NFR4MDD: Survey protocol

"How do companies deal with NFRs in MDD"

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SUMMARY

This document details the protocol to execute an empirical study about the industrial practices in model-driven development, focusing in the particular topic of handling non-functional requirements. The empirical study described in this document is a multinational (Europe-wide) survey based on interviews to practitioners.

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PROTOCOL DESCRIPTION

For this study, we follow Ciolkowski et al.'s guidelines for driving empirical studies based on surveys [1], which adapted the general guidelines on experimentation in software engineering discussed in [38] for planning and conducting surveys. In these guidelines the following steps are defined which need to be covered during the survey process:

1. *Survey definition*. Objective and research questions.
2. *Survey design*. Planning the key elements of the study, including population, sample, variables, data collection and analysis, and mitigation of threats to validity.
3. *Survey implementation*. Make the survey executable.
4. *Survey execution*. Data collection and processing.
5. *Survey analysis*. Analysis and interpretation.
6. *Survey packaging*. Report the results of the study.

As shown in Figure 1, these steps are performed in an iterative manner. Typical iterations occur at three levels: within a process step, between the steps definition and design, and between the steps analysis and packaging, when learning from one survey to the next (e.g., survey piloting; replications; similar study designs) [1].

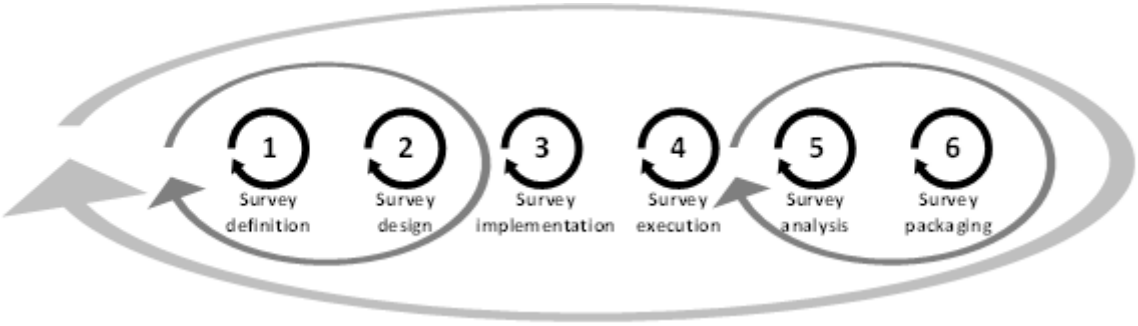

Figure 1: Survey iterative process

The protocol (this document) will be also iteratively constructed and validated (see Figure 2):

1. *Internal iterations*: the study authors have worked together until they fully consolidated a draft protocol.
2. *External reviews*: the protocol draft will be reviewed by the rest of researchers that will participate in the study.

Figure 2: Protocol iterations

1 SURVEY DEFINITION

According to Ciolkowski et al. [1], this section includes the study's goal definition, a review of the existing literature related to the topic of the study, and a justification for the need to perform the study. We complement this information with an introductory definition of the fundamental concepts involved in the study, a detailed description of the type of study

planned, and, finally, but not least important, a set of research questions derived from the goal of the study.

1.1 Fundamental concepts

This study is related to two fundamental concepts that need to be defined in order to avoid different interpretations from all the participants in the study.

1.1.1 Model-Driven Development

Model-Driven Development (MDD) is a development paradigm where models play a central role [2, 3]. MDD is based on the separation of the essential specification of the system and its implementation with concrete technologies. One of the benefits of using MDD is higher abstraction level by providing platform independence. A clear example of this benefit is the adaptation to new technologies. MDD is defined as: "*the notion that we can construct a model of a system that we can then transform into the real thing*" [3].

Other variants of this term are Model-Driven Architecture (MDA) and Model-Driven Engineering (MDE). MDA [4] is a concrete implementation of MDD using the OMG standards while MDE [5] includes other software engineering activities in addition to development (e.g., monitoring and validation). An extended view on the different kinds of approaches is presented in [MDEbook]. In this study, we will focus on MDD approaches for software production. Figure 3 shows the three mentioned model-driven approaches.

Figure 3: Model-driven approaches

1.1.2 Non-Functional Requirements

Non-Functional Requirements (NFRs) are one of the main research targets in the Requirements Engineering community [6] and their industrial impact has been documented in individual case studies [7] and types of industrial projects [8]. There are many NFR definitions (see [6, 9]), for instance: "*[NFR is] a requirement that specifies system properties, such as environmental and implementation constraints, performance, platform dependencies, maintainability, extensibility, and reliability*" [10]. However there is no common agreement on the concrete meaning of the term NFR [Glinz2007].

