A Feature-based Process for Effective Stakeholder Management in Software Product Development

Karam Ignaim and João M. Fernandes

***Abstract*—Successful product development is mostly dependent on how well contributions from stakeholders are taken into account. There are signs that the way stakeholders are involved in a project is directly linked to how well software products are delivered. Engagement of stakeholders enables organisations to proactively consider the requirements and expectations of anyone with a stake in the product under development. For a given stakeholder management process (SMP) to work well, it is recommended that all stakeholders be listed in a reference document, and their involvement in the process to be kept up-to-date. For this purpose, this study presents a solution to this problem by coming up with a feature-modelling-based stakeholder management process (FM-SMP) for capturing and documenting the right stakeholders during the SMP. The FM-SMP supports ongoing monitoring of the status and attributes of stakeholders during this process. This manuscript includes the description of a case study on smart homes, where the proposed FM-SMP was adopted and evaluated successfully. The result of the case study reveals that the use of FM-SMP improves the ability of software engineers to effectively and precisely identify the appropriate stakeholders, thereby enhancing end-user satisfaction in software product development.**

***Index Terms*—Stakeholder management process, Feature model, Feature model refactoring, Software product.**

I. Introduction

A PERSON who has a legitimate interest in a given system is considered a stakeholder [1]. It is important to interpret the term "person" broadly to include not only individuals but also groups of people and even organisations. The concept of interest is equally broad and might arise from using the system, from being impacted (benefited or injured) by it, or from having some sort of responsibility for it. Stakeholders are not just the end users [2], but include anybody with an interest in the system, like, operators, developers, architects, consumers, and testers.

Without engaging key stakeholders, project managers may overlook important perspectives and fail to address potential issues. This can lead to resistance and conflict later in the project, hindering progress. Stakeholder selection is the process of identifying appropriate stakeholders to elicit requirements for a certain product [3], [4]. Stakeholder management is an iterative process that eases the identification and documentation of the stakeholders [5].

Manuscript received February 7, 2024; revised August 4, 2024.

Karam Ignaim is an assistant professor at Department of Software Engineering, Al Balqa' Applied University, Salt, Jordan; karam.ignaim@bau.edu.jo 0000-0001-8650-8021.

João M. Fernandes is a full professor at Centro ALGORITMI/Department of Informatics, University of Minho, Braga, Portugal; jmf@di.uminho.pt 0000-0003-1174-1966.

This work was supported by FCT—Fundação para a Ciência e Tecnologia within the R&D Units Project Scope UIDB/00319/2020.

A. Problem statement

The selection of appropriate stakeholders in a software project is a critical stage and a prerequisite for the requirement elicitation task. When compared to other viable options for requirements, stakeholders are by far the most essential [4]. Typically, stakeholder elicitation often starts with suggestions from management or domain experts about who the relevant stakeholders are and what they want [6], [7]. When working with constrained resources, it is important to choose the most suitable stakeholders for requirement elicitation [8]. If stakeholders do not receive sufficient attention from the software engineer, they may be too critical about the product development process [9]. This implies that the different stakeholders must be appropriately mapped through user management and access rights administration. Studies have shown that improper stakeholder selection typically results in a poor requirement elicitation procedure. Such occurrences would afterwards have severe effects on the product development process, including expensive rework, timetable overruns, and poor software [4], [10].

The process of stakeholder identification during requirements elicitation is often inadequately managed and underappreciated inside software projects. A possible reason could be that the process is perceived as an inherently straightforward undertaking, with the primary stakeholders being limited to the immediate users and the development team. This is a common problem and there is a lot of confusion about why software companies often forget about or ignore indirect stakeholders in the development of software applications.

Software engineers employ traditional techniques and strategies, such as focus groups, interviews, and snowball sampling, to identify stakeholders [3]. In addition, correctly identifying stakeholders is the first step in attaching the system interests together and correctly identifying the problem at hand [11]. The identification of stakeholders is of the utmost significance for reducing the uncertainty of the validity of a system. Stakeholder identification has received less attention in the software engineering literature, as indicated for example by Khan et al. [12], despite its significance in requirements elicitation. Keeping in view the importance of key stakeholder identification for requirements engineering, we propose a feature-modelling-based stakeholder management process (FM-SMP) for stakeholder management in software development projects. We also conducted a case study to evaluate its effectiveness in terms of ease of use and usefulness from software engineers' perspective.

