Systematic Mapping Protocol: Reasoning Algorithms on Feature Model

Final version

March 31, 2021

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**Abstract**

**Context:** The importance of the feature modeling for the software product lines considering the modeling and management of the variability.

**Objective:** Define a protocol to conduct a systematic mapping study to summarize and synthesize the evidence on reasoning algorithms for feature modeling.

**Method:** Application the protocol to conduct a systematic mapping study according the guidelines of K. Petersen.

**Results:** A validated protocol to conduct a systematic mapping study.

**Conclusions:** Initial findings show that a more detailed review for the different reasoning algorithms for feature modeling is needed.

**Keywords:** Reasoning algorithm, Feature model, Software product lines, systematic mapping.
1 Introduction

This paper aims to present the protocol definition to carry out systematic mapping over the last ten years about reasoning algorithms in feature models (FM), used in the stages and activities that compose the software product line framework.

The idea behind considering only works from the last 10 years is due to the fact that a similar report was published in 2010 [1] which considers very similar aspects. Therefore, this proposal would only consider works posterior to the publication of Benavides.

The systematic mapping will be the beginning of the DIUFRO DI20-0014 research project that aims to evaluate the development and implementation of reasoning algorithms based on the modeling driven development (MDD) approach.

This report is structured as follows. The next section section describes the research method conducted, including the definition of search string, search process and the criterion for including and excluding papers. Finally, section 3 presents the conclusions and future work.

2 Protocol definition

This section describes the protocol definition to conduct a systematic mapping study (SMS) according the guidelines defined by Petersen [2].

2.1 Objective

Collect reasoning algorithms proposals for feature models, present in the literature of the last 10 years, with the intention of collecting the largest amount of data from the proposals found for their analysis, synthesis and subsequent publication of the results generated.

2.2 Need

In order to generate a proposal for reasoning algorithms based on MDD approaches is necessary to know in detail the proposals that exist today within the area, as this will allow:

a) To know the necessary requirements to be able to create algorithms of
b) Know what technologies, tools, approaches or others are used in the creation of these algorithms and understand the justifications for use in each case.

c) Avoiding activities or processes already carried out by other authors.

d) Avoid designing or creating processes/assets that have already been exposed by other authors.

However, the last report/study that collects this information is 10 years old [1] and while similar and more recent state of the art reports have emerged [3, 4], these have a different focus than the one we wish to address in this paper, in particular [3] is an extension of [1] and seeks to answer questions related to FM reasoning algorithms that can be applied in configuration modeling, and on the other hand Galindo presents results focused mostly on bibliometrics [4].

It is expected that the publication of the results will not only serve as an input for the following stages of the research project or for the formulation of future works, but it will also serve the research community in SPL and FM as a synthesis of what happened in the last 10 years in reasoning algorithms, both at the theoretical and bibliometric levels.

2.3 Research questions

According to Kitchenham and Charters [5], we define a context for the research questions (RQ) guiding this study. The context for the RQs arises from the hypotheses of this project and from a more general question: *Will it be possible to build a set of reasoning algorithm based on a modeling language composed by a metamodel and OCL constraints for feature models in SPL context?*

To answer this question, it is necessary to know the existing proposals in the literature related to reasoning algorithms, this information will be useful to also know the technologies used and the context in which these algorithms has been used.

The table [1] shows each RQ defined for the protocol, the table also shows a possible classification and sub-questions derived from this, finally specifies
the objective that the RQ seeks to clarify.