Chung et al. [9, 11] discussed that the lack of integration of NFRs with functional requirements can result in long time-to-market and more expensive projects. This fact has been recurrently mentioned in other publications from more than two decades ago [12].

Even if this could be a matter of discussion, in the context of this study, we will consider system/software quality requirements (QRs) as a synonymous of NFRs. Process/project quality will not be covered. Software quality attributes (QAs) can be used to classify NFRs or QRs into several types (e.g., ISO/IEC 25010 [13], see Figure 4). In this study we will target NFRs and QRs

as specific requirements of a particular software product, and QAs as general quality aspects or NFRs types of the software product.

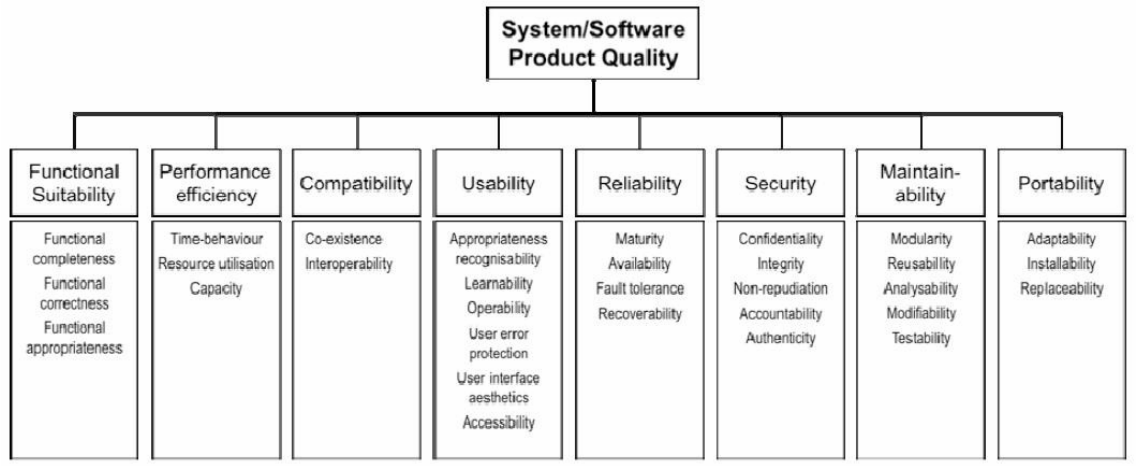

Figure 4: ISO/IEC 25010 quality model [13]

1.2 Previous research on the topic

Ameller et al. [14] presented a vision paper on the impact and possible ways to deal with NFRs in MDD processes. An ongoing review on the adoption of MDD in service-oriented system design includes a research question focusing on the consideration of NFRs in the surveyed primary studies [15]. These works are based on literature surveys. If we adopt a practitioners' oriented perspective, the following works studying the adoption of MDD in industry have been found in the literature (see Table 1):

- *Hutchinson et al. [16-21] (2011-2014).* This study targets the technical, organizational and social factors that apparently influence organizational responses to MDE. In other words, why and under which circumstances MDE is adopted by the industry.
- *Mohagheghi et al. [22-25] (2008-2013).* This study has also been published in several venues. Its target is to understand the perceived usefulness, ease of use and the tool maturity to be important determinants on the adoption of MDE.
- *Agner et al. [26] (2013).* This survey studies the Brazilian use of UML modelling and the factors that hamper or impair its use. The survey also collected data about the use of model-driven approaches for embedded software development in Brazil.
- *Torchiano et al. [27-30] (2011-2013).* The main goal of these papers is assessing the dissemination and relevance of software modelling and MD techniques in the Italian industry, to understand the expected and achieved benefits, and to identify which problems limit or prevent their adoption.
- *Forward and Lethbridge [31, 32] (2008-2010).* This work explains the reasons why the studied developers chose code-centric versus model-centric software engineering, and also gathered data about the notations and tools used.

None of the mentioned empirical studies have considered NFRs as part of their study, therefore we will not be able to compare the results obtained in our study related to NFRs with other empirical studies.

Table 1: Technical profiles of other empirical studies on MDD in practice

AUTHORS	INSTRUMENT	ANALYSIS	PARTICIPANTS	COUNTRY
Hutchinson et al.	e-survey, interviews,	Quantitative and	450, 22, and 3 (17 companies)	International

	case studies	qualitative		
Mohagheghi et al.	e-survey and interviews	Qualitative	Unknown (4 companies)	International
Agner et al.	e-survey	Quantitative	209	Brazil
Torchiano et al.	e-survey	Quantitative	155	Italy
Forward & Lethbridge	e-survey	Quantitative	113	International

1.3 Need to perform the study

There are several reasons to execute this study:

- *Unexplored territory*. To our knowledge, the empirical studies about MDD in practice have omitted studying how practitioners deal with NFRs.
- *Lack of approaches to handle NFRs*. Ameller et al. published a paper [14] in which it was mentioned the lack of support of NFR in MDD (based on a literature review), afterwards they corroborated in a systematic mapping on MDD for Service-Oriented Architecture (SOA) [15] that this lack of support is still persistent in the academic literature of MDD for SOA (only 31 of the 129 selected papers claim some NFR support), therefore this situation is probably even more dramatic in the industrial practice.
- *How NFRs in MDD are supported*. Dealing with NFRs is a major challenge in the software development and MDD is no exception; being supported or not by MDD approaches, practitioners have to deal with NFRs in one way or another.
- *Verify theories*. In Ameller et al. [14] the authors explained their vision on how the NFRs should be integrated into the MDD process and theorized about the impact that could have NFRs in the MDD process. Architecture was mentioned as a required intermediate model to handle NFRs.

1.4 Type of study

Among the variety of types of empirical studies (e.g., surveys, case studies, experiments) this empirical study will be a survey. Surveys (e.g., interviews, online questionnaires) are a common way for collecting qualitative and quantitative information [33]. Surveys provide a snapshot of the current state of the studied topic by collecting information to describe, compare, or explain knowledge, attitudes and behaviour [33]. Surveys aim at understanding a population from which a sample will be drawn.

This survey will include descriptive and exploratory intentions. Descriptive surveys are conducted to enable assertions about some population. They are designed to measure what occurred, rather than why. The concern is not why phenomenon exists, but what the phenomenon is. Exploratory surveys are used as a pre-study to a more thorough investigation.

1.5 Goal

The role of Non-Functional Requirements (NFRs) has been widely studied and always considered fundamental for the success of any software product. However, current Model-Driven Development (MDD) methods, techniques and tools have scarce support when dealing with NFRs. This is particularly true when we limit our scope to the available tools ready for production. Therefore, the reason for conducting this survey is to understand how companies deal with NFRs when they use MDD approaches. Following the Goal-Question-Metric approach [34], the goal of our study is defined as follows:

- *Purpose*: To explore, analyse, and characterize
- *Issue*: Dealing with NFRs

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- *Object*: MDD approaches
- *Viewpoint*: Companies

The expected outcome of this survey is a detailed understanding on *how companies handle NFRs when they use MDD for software production*.

1.6 Research questions

Based on the goal of the study we defined the following research questions:

Table 2: Research questions

RQ1	**In which context is MDD adopted by companies?**
RQ1.1	What factors motivate or discourage the adoption of MDD?
RQ1.2	Which types of NFRs are linked to these factors?
RQ1.3	To what extent are NFRs relevant for those projects that adopt MDD?
RQ2	**To what extent do MDD approaches adopted by companies support NFRs?**
RQ2.1	Which types of NFRs are supported by the adopted MDD approaches?
RQ2.2	Which characteristics do these NFRs exhibit?
RQ2.3	Which notations and tools are used for the supported types of NFRs?
RQ2.4	At which stages of the adopted MDD approach are these NFRs handled?
RQ3	**How do companies deal with NFRs when the adopted MDD approach does not support them?**
RQ3.1	How are MDD approaches customized to take into account the previously unsupported types of NFRs?
RQ3.2	How do companies deal with an NFR which is not supported by MDD?
RQ3.3	To what extent do the drawbacks of dealing with unsupported types of NFRs compensated by the benefits of adopting MDD?

The first RQ (RQ1) shall provide an overview of the context in which MDD approaches are used by European companies. In particular, we are interested in identifying the factors (e.g., speed up the development process, improve the reusability, better documentation) that motivate the adoption of MDD as the most suitable option (RQ1.1). Specifically, we want to search for links between these factors and specific types of NFRs (RQ1.2). Since our working hypothesis is that most MDD approaches do not handle any type of NFRs, with RQ1.3 we want to know if MDD is adopted in projects where the NFRs are less important than functional requirements, or whether relevant NFRs are already satisfied by the technologies or the infrastructure used. While RQ1.1 shall allow us to compare our findings with other surveys on MDD in practice (see Section 1.2), RQ1.2 and RQ1.3 aim at characterizing the participating companies with regard the topic of study.

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The second RQ (RQ2) is focused on understanding how NFRs are supported by the MDD approaches currently used by the participating companies. First, we want to know if there is any type of NFRs supported by the adopted MDD approaches used by the companies, and if so, which of them prevail (RQ2.1). For the supported NFRs, we want to determine: a) their characteristics, for example, how near or far the NFRs are from the solution, the granularity of their specification, etc. (RQ2.2); b) how are they represented in the models, for example, the languages or extensions used (RQ2.3). Also, we want to map the supported NFRs in the adopted MDD approaches, in particular against the stages at which the NFRs are handled (RQ2.4). As part of our study, we plan to compare the results of the survey to previously published findings to explore the relation to existing evidence.

