysis of the extracted data. The details about this activity are presented in Section 6.

2.1.2 Documenting

The main activities performed in this phase are: (i) a thorough elaboration of the data extracted in the previous phase with the main aim of setting the obtained results in their context, (ii) the discussion of possible threats to validity, specially to the ones identified during the definition of the review protocol (in this activity new threats to validity may emerge too), and (iii) the writing of a final report describing the performed mapping study. Firstly, the produced report will be evaluated by a set of experts, then it will be submitted to an academic conference or journal, thus undergoing a peer reviewed evaluation by the community too.

2.2 Team

Four researchers will carry out this study, each of them with a specific role within the research team:

- *Principal researcher*: Roberto Verdecchia, PhD candidate focusing on ATD and related fields of research. He will be part of all the activities, i.e., planning the study, conducting it, and reporting;
- *Secondary researcher*: Lars Cordewener, MSc. Computer Science student, supporting the research as part of his course "Literature Study"[1]. The activities assigned to him will include the search and selection of primary studies under the supervision of the principal researcher. He will then conduct a separate analysis of a subset of the identified literature in order to fulfill the requirements of the aforementioned course.
- *Research methodologist*: Ivano Malavolta, assistant professor with expertise in empirical software engineering, software architecture, and systematic literature reviews; he is mainly involved in (i) the planning phase of the study, and (ii) supporting the principal researchers

[1] https://goo.gl/xBuiKv

during the whole study, e.g., by reviewing the data extraction form, selected primary studies, extracted data, produced reports, etc.;

- *Advisor*: Patricia Lago, full professor with many-years expertise in software architecture, software design and modeling, software quality assessment, service oriented design and systematic literature reviews. She takes final decisions on conflicts and methodological options to 'avoid endless discussions' [15], and supports the other researchers during the processes of the SLR.

3 Research questions

This study aims at characterizing the current state of the art for understanding what we know about scientific research on ATD identification. The results of this study are targeted to both (i) researchers willing to further contribute to this research area, and (ii) practitioners willing to understand existing research on ATD analysis and thereby to be able to adopt those solutions that better fit with their business goals. More formally, we formulate the goal of this study by using the Goal-Question-Metric perspectives (i.e., purpose, issue, object, viewpoint [16]). Table 2 shows the result of the above mentioned formulation.

Purpose	Identify, classify, and evaluate
Issue	publication trends, characteristics, and potential for industrial adoption
Object	of existing approaches for ATD identification
Viewpoint	from a researcher's and practitioner's point of view.

Table 2: Goal of this research

This abstract goal can be refined into the following research questions (for each research question we also provide the rationale for it being part of this study):

RQ1: *What are the **publication trends** about approaches for ATD identification?*

Rationale: academic research is a dynamic ecosystem, where a multitude of researchers and research groups investigate on specific scientific problems over time with different degrees of independence and different methodologies. By answering this research question we aim at characterizing the ongoing trends of scientific interest on ATD identification, the relevant venues where academics are publishing their results on the topic and their contribution types; depending on the number of primary studies, trends will be assessed over the years.

RQ2: *What are the **characteristics** of existing approaches for ATD identification?*

Rationale: ATD identification results to be a relative young a multi-faceted research topic, where researchers can focus on very different aspects (e.g., dependency analysis of architectural components, violations of architectural patterns and policies, impact of sub-optimal design decisions on quality requirements, etc.), applying very different research methodologies (e.g., industrial case studies, empirical evaluations, feasibility studies), providing different types of contributions (e.g., tools that allow for automatic or semi-automatic analysis process, methods or a techniques to analyze a specific aspect, specification languages for describing semantic characteristics, etc.). By answering this research question we aim at providing (i) a solid foundation for analyzing and classifying existing (and future) research on ADT identification approaches, and (ii) an understanding of current research trends and gaps in the state of the art of such approaches.