B. Objectives

This study addresses the identification of stakeholders by proposing a featuremodelling-based stakeholder management process (FM-SMP) with the aim of capturing, documenting, and monitoring stakeholders from the start of a software project until its closure. The findings of research indicate that selecting stakeholders with appropriate characteristics, such as the stakeholder's role, knowledge, interest, communication skills, and personality, has significant effects on the requirements elicitation phase [9]. This work aims to enhance the SMP with Feature Models (FMs). FMs represent stakeholder involvement in the SMP, which influences the appropriate stakeholder selection with respect to the requirement elicitation process. Our study does not use FMs to represent software product lines [13], as is typical. Instead, we aim to exploit FMs to document stakeholders in a reference artefact to support their engagement in software product development through continuous monitoring. A common way to get information is through stakeholder analysis, which involves getting to know the stakeholder well and finding out things like who they are and what their attitudes and interests are [14].

Prioritising stakeholders requires taking into account the myriad ways in which they can contribute to the product development process. The prioritisation of stakeholders was found to regularly make use of various attributes in the associated studies, in particular, type, interest, level of influence or impact, level of understanding, capacity for interpersonal involvement, and relationship. Few studies have examined stakeholder selection using stakeholder prioritisation [15]; thus, we decided to include this issue in our own research.

II. Background

A. Stakeholder management process

Fig. 1 shows how the stakeholder management process (SMP) works in a given project. The process has four major steps, which are conducted by the software engineers:

1) **Identify the stakeholders**. The software engineers do not need to collect all the stakeholders, but they must identify the most important ones. There are numerous methods for accomplishing this, including the so-called content analysis and brainstorming [4].
2) **Capture and document the stakeholders in a reference document**. Typically, this step is accomplished using a document, such as the Stakeholder Register or the Stakeholder Influence Matrix.
3) **Analyse and classify the stakeholders**. This is accomplished by utilising a variety of metrics and techniques; the most frequent method involves determining each stakeholder's level of power and interest in the project.
4) **Engage each stakeholder**. This step focuses on determining the optimal frequency and method of communication with each individual.

This process is iterative, which means that it can be repeated as many times as needed. Thus, software engineers continue identifying, documenting, analysing, classifying, and implementing engagement during the project, which is referred to as **monitor and update**.

B. Feature models

FMs are represented by feature diagrams, whose essential notations are shown in Fig. 2. Features represent the functionalities or characteristics of the software product. Each

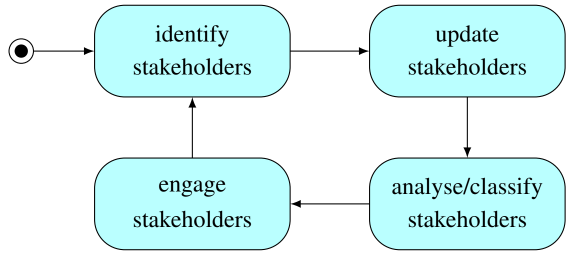

Fig. 1. Major steps of the stakeholder management process (SMP).

feature can be either mandatory or optional. An optional feature may or may not be included in a particular product variant, while a mandatory feature is always present in every product variant. Abstract features represent general or high-level characteristics of the software product. They are used to structure an FM, but they do not have any impact at the implementation level. Contrarily, a concrete feature represents a specific functionality of the software product and is directly implementable. Concrete features are at the lowest level in the hierarchy of the FM. Groups represent variability among features. An alternative group represents a set of features, where only one feature can be selected for inclusion in a particular product variant. In an OR group, one or more features can be selected for inclusion in a product variant. Collapsing a feature hides its subtree to ease the visualisation. The number inside a rounded rectangle indicates the number of features in the subtree of a collapsed feature.

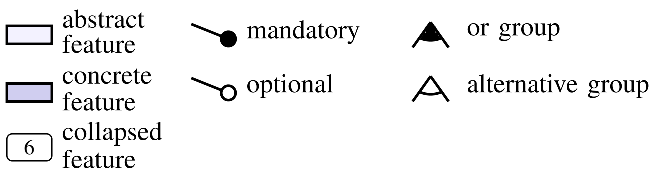

Fig. 2. Notations for FMs.