Even if some types of NFRs might be supported by the MDD approaches adopted by companies, in most cases we expect to find only limited support [14]. For this reason, we aim with RQ3 at understanding the strategies used by the companies when they have to deal with those types of NFRs that are unsupported by the MDD approaches adopted in their context. Ameller et al. [14] envisaged two possible strategies: the first one is to adapt the MDD process so that it can account for the unsupported types of NFRs (RQ3.1) and the second one is to manually adapt the resulting artefact of the MDD process in order to satisfy the unsupported NFRs (RQ3.2). However, we expect that companies may well use other strategies, for example, postpone the NFRs for future releases, or simply remove the NFRs from the software product (RQ3.2). Finally, since all of these situations can affect the development, we want to better understand their impact from the point of view of the participating companies (RQ3.3), i.e., we want to determine if bearing the drawbacks due to the loose integration of NFRs into the MDD process is compensated by the benefits provided by MDD approaches.

2 SURVEY DESIGN

Following Ciolkowski et al.'s guidelines [1], the survey design should consider: the target population and the survey sample, the conceptual model of the objects and variables of the survey, the approach for data collection, the questionnaire design, the approaches for data analysis, and the validity issues.

2.1 Population and survey sample

Our population are the software companies. We do not restrict our population with regard to the company size or application domain, but we require experience using MDD in software projects. We deliberately avoided a more restrictive population in order to facilitate the selection of candidates and to avoid a narrow view on the topic of study. However, we require that the representative of each participating company has the adequate background in MDD (i.e., s/he has participated, at least, in one project that used MDD in the company).

Table 3 describes what would be the ideal participant and the minimum requirements to participate as representative of one company for this study.

Table 3: characteristics of the participants

	Desired	**Required**
Participant's MDD experience	Participation in many finished MDD projects (some with success others not) with different roles.	Participation in at least one finished and successful MDD project.

Participant's MDD projects characteristics	A project which includes most of the following elements: models, metamodels, custom metamodels, DSLs, custom DSLs, transformations, custom transformations, and generation of code. MDD is used as the main development paradigm in the project.	A project which includes all of the following elements: models, metamodels, and transformations. Projects that used MDD partially, e.g., only to define certain parts of the software can be accepted, but MDD cannot be a marginal part of the project.
Participant's role in the MDD projects	Technical with engineering background (e.g., software architect, software analyst, etc.) and management functions (project leader).	Technical with engineering background (e.g., software architects, software analysts, etc.).
NFRs	Any type of NFR. NFRs are handled within the MDD (fully integrated in the development process).	Any type of NFR.
Company size	Any size.	Any size.
Company domain	Any domain.	Any domain.

There are two major approaches for sampling, probability sampling [35] and non-probability sampling [36]. The sampling method used in this study is non-probability sampling. Our selection of candidates is made up by the national representatives using their known industrial contacts. Taking into account the geographical distribution of the participants, we consider that our sampling method is a good approach to obtain the sample of the target population. Since we do not have a sufficient theoretical basis to make estimates on the target population, we will limit our findings to the obtained sample rather than inferences over the population.

Sample matching techniques [36] are not applicable because, to our knowledge (see Section 1.2), the available studies on the target population are also based on non-probability samples. Therefore they could not be used to "match" the sample of our study. Network sampling techniques [36] such as *Respondent-driven Sample* are also discarded because they would difficult the execution of the study, and hardly guarantee probability sampling qualities.

The expected sample size is obtained from the number of participating countries and the number of interviews executed in each country. Our intention is having 9 participating countries and between 3 and 4 interviews executed in each country. This gives a sample size between 27 and 36 interviews.

2.2 Conceptual model

The main entities of study are companies, for which the participants will act as their representative. If a participant has experience in several companies, we will ask him to limit

his/her answers to MDD experiences in one single company of his/her choice.
To contextualize the answers, we will collect information about the company (e.g., its typical projects domains, and the company common practices with regard to NFRs). We are interested in the company experiences, therefore we will not limit the interview to one individual project experience.

We will also gather information about the participant. This information has two important uses: first to give better contextualized answers, and second to verify that we are interviewing the correct profile for this survey. In particular, as mentioned in Section 2.1, the participant should be an experienced member of the company who has actively participated in projects that used MDD to develop software (i.e., they had direct contact with the development activities such as modelling, writing or adapting the code).

A theory is a conceptual framework that allows the organization and structuring of facts and knowledge in a concise and precise manner. Theories should offer explanations of why certain phenomena occur in the sense of predicting them. In SE theories should, at least, be useful to the software industry. Sjoberg et al. [Sjoberg] suggests that the description of a theory should include constructs (basic elements, entities or instruments in terms of which a theory offers description, explanation, prediction or prescription).