RQ3: *What is the **potential for industrial adoption** of existing approaches for ATD identification?*

Rationale: by answering this research question we aim at assessing how and if the current state of the art on ATD identification is ready to be transferred and adopted in industry. In this study we consider the potential for industrial adoption as the combination of rigor and industrial relevance of a study [17]. Criteria concerning rigor and industrial relevance of a study include the rigorousness of its validation strategies (e.g., controlled experiment, and industrial application), rigorousness of its evaluation of potential biases and influences, clarity of its research goals and presented results.

Identified research questions will drive the whole study, with a special influence on (i) search and selection of primary studies, (ii) data extraction, and (iii) data analysis.

4 Search and selection process

The main goal of our search and selection process is to retrieve a comprehensive set of research studies that are relevant and representative enough for the topic being considered. More specifically, it is fundamental to achieve a good trade-off between the coverage of existing research on the topic considered, and to have a manageable number of studies to be analysed. In order to achieve the above mentioned trade-off, our search strategy consists of two complementary methods: an automatic search through a popular scholarly literature indexer and a backward and forward snowballing. Our search and selection process has been designed as a multi-stage process in order to have full control on the number and characteristics of the studies being either selected or excluded during the various stages. In the following we detail each step of our search and selection process.

The search strategy is divided into two subsequent and complementary steps. The first step is carried out by automatically searching the body of literature through the scholarly literature indexer Google Scholar[2]. The papers identified through this first step will then be utilized as input for a backward and forward snowballing[3] process [18].

In order to ensure the correctness of the adopted automatic approach, the backward snowballing activities will be based exclusively on the papers from the automatic search selected according to a rigorous and well defined set of inclusion and exclusion criteria. Furthermore, the backward snowballing results will be further contemplated by adopting a forward snowballing process, that will ensure the soundness and relevance of the set of selected primary studies.

The search and selection processes are conceived as multi-stage processes in order to control through a rigorous and pre-defined methodology the number and characteristics of the studies being either selected or excluded during the various stages. In the following sections each of the steps composing the search and selection processes are presented and detailed.

1. Initial search. In this initial stage we will perform an automatic search by considering the popular scholarly literature indexer Google Scholar. As reported in a recent set of guidelines by Wholin et al. [19], the adoption of such indexer results to constitute a sound choice in order to identify the initial set of literature on which snowballing processes can be based.

The research query adopted is conceived in order to encompass as much studies focusing on ATD identification as possible. The research query is structured as follows:

```
(intitle:architecture OR intitle:architectural OR intitle:architect OR
intitle:architecting OR intitle:TD OR intitle:"technical debt" OR intitle:ATD)
AND (architecture OR architectural OR architect OR architecting) AND ("technical
debt")
```

As can be seen in the above defined query, the title of the selected studies must contain either a keyword referring to “architecture” or “technical debt” and related acronyms. In addition, the full

[2] https://scholar.google.com/

[3] Inspection of the studies referenced by a paper (*backward snowballing*) and of the studies referencing it (*forward snowballing*)

text of the potentially relevant studies must contain both on of the keywords referring to "architecture" and the phrase "technical debt" (the exclusive presence of related acronyms, i.e. "TD" and "ATD" is not considered as valid).

The publications identified through this initial step will be thoughtfully examined by adopting several exclusion rounds in an adaptive reading depth fashion [20]. In the first round, the title of the researches will be examined. This first step will enable us to discard all those researches that clearly do not fall in the domain of ATD identification. In the second exclusion round, the abstract of the remaining researchers will be considered. In the third round, the conclusion of the remaining researches will be inspected. Finally, the selected researches will be further inspected by considering their full text in order to ensure that only the ones relevant for answering the research questions.

The time span of our search will be set to the time of the first execution of the query. The start date is not set, even it could be chosen according to the publishing date of the first study in which the Technical Debt metaphor was referenced, namely in the study of Cunningam the term was coined [1]. Nevertheless we chose not to set such start date in order to a void the introduction of a potential bias. The end date is set to the first execution of the query, in order to avoid potential discrepancies of results due to different query execution times.

From a preliminary execution of the aforementioned search query on Google Scholar a total of 551 potentially relevant studies were identified.