FMs are commonly used to represent the commonality and variability of a product in terms of mandatory, optional, and exclusive features, as well as propositional constraints over the features. Engineers typically use FMs to represent features and their connections in a tree-like structure. FMs provide various modelling notions for this purpose, such as mandatory and optional features, a feature hierarchy, feature groups, and cross-tree constraints. Fig. 3 shows a demo example for the "Car" FM. There is always a single root feature present in every FM. The "Car" is the name of the root node. The "Car" FM supports "Engine" and "Brake" common features. A common (or mandatory) feature is present in all members of a family. "Engine" is available as "Hybrid," "Petrol," or "Electric," while "Brake" as "Regenerative" and "Drum". These features available on an optional basis. In contrast, a feature like "Music Player" is optional, since it is not present in every member of a family. Features could also be grouped using "Or" (such as "CD" or "Cassette") or "Alternative" (such as "Hybrid", "Petrol", or "Electric"). The dependence relationships between model features can be described as "requires," indicating that selecting one feature requires selecting another, or "excludes," indicating that two features mutually exclude one another. For instance, the "Electric" engine of the "Car" requires a "Regenerative" brake type (i.e., "Electric" requires "Regenerative").

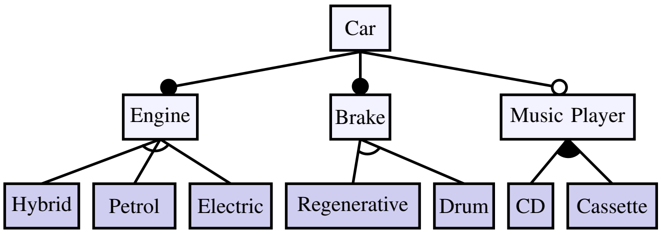

Fig. 3. FM of the "Car".

Extended FMs offer more information through the use of feature attributes or parameters [16]. An attribute of a feature is any measurable property of the feature that can appear in complex cross-tree relations. Using the attributed FM, every feature may have one or more attributes with a domain value type like Integer, Double, String, or Boolean. Thus, attributes of a specific feature can enhance the graphical FM with such information. Fig. 4 depicts a portion of the FM in Fig. 3 with attributed features and our unique notation, inspired in the work presented by Benavides et al. [17]. As certain features contain attributes or parameters, Fig. 4 shows the simplified version of the attributed FM for the "Car" FM (presented in Fig. 3). The upper side of the picture depicts the FM, while the lower side depicts the attribute "HEV" (Hybrid Electric Vehicle) of the "Hybrid" feature, where possible values for the attribute are "mild-hybrid", "full-hybrid". The value of the "HEV" attribute in this example is "fully-hybrid".

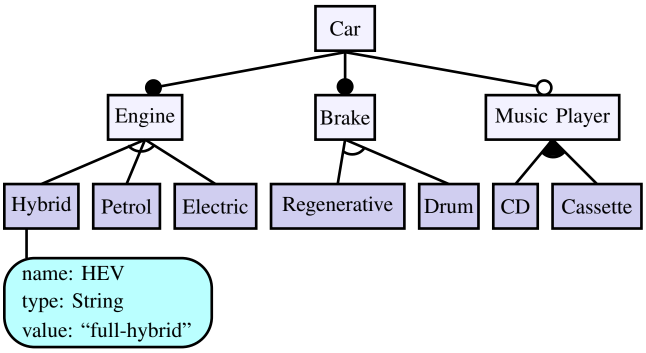

Fig. 4. Attributed FM of the "Car", presented in Fig. 3.

III. Related Work

The aim of this section is to give an overview of the SMP during the requirements elicitation phase.

A. Stakeholder importance

Stakeholders can be involved at any phase of the development process. Many studies have been conducted in this subject to offer strategies for increasing the effectiveness of stakeholders' participation in the product development process. Anwar and Razali [4] confirm that improper stakeholder selection can be the primary cause for software project failure. To tackle this problem, the authors developed a model for identifying appropriate stakeholders based on criteria such as stakeholder role, knowledge, interest, and communication competence. The results of the statistical analysis revealed that all independent variables were statistically significant, with the exception of stakeholder interest. This model assists project managers in determining which stakeholders should be chosen based on their characteristics. This study is considered in this manuscript to construct the stakeholder FM with suitable stakeholder attributes (referred to as characteristics in [4]).

Razali and Anwar [18] stress how important it is to have the right stakeholders during the requirement engineering phase, since mistakes made during this phase can cause the project to fail. Through a content analysis of the chosen literature, the elements of a successful stakeholder selection procedure were determined. The elements were developed as a procedural framework for the methodical selection of stakeholders that includes three steps: identifying, filtering, and prioritising. The first phase classifies the project stakeholders according to their roles, stakeholder types, and project definition. The second phase assesses the mental ability of the stakeholders, meaning their knowledge and interest. In the last phase, stakeholders are selected based on their interpersonal abilities. The framework might serve as a guide for future research by highlighting the crucial features that require additional study. This study also influences our research about the types of stakeholders that might be considered and the selection and ranking of stakeholders.