For our study, we propose to define three types of constructs:

- Context constructs: elements related to the participant who will be interviewed and to the selected companies who will be analysed that may affect to the results of the study. See Table 4.
- Input constructs: elements related to MDD approaches applied for the companies (the object of the study, defined in Section 1.5) that have a direct impact on the output constructs. See Table 5.
- Output constructs: elements that allow giving answers to the research questions of the study (considering the issue dealing with NFRs, defined in Section 1.5). See Table 6.

Table 4: Context constructs

COSTRUCT	SOURCE Q
Participant education and MDD expertise	pre-interview form
Company MDD expertise	pre-interview form
Company application domain	pre-interview form
Company size	pre-interview form
Company understanding of MDD	Q1
Company understanding of NFRs	Q2

Table 5: Input constructs

COSTRUCT	SOURCE Q
Level of MDD adoption	Q3.a
Reasons that favour the adoption of MDD	Q4.a.b
Benefit/challenge factors for MDD	Q4.c.d
Reasons that make a project fit well or inadequate to adopt a MDD	Q5.a
Domain of projects that fit well to a MDD approach	Q5.b
Importance of NFRs in the projects that fit well	Q5.c

to a MDD approach	
Types of NFRs that fit well to or are inadequate for MDD	Q5.d.e

Table 6: Output constructs

COSTRUCT	SOURCE Q	RELATED RQ
Factors for MDD adoption	Q3.b Q4.a.b.c.d Q5.a.b	RQ1.1
Factors for MDD adoption related to NFRs	Q4.a.b.c.d Q5.d.e	RQ1.2
NFR relevance in MDD	Q5.c	RQ1.3
NFR handling (divided into four groups)		
1. NFRs supported by MDD, as it is	Q7.a.b.f.i	RQ2.1 RQ2.2
● *MDD techniques and tools with NFR support*	Q7.c	RQ2.3
● *NFR notation*	Q7.d.f.ii	RQ2.3
● *Types of models where NFRs are represented*	Q7.e.i.f.iii	RQ2.4
● *NFRs impact on MDD transformations*	Q7.e.ii.f.iii	RQ2.4
● *MDD flexibility thanks to NFRs*	Q7.e.iii.f.iii	RQ2.4
2. MDD process adapted by the company to support NFRs	Q8.a	RQ3.1
● *Types of adaptation*	Q8.b.c	RQ3.1
3. NFRs manually supported	Q9.a	RQ3.2
● *Types of manual modification*	Q9.a.b.c	RQ3.2
4. NFRs not taken into account	Q10.a.b.c	RQ3.2
Does MDD still pay ... (divided into three groups)		
1. When adapting MDD process to support NFRs	Q8.d	RQ3.3
2. When NFRs are manually supported	Q9.d	RQ3.3
3. When excluding NFRs	Q10.d	RQ3.3

Figure 5 provides an explicit model representing all the defined constructs using a UML class diagram.

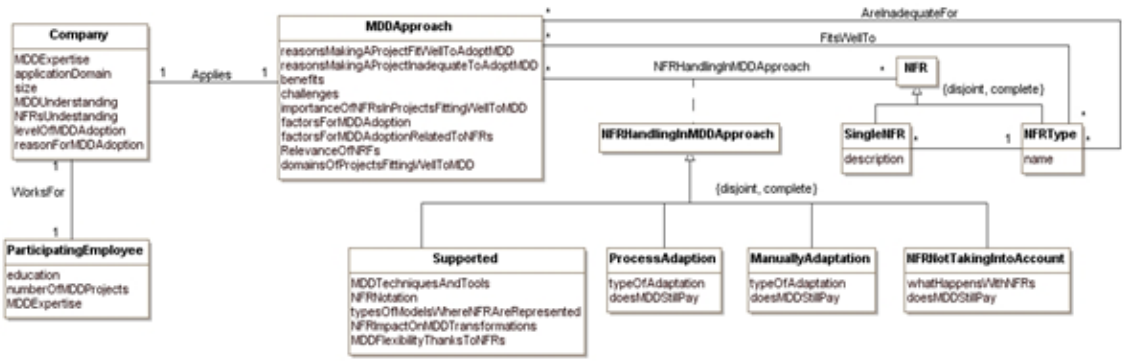

Figure 5: Theory model

2.3 Data collection

The data collection instrument, will be face-to-face interviews, which gives us the possibility to get the participant answer our questions without skipping any question (providing clarifications when necessary). Also, it is possible for the interviewer to observe and ask questions to the participants to extend their responses (e.g., to understand the reasoning of the participant, or to go deeper into the details).