| ID | RQ | Classification | Objective |
|----|----|----------------|-----------|
| RQ1 | In what stages of SPL are these algorithms used? | - Domain Engineering  
- Application Engineering  
Sub Classification:  
RQ1.1 In what process of the stage is it used?  
RQ1.2 What is the purpose of the algorithm? | Highlight areas where algorithms are applied and for what purpose. Highlight areas that have more/less research. |
| RQ2 | What type of technologies do algorithms mainly use? | Meta-model, UML, OCL, Transformations, Solver, others. | To know the most used technologies that the algorithms are based. Highlight the different existent possibilities for researchers to implement new algorithms. |
| RQ3 | Which is the origin of the proposal? | - Academy.  
- Industry.  
- Both. | |
| RQ4 | Which is the level of validation? | Wieringa's classification 6 | Gain insight into the research maturity level based on the Wieringa research taxonomy. |
| RQ5 | What kind of FM does the algorithm work on? | Extended FM, Multiplicity, Orthogonal Model, Multi FM, Complex FM, others. | Highlight the most used FM when creating algorithms. To know what type of models each algorithm works on. |
| RQ6 | What problems does the algorithm solves? | Null FMs. Valid product. Valid partial configuration. | Highlight which problems have more solutions and which don’t. |

Table 1: RQ and details.

2.4 Publication Questions

Additionally, a set of publication questions (PQs) has been included to complement the gathered information and characterize the bibliographic and demographic space. This includes the type of venue where the papers were published, and the amount of papers per year, details are shown in Table 2.
### 2.5 Data Sources

According to [5,7] we consider the data sources detailed in Table 3, that are recognized among the most relevant in the SE community.

| Library              | Url                                           |
|----------------------|-----------------------------------------------|
| ACM Digital Library  | https://dl.acm.org                            |
| IEEE Xplore          | https://ieeexplore.ieee.org/Xplore/home.jsp  |
| Science Direct       | https://www.sciencedirect.com                 |
| Springer Link        | https://www.springer.com/                    |
| Wiley Inter-Science  | https://www.onlinelibrary.wiley.com/search/advanced |

Table 3: Data Sources

### 2.6 Search String

The search string has been constructed according to the steps defined in [5], that is, from the context and research question have been extracted a set of keywords, then for each keywords has been proposed a set of synonyms. Finally using PICOC [8] the search string is constructed.

The list of keywords and synonyms is listed as follows:

- feature model / modelling - variability model / modelling - feature diagram
- reasoning / reasoner - analysis / analyzer - automated - automated support
- automatic verification - computer-aided - automated analysis
- software product family - software product lines
- algorithm - solver (?) - model checking/ validation / verification / querying
- reasoning model

The final query string is described as follows:

("feature model" OR "feature models" OR "feature modelling"
OR "feature diagram" OR "configuration model"
OR "variability model" OR "variability modelling")
AND
("reasoning" OR "analysis" OR "analyses")
AND
("algorithm" OR "automated" OR "computer aided")
AND
("software product line" OR "software product lines"
OR "product family" OR "product families"
OR "product line" OR "product lines")

Figure 1: Search String

It is important to mention that the search string has been adapted for some search engines, due to the limitations of each one. However, each adaptation does not add or remove any filter. Table 4 shows the total results for the search string used in the data sources selected.

| Library               | Result |
|-----------------------|--------|
| ACM                   | 777    |
| Springer Link         | 819    |
| IEE Xplore            | 133    |
| Wiley Online Library  | 35     |
| Total Result          | 1764   |

Table 4: Search string, total results (17th November 2020).

2.7 Search and Selection Process

The search process starts with an automatic search on selected electronic databases using the search string. The goal of this is to get the first collection of papers to distribute to the team researchers. Each researcher
independently have to filter this collection according to the following criterion, allowing to decide if the initial papers collection are relevant or not for this study, only reviewing title, abstract, and keywords for each papers.