McManus [19] confirm that successful software engineering projects result when stakeholders care about the issues and are aware that their contributions are valued. The author claimed that the effective execution of software projects is directly tied to how the project manager includes stakeholders in the decision-making process. Thus, the author discussed the amount to which stakeholders participate in the project management process and the extent to which stakeholders impact it. The findings of this study indicate that the existing literature devotes considerable attention to identifying stakeholders and assessing the extent and quality of stakeholder participation but very little attention to assessing the costs and benefits of stakeholder participation.

Polonsky and Michael [20] examine how to employ the SMP and the stakeholder matrix when developing marketing strategies. Most marketing theories recognise the need to design strategies that satisfy the demands of the stakeholders, but the author contends that present marketing theories do not employ the stakeholder management approach. Marketers should be able to design more effective marketing strategies by knowing and utilising stakeholder theory. While management literature on stakeholder theory is rich, marketing material on this topic is scarce, thus, Polonsky and Michael seek to partially address this gap. Our FM-SMP also supports the employment of SMPs when developing a software product by using an artefact called the stakeholder FM.

The research by Sutterfield et al. [21] shows that stakeholder theory is a useful way to look at the behavioural parts of project management. The authors also believe that the agendas of diverse stakeholders within the organisational structure might pose obstacles to projects. When this occurs, a solid stakeholder management plan must be implemented to maximise the likelihood of project success. This is a case study of a failed Department of Defence initiative that was properly justified and urgently required. This case analysis explores the potential causes of the project failure by applying stakeholder theory as its theoretical foundation. The failure-learned project management lessons and a project stakeholder management FM-SMP framework are offered to aid project managers in making better decisions and raise the likelihood of successful project management outcomes.

B. Stakeholder management process

Freeman [22] suggests that project managers should prioritise stakeholders based on their level of power, legitimacy, and urgency. This approach helps project managers allocate resources and efforts more effectively, focusing on stakeholders who have the most influence on the success of the project. Additionally, effective stakeholder management can minimise conflicts, enhance communication, and facilitate collaboration, leading to smoother project execution and increased stakeholder satisfaction. By prioritising stakeholders based on their power, legitimacy, and urgency, project managers can effectively address their concerns and make informed decisions that align with the project objectives. The limitation of this work is that it relies heavily on effective communication and cooperation from stakeholders. If stakeholders are not willing to engage or provide the necessary information, it can hinder the ability of the project manager to effectively address concerns and make informed decisions. Additionally, if stakeholders have conflicting interests or priorities, it may be challenging to reach consensus and alignment on project objectives.

Emshoff and Freeman [23] suggest that effective stakeholder engagement is crucial for project success. They argued that involving stakeholders in the decision-making process and addressing their concerns, project managers can build trust and collaboration. This increases the likelihood of achieving project objectives and mitigating risks. Thus, project managers should prioritise open communication, stakeholder analysis, and ongoing engagement to ensure the smooth execution of projects. A limitation of this work is the potential for conflicting stakeholder interests. This limitation highlights the need for effective stakeholder analysis and ongoing communication to identify and manage potential conflicts, ensuring that project objectives are still met while addressing the concerns of all stakeholders involved.

Caputo [24] looks at the real estate industry stakeholder management system while thinking about theories on how people negotiate and make decisions. He conducted a comprehensive evaluation of studies from real estate and management literature to organise what he already knew about stakeholder management. According to Caputo, an external stakeholder should do the following: (1) identify external stakeholders; (2) estimate external stakeholder needs and interests; (3) consider the potential impact these can have on project decisions; and (4) evaluate project implementation solutions while respecting stakeholders' interests. In addition, groupings of stakeholders and the nature of their effect may change substantially over time, necessitating an iterative method for addressing this matter. The systematic approach to stakeholder management enables managers to organise and assess information on stakeholders and their influence on project decisions. Therefore, their impact also depends on the expressed demands of interested parties and the level of satisfaction they obtain, without compromising the project primary purpose.

C. Stakeholder identification

Stakeholder identification includes the process of identifying all the individuals, groups, or organisations that have an interest in the project [3]. This step involves conducting interviews, surveys, and analyses to gather information about potential stakeholders. Both internal and external stakeholders must be identified to ensure all perspectives are considered. Stakeholder types are typically categorised as primary, secondary, and external [18]. The project team, clients, and end users are the project primary stakeholders. Secondary stakeholders have an indirect interest in the project, such as regulators, suppliers, and shareholders. External stakeholders have a general interest in or potential impact on the project, such as the local community or media. By identifying and understanding the different