Specific details with regard to the data collection of this study are:

- *Data format*: each interview will be recorded and transcribed unless some concerns about privacy arise, which will be handled in a case-by-case basis.
- *Language*: the questionnaire will be provided in English, but since the interviews will be executed by local researchers, we leave the decision to the interviewer and the participant to execute the interview in the language of their choice.
- *Data verification*: the transcription will be validated by the participants and they will be allowed to make amends to their answers.
- *Translation*: If the selected interview language is different from English, the transcribed interview must be translated to English.
- *Translation verification*: The translation will be validated by the interviewer or the local domain expert who will know the correct translation of the terms specific to the field of study.

Specific details on how the data will be collected during the interviews execution are described in Section 4, *Survey execution*.

2.4 Questionnaire design

In this section we describe the characteristics and the design method of the questionnaire. The questionnaire of this study is presented in Section 3, *Survey implementation*.

The questionnaire will be designed as a way to answer the research questions of this study (see Section 1.6). It will contain a list of questions separated in three sections corresponding to the three major research questions.

The questionnaire will contain the following kinds of questions:

- *Open-ended questions*: most of the questions will be open questions (i.e., no specific set of answers will be provided to the participant). This is the typical kind of question in exploratory surveys [1].
- *Closed questions*: there will be several closed questions (also known as pre-coded questions) that will require that the participant states a concrete answer (e.g., Yes/No questions). These questions will be used for frequency analysis. This kind of questions is typical in exploratory and descriptive surveys [1].

The two kinds of questions can be combined, e.g., an open question may require the participants to provide a concrete position after providing their own answer.

We followed the writing recommendations given by Dillman et al. [35] to reduce the common mistakes when designing a questionnaire (e.g., keep positive and negative sides in the questions; questions polarized to one side can bias the responses).

The questions have been complemented with extra information for the interviewer. This is especially important for open questions, where the participant's answer may not cover all the aspects targeted by the question. This extra information will help the interviewer to reorient the participants' answers to the topics of interest of the study and also will help to reduce the

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interviewers' bias. This strategy is fundamental in a case like this study, in which the interviewers will be different and furthermore, located in geographically distant places.

The design of the questionnaire also contemplates an iterative approach for its piloting divided into two phases with the objective of improving quality aspects such as suitability, understandability, and correctness. The two phases are (see Figure 6):

1. *Internal pilot*: the questionnaire of the survey will be piloted, and identified problems will be revised accordingly.
2. *Real case pilot*: the questionnaire will be tested with participants from target population. The questionnaire will be adapted as required (e.g., participants will be asked to explain their understanding of the questions to ensure that questions were understood).

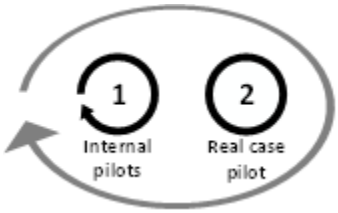

Figure 6: Pilot iterations

2.5 Data analysis approach

This survey is descriptive and exploratory (see Section 1.4), therefore the obtained data will be analysed using basic descriptive analysis and content analysis.

- *Basic descriptive analysis*. Frequency analysis and comparison of different variables. The use of statistical correlation analysis may not be feasible due to the expected sample size.
- *Content analysis.* We will identify categories using coding techniques, and we will use qualitative analysis techniques (which often work well with small samples) such as summarizing, explaining, and structuring [37].

The basic descriptive analysis will fit well for the results obtained in closed questions while the interview transcriptions will be analysed with content analysis because the interview contains open-ended questions. However, both types of analysis will be used together when necessary; for example, since the interviews will be semi-structured, we may require content analysis for a closed-ended question, or we may find adequate to use basic descriptive analysis after the content analysis for the identified categories.

The concrete analysis plan for this study is defined in Section 5, *Survey analysis*.

2.6 Threats to validity

Every empirical study is subject to validity threats. The threats mentioned in this section are inspired from the well-known books on empirical studies (e.g., [1, 35, 38, 39, and 40]), while others come from the experience of the authors of this study. We classified the threats into internal, external, conclusion, and construct validity as defined in the book by Wohlin et al. [38].

2.6.1 Internal validity

- *Understandability problems.* Some questions may be understood differently of what they are intended for resulting in lower quality answers, or even not valid answers. As mitigation the questionnaire was designed following the indications given by Dillman et al. [35] and will be piloted in several iterations to ensure its understandability.