2. Application of selection criteria. Once the papers will be selected through the initial search phase, the resulting studies will be filtered according to a set of well-defined selection criteria. The adopted criteria are detailed in Section 4.0.1. An adaptive reading depth [20] will be utilised, in order to carry out the exclusion process in a time-efficient and objective manner.

3. Backward snowballing. In order to mitigate a potential bias with respect to the construct validity of the study, the automatic search previously presented is complemented with an additional snowballing process [21]. The snowballing activity will be adopted in order to further expand the number of considered researches by taking into account also studies that were not identified in the initial search phase. In particular, this process will be carried out by considering the studies selected in the initial search, and subsequently selecting relevant papers among those cited by the initially selected ones. This method is commonly referred to as a *backward snowballing* activity [22]. As for the selection of the papers through the initial phase, an adaptive reading depth [20] is adopted to select the papers. The final decision about the inclusion of the papers will be based on the adherence of the full text of the studies to the predefined selection criteria presented in Section 4.0.1. It is important to note that, during the snowballing phase, entries that do not correspond to research papers, such as workshop proceedings, international standards, textbooks, book series, etc. might be encountered. In order to analyze exclusively studies relevant to answer our research questions and ensure the quality of the selected studies these results will be excluded from our set of primary studies.

4. Forward snowballing. In addition to the backward snowballing, we also analyzed the researches citing the studies selected through the initial search will also be analyzed. This process is usually referred to as a *forward snowballing* activity [22]. We include this further literature search method in order to further expand and refine the selection of studies gathered through the initial search and the backward snowballing activity. Regarding the forward snowballing process, the *Google Scholar*[4] bibliographic database will be adopted to retrieve the studies citing the ones selected through the initial search phase. The adopted publication timeframe of the studies to be considered is in line with the one adopted for the initial automatic search. As for the other search activities, an adaptive reading depth [20] will be adopted while evaluating the researches against the inclusion and exclusion criteria. Elements discovered through this search activity that will not correspond to research papers, such as textbooks or technical reports, will not be included in the

[4] https://scholar.google.it/

set of primary studies.

4. Merging and duplicates removal. In this final stage the results gathered through the initial search, the backward snowballing activity, and the forward snowballing one will be merged together. During this process duplicated entries resulting from the merge of the search process will be identified and merged into a single one. This latter identification process will be carried out in a automatic way by confronting the `title` and `year` attributes of the selected studies.

4.0.1 Selection criteria

Following the guidelines for systematic literature review for software engineering [13], in order to reduce the likelihood of biases, we have to define a rigorous set of inclusion and exclusion criteria during the initial protocol definition phase of the literature review. In the following we detail the set of inclusion and exclusion criteria that will guide the selection of the primary research studies for the proposed systematic literature study. A research paper will be included in the set of primary studies if it satisfies *all* the inclusion criterion stated below. A study will be discarded if it satisfies *at least one* of the exclusion criteria reported below.

Inclusion criteria

I1 - Studies focusing on TD identification in software-intensive systems. This inclusion criterion is utilized to select exclusively studies considering TD.

I2 - Studies considering the architectural level for TD identification. This inclusion criterion is utilized to select exclusively studies considering techniques aimed to detect TD at the architectural level.

I3 - Studies presenting or using a technique aimed to the identification of ATD in software-centric systems. With this inclusion criteria, we ensure that only papers discussing the identication of ATD are included.

Exclusion criteria

E1) Secondary or tertiary studies (e.g., systematic literature reviews, surveys, etc.). This exclusion criterion is adopted in order to exclude studies which do not report the desired level of detail of ATD identification techniques.

E2) Studies in the form of editorials and tutorials, short papers, and poster, as they are deemed to not provide the required level of detail and information.

E3) Studies that have not been published in English language, as their analysis would result to be too time consuming.

E4) Studies that have not been peer reviewed, in order to ensure the high quality of the studies considered

E5) Duplicate papers or extensions of already included papers, in order to avoid possible threats to conclusion validity.

E6) Papers that are not available, as we cannot inspect them.