The first filter is to apply the inclusion criteria (IC) and the remaining papers will be filtered applying the exclusion criteria (EC). The definition of each IC and EC is shown in Tables 5 and 6.

| ID | Criteria |
|----|----------|
| CI1 | For papers with more than one version, the last version will be included and the others will be excluded. |
| CI2 | Works written in English. |
| CI3 | Type of paper:  
| | • Proceeding.  
| | • Research Article.  
| | • Article.  
| | • Conference Paper.  
| | • Journal. |
| CI4 | Papers published between 2010-2020. |
| CI5 | Papers whose abstracts show the relationship with the automatic analysis of Feature Models. |
| CI6 | Topic:  
| | • Computer Science. |

Table 5: Inclusion criteria

2.8 Resolving differences and avoiding bias

In order to reduce the differences as much as possible, our protocol declares the following decisions

- Collaborative definition of the SLR protocol and RQs.
- External validation for the search string
- Publication of the protocol for public scrutiny on the arXiv platform
- To avoid any potential bias due to a particular researcher examining each paper, we verified that the manner of applying and understanding
| ID  | Criteria                                                                 |
|-----|---------------------------------------------------------------------------|
| CE1 | Duplicated papers will be excluded                                        |
| CE2 | The following types of papers will be excluded:                           |
|     | • Tutorials.                                                              |
|     | • Short Paper.                                                            |
|     | • Abstract.                                                               |
|     | • Poster.                                                                 |
|     | • Keynote.                                                                |
|     | • Paper in progress (incomplete).                                         |
|     | • Books.                                                                  |
|     | • Book Chapter.                                                           |
| CE3 | Papers whose abstracts doesn’t show the relationship with the automatic analysis of Feature Models. |
| CE4 | Secondary researches. (If they exist, they will be added as related work). |
| CE5 | Papers that cannot be accessed.                                           |
| CE6 | Papers published before 2010.                                             |
| CE7 | Articles with an extension of less than 4 pages.                          |

Table 6: Exclusion criteria

the exclusion criteria was similar for the researchers involved in the SMS (inter-rater agreement).

- The researchers individually decide on the inclusion or exclusion of a sub set of assigned papers randomly chosen from those retrieved by a pilot selection.

- A test of concordance based on the Fleiss’ Kappa statistic will be performed as a means of validation [9]. If $Kappa \geq 0.75$ then the criteria is clear enough [10], else, the criterion must be reviewed to get by its interpretation and application.

Another way to do this task is by following the criteria defined by [2].
2.9 Results and Reporting

Finally, for the selected papers, relevant data will be extracted to answer the RQs and PQs.

The meta-data collected for each paper: (i) title, (ii) authors (each of them), (iii) publication year, (iv) type of publication and ranking, (v) algorithm reported (vi) technology based reported, (vii) and (viii) results and future work.

Another result will be a bubble diagram that graphically represents the number of papers found divided into categories. An example is represented in the figure 2.

Figure 2: Bubble Diagram Example

Presenting the results of this SMS considers 2 stages:

- stage 1: publish the SMS protocol at Arxiv web platform\(^3\)

- stage 2: publish the SMS results in an academic journal or conference focused on the topic of FM and SPL.

\(^3\)https://arxiv.org
The structure recommended by [5] will be used to report the results for stage 2. The main sections are:

- **Introduction**
  - Context
  - Motivation
  - Aim and need

- **Background**
  - SPL
  - Variability
  - Feature modeling
  - Reasoning algorithms

- **Methodology**

- **Results and discussion**
  - Answers to RQs
  - Threats to validity

- **Related work**

- **Conclusion**
  - Conclusions
  - Future work

### 3 Conclusion and Future Work

We presented a protocol definition of a SMS to summarize and synthesize the evidence about the automation on feature modeling reasoning algorithms.

The initial results show that we need to do a more detailed review for the
different kind of reasoning algorithms for feature modeling and their impact on an eventual proposal and prototype tool support.

As a future work we plan to define a set of FM reasoning algorithms improving performance over large FMs and streamline variability management in SPL.

Acknowledgments

Samuel Sepúlveda thanks to Vicerrectoría de Investigación y Postgrado, Universidad de La Frontera, research project DI20-0014. Thanks to Jonathan Jara and Sebastián Pardo for their useful technical support.

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