- *Language problems.* The language used during the interviews will be chosen by the participant, therefore, in some cases, we will need to translate the transcription of the interview. Some information may be lost, or not well translated, especially for technical terms. As a mitigation, the translation will be verified by the local researchers.
- *Insufficient knowledge of the participant.* Having a wrong profile participating in the survey may result in lower quality answers, or the inability of the participant to provide an answer to some questions. As mitigation our criteria selecting the participants is that they are practitioners with experience using MDD for the development of software products in the current company.
- *Untruthful answers.* Participants may be reluctant to provide sincere responses when they have to explain negative aspects about their work and their company. In order to minimize this situation, when the survey is executed, we will inform to the participants that the data collected will be used anonymously and that the purpose of the interview is not evaluate them or their company.

2.6.2 External validity

As it is the usual case in interview-based surveys, the sample size and the sampling technique used do not provide the statistical basis to generalize the results to the target population. The results should yield, however, an initial theory which can be used to steer future research.

2.6.3 Experimental validity

- *Interviewers' bias.* Due to the context of this study, the interviews will be executed by several different interviewers, therefore there is a risk that the interviewers conduct the interview in different ways (e.g., making more emphasis on some parts than others). As countermeasure we are documenting the material used for the execution of the survey, including a guide for the execution of the interview. We expect to reduce this threat because the guide will provide instructions for all the interviewers of the study.
- *Replicability of this study.* Once the study is finalized, the protocol, and all the related material used to perform this study will be made available under CC-BY (creativecommons.org/licenses/by/4.0) license. The open character of our project will support researchers and practitioners to replicate this study, and, in the long run, to generalize and verify the results.

2.6.4 Construct validity

- *The underlying methodology is not robust.* The protocol may be incomplete, or provide insufficient details for the success of the project. To guarantee a solid foundation, we have followed Ciolkowski et al.'s guidelines [1]. These guidelines cover the most important aspects to be considered when performing a survey. As result, we defined this detailed protocol.
- *The questionnaire used to drive the semi-structured interview is not well linked to the research questions.* Missing important data during the interviews may lead to the impossibility to provide an answer to some of the research questions. To verify the suitability of the questionnaire, we have related each question in the questionnaire with one or more variables (to be used for the analysis), and, these variables with the research questions (one variable may provide insightful information for more than one research question). We are currently working on a conceptual model that clarifies the relationships between the variables (e.g., context, input and output factors of the

MDD process), which we will use as the foundation for our research questions. The model will be available in the next iteration of the protocol.

3 SURVEY IMPLEMENTATION

The survey implementation consists in the following material:

- *Invitation letter*. This is the general proposal for invitation to participate in the survey. Each national contact can adapt or translate it, but the essential information of the letter needs to be kept (e.g., the requirements to be a participant, the expected duration of the interview, the fact that it will be recorded, etc.).
- *Participant form*. Form to gather basic information of the participants and the company which they belong to.
- *Questionnaire*. This document includes the detailed list of questions and the notes for the interviewer.

This material is available in the common repositories of the study (see Section 3.1).

3.1 Common repositories

This study will have two repositories shared by all the researchers: 1) the consolidated repository, managed by the UPC, will contain the consolidated versions of the documents and the material used in the study; 2) the working repository, where all the researchers can comment and modify the contents of the documents.

- *Consolidated repository*. This repository will be a *Dropbox* folder with the following access rules:
    - Only UPC can modify its contents.
    - UPC will be responsible of keeping that last consolidated versions of the documents and material of the study. The process will be as follows:
        1. UPC will create a new version of the document from the contents in the working repository.
        2. Conflicting changes will be resolved by the UPC.
        3. The consolidated version will be made available in the working repository for further changes.
- *Working repository*. This repository will be a shared folder through *Google Drive* to facilitate discussion among researchers.
    - All the researchers involved in the study can add comments or modify the documents.
    - Every researcher should be responsible of closing their own comments when resolved.

4 SURVEY EXECUTION

The execution of this study has one particularity: there will be different interviewers involved in different interviews. Therefore, there is a threat to validity of having different interviewing styles, different degrees of interaction, different subjective positions, and even different understanding of the concepts involved in the study. To mitigate this situation we have done the following actions:

- *Annotated questionnaire*. The notes added to the questions will help to the interviewers to have a common reference to extract the same information from all the participants.

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- *Execution guidelines*. Guidelines with general advises to execute interviews, and in particular semi-structured interviews. Keeping them in mind will help having the same interaction with the participant. These guidelines are in the form of meta-text embedded in our interview questionnaire.
- *Meetings*. Before starting the execution of the survey we will schedule a meeting with all the interviewers using teleconference means to clarify any question regarding the execution procedure.

The questionnaire and the execution guidelines are available in the common repositories of the study (see Section 3.1).