In order to reduce possible bias, two researchers will perform the selection of the studies independently by applying the above mentioned criteria.

5 Data extraction

The main goal of the activity reported in this section is to (i) create a classification framework for the primary studies and (ii) to collect data from each primary study.

In our study, the classification framework will be composed of three distinct parts, each of which addresses one of the research questions of our study (see Section 3):

1. *Publication trends*, addressing RQ1, see Section 5.1,
2. *Characteristics*, addressing RQ2, see Section 5.2,
3. *Potential for industrial adoption*, addressing RQ3, see Section 5.3.

In order to carry out a rigorous data extraction process, as well as to ease the control and the subsequent analysis of the extracted data, a predefined data extraction form will be designed prior the data extraction process.

The structure will be composed of the various categories of the classification framework. For each primary study, the principal researcher will collect in a spreadsheet a record with the extracted information for subsequent analysis: the spreadsheet columns will be the parameters, while each spreadsheet row will represent the data of each primary study.

In order to validate the data extraction process, the principal researcher will provide to the Research methodologist and the Advisor a random sample of 10 primary studies. Subsequently, they will analyze such studies independently by filling in the data extraction form for each primary study. Then, the whole team will assess their level of agreement and each disagreement will be discussed and resolved jointly, if required.

When going through a primary study in detail for extracting information, researchers can agree that the currently analyzed study may be semantically out of the scope of this research, and so it can be excluded.

We will follow a systematic process called *keywording* [23] for defining some of the parameters of our comparison framework. Basically, keywording aims at reducing the time needed to develop the comparison framework while ensuring that it takes the existing studies into account.

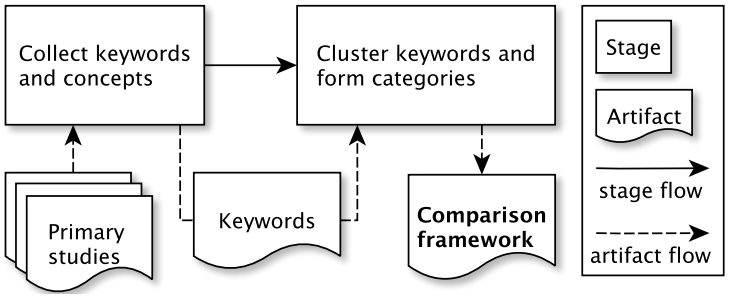

Figure 2: Overview of the keywording process

Figure 2 shows our keywording process in more details. Keywording is done in two steps:

1. *Collect keywords and concepts*: the principal researcher will collect keywords and concepts by reading the full text of each primary study. When all primary studies will be analyzed, all keywords and concepts will be combined together to clearly identify the context, nature, and contribution of the research. Bearing in mind that the authors of the primary studies may use different terms for the same concepts and viceversa (e.g., software quality vs non-functional requirements), we will collate different keywords and terms to ensure consistency and compatibility. The output of this stage will be the set of keywords extracted from the primary studies.

2. *Cluster keywords and form categories*: once the keywords and concepts will be finalized, the principal researchers will perform a clustering operation on them in order to have a set of representative clusters of keywords. The output of this stage will be the classification framework containing all the identified parameters (each of them having a specific type and possible values), representing a specific aspect of ATD identification.

5.1 Publication Trends (RQ1)

In the following we list all the parameters that will be extracted in order to answer the first research question of our study. Some examples of the subsequent analysis of the extracted data is also reported in this section.

1. *Publication year*: for extracting the publication tendency per year;
2. *Publication venue type*: it will be analysed in terms of their distribution, and also with respect to their distribution over time. These are the types of publication venues we will consider:
   (a) journal paper,
   (b) conference paper,
   (c) workshop
3. *Publication venue name*: gathered in order to identify in which venues researches on ATD identification appear more frequently.

5.2 Characteristics (RQ2)

Among all the research questions of this study, this one (i.e. RQ2) is the one which relies the most on the keywording process. In particular, once the primary studies will be identified, the selected literature will be inspected in order to identify which recurrent attributes can be extracted from the researches. The reminder of this section will present a tentative subset of attributes that could be potentially be extracted from the paper. The consolidated set of attributes will be available exclusively after classification framework definition process will be concluded.