4.1 Survey execution steps

The survey execution consists of the following steps:

1. *Contacting the participants*. The invitation letter will be sent to potential participants in the survey.
2. *Acceptance and scheduling the interview*. The scheduling of the interview shall take into account the general agenda of the study. Company employees normally prefer to be interviewed in their own premises.
3. *Preparing the interview*. Before the scheduled date, the participant will be provided with the questionnaire of the interview and, if necessary, a description of concepts subject to misinterpretation (e.g., NFR, NFR type, etc.). Along with the questionnaire, a form to be filled with the basic information of the company and the participant will be provided. This form can be filled before the interview or the day of the interview.
4. *Perform the interview*. The interviews shall be recorded unless some concerns about privacy arise. However, the participants will have the chance to change their statements when they verify the transcriptions (they must be informed of this before starting the interview). They must be informed also that the data obtained will be treated anonymously. Face to face interviews are highly preferred over teleconference interviews, which will be used only exceptionally. More details in this step are provided in the execution guidelines.
5. *Transcription of the interview*. For the data analysis we will need a literal transcription of the interview in plain text. Each national representative is responsible to ensure a transcription of high quality. The language for the data analysis will be English, therefore translation and translation validation might be necessary in some cases (see Section 2.3).

4.2 Duration of the interview

The interview should take approximately one hour. We will obtain a precise timing when we pilot the questionnaire, however we can expect some variability (i.e., some interviews will be shorter or longer than others).

5 SURVEY ANALYSIS

In this section will be defined the analytical instruments that will be used, and the variables used by these instruments. The contents of this section will be available in a next iteration of the protocol when the potential data to be analysed becomes clearer (e.g., the protocol is reviewed, questionnaire finalized, pilots, etc.).

We envisage the use of some tool to support the data analysis (e.g., QDA Miner Lite). Still to be decided.

A general view of the analysis can be found in Section 2.5.

6 SURVEY PACKAGING

The results of the survey will be internally published as a report, and externally as one or more paper publications in journals and/or conferences. The internal report will be also made available to the participants that are willing to receive the results of the survey.

The planned agenda for this study is described in Section 6.1. As in any endeavour of this ambition, slight adjustments may occur, but it is crucial for the success of the study that they are short, exceptional and for justified reasons.

The publications (including the internal report) must comply with the authorship and legal issues described in Section 6.2.

6.1 Planned agenda

The expected agenda for this study is:

December 15th 2014 to January 31st 2015 (1.5 months)

- **Task:** Complete the research team
- **Task:** Complete and share the first version of the protocol
- **External**: Accept invitation and read the first version of the protocol
- **Milestone**: Research team closed

February 1st to April 15th (2.5 months)

- **Task:** Discussion and review of the protocol among all the participants
- **Task:** Produce a consolidated version of the protocol and questionnaire
- **Task:** Execution of pilots (internal and external)
- **Task**: Selection of participants
- **External**: Selection of candidate participants
- **External**: Revise and provide feedback on the protocol and questionnaire
- **External**: ensure the engagement of industry participants
- **Milestone**: Study ready to be conducted

April 16th to July 15th (3 months)

- **Task**: Precise description of the data analysis added to the protocol
- **External**: Conduct the interviews
- **External**: Prepare the transcriptions
- **External**: Validate transcriptions with the industry participants
- **Milestone**: Data collection finalized

Summer break (1.5 months)

September 1st to November 31st (3 months)

- **Task**: Review and align the data gathered
- **Task**: Data analysis
- **Task**: Produce a report with the results
- **External**: Provide the required clarifications on the data gathered
- **External**: Provide feedback on the data analysis shown in the report
- **Milestone**: Data analysis completed and results reported

December 1st to December 15th (0.5 months)

- **Task**: Identify papers and venues
- **Task**: Define the time schedule for the publications
- **External**: Participate in the planning
- **Milestone**: Publishing plan completed

Starting January 1st 2016

- **Task**: Paper writing
- **Task**: Paper internal reviews
- **External**: Provide feedback while the paper(s) grow and write selected short sections

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- **Milestone**: Paper(s) incrementally submitted

6.2 Authorship and legal issues

6.2.1 Authorship

All the documents and publications produced by this study will be authored by:

- The three first authors will be the three GESSI@UPC researchers, in alphabetical order.
- The national representatives will appear next, also in alphabetical order. For every country, we normally will have one national representatives but occasionally there are two.
- Last, the researchers supporting the national representatives will appear next, in alphabetical order too. Similarly, it is expected that for every country will be one supporting researcher, but occasionally there are two.

In total, every country should have no more than three participants.

6.2.2 Legal issues

All the material produced in this study (interviews, transcriptions, reports, analysis documents) will become a common asset for the previously mentioned authors. Meaning that, after concluding this study and producing all the planned publications, the authors may use this material for other research. The only requirement is to provide an acknowledgment to the origin of the material, i.e., this study.

All documents (e.g., protocol and questionnaire) will be made available under Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/). If possible, papers resulting from this study will be published under open access policy.

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