1. *Level of abstraction*: `string` type, definition of Software Architecture in the study. Brief description on how software architecture is defined in the study.
2. *ATDI definition*: `string` type, definition of ATDI in the specific research, e.g. pattern violation or source code software metric. A *keywording* process will be adopted to identify appropriate clusters of keywords for this attribute.
3. *Analysis type*: `string` type, general analysis technique utilized by the approach presented in the paper, e.g., based on software models, software quality attributes etc. The discrete values that this attribute can assume will be defined through a *keywording* process.
4. *Analysis Input*: `string` type, input of the ATD identification approach. A *keywording* process will be adopted to identify appropriate clusters of keywords for this attribute.
5. *Temporal dimension*: `boolean` value, identifying if the approach considers temporal aspects (in terms of software evolution) in order to identify ATD.
6. *ATD Resolution*: `boolean` value, specifying if the approach considers the resolution of ATD.
7. *Tool support* `string` type, identifying if and which tool were utilized in order to carry out the ATDI identification processes.

5.3 Potential for industrial adoption (RQ3)

This latter set of attributes has been selected in order to assess to what extent the ATD identification approaches presented in the primary studies can be adopted in an industry projects. The selected parameters are as follows:

1. *Tool availability*: `boolean` type, reports if an implementation of the ATD identification approach presented in the research is available online or not.
2. *Rigor*: `double` type, value between 0 and 1 adopted to assess the rigor of the research presented in the studies. This evaluation methodology is taken from the guidelines provided by Ivarsson et al. [24] and considers if the study considered documents correctly the context, study design and threats to validity.
3. *Industrial relevance*: `double` type, value between 0 and 1 reporting the industrial relevance of the study. As for the previous attribute, this one is adopted from the assessment methodology presented by Ivarsson et al. [24]. This attribute takes into account if the study describes the subjects considered, the context, the scale of the evaluation and the research method utilized.
4. *Industry involvement*: custom categories, assessing the affiliation of the authors of the research. This attribute can assume three distinct values, namely:
   (a) "Academic": if the authors are exclusively affiliated to an academic organization, e.g., university or research center.
   (b) "Industrial": if the authors are exclusively affiliated to an industrial organization, e.g., an industrial enterprise.
   (c) "Mix": if some of the authors are affiliated to an academic organization and some others to an industrial one.

6 Data synthesis

The data synthesis activity involves collating and summarising the data extracted from the primary studies [25, § 6.5] with the main goal of understanding, analysing, and classifying current research on ATD identification.

In this phase we will have a fully populated spreadsheet with all the information coming from the data extraction form of each primary study. When performing *vertical analysis*, we will analyze the extracted data to find trends and collect information about each parameter of each category of our classification framework. In his phase we will perform a combination of content analysis (mainly for categorizing and coding the studies under broad thematic categories) and narrative synthesis (mainly for explaining in details and interpreting the findings coming from the content analysis).

Vertical analysis. Depending on the parameters of the classification framework (see Section 5), in this research we will apply both quantitative and qualitative synthesis methods, separately. When considering quantitative data, depending on the specific data to be analysed, we will apply descriptive statistics for better understanding the data. When considering qualitative data, we will apply the *line of argument* synthesis [14], that is: firstly we will analyse each primary study individually in order to document it and tabulate its main features with respect to each specific parameter of the classification framework, then we will analyse the set of studies as a whole, in order to reason on potential patterns and trends. When both quantitative and qualitative analyses are completed, we will integrate their results in order to explain quantitative results by using qualitative results [25, § 6.5].

7 Dissemination strategy

In the following we list the actions we will undertake in our dissemination strategy:

1) we will report our main research-oriented findings and a detailed description of this study into an scientific publication in an international scientific conference;

2) an accompanying *technical report* will present all the details and raw data of the study; the chief aim of the technical report is to make our study replicable by interested researchers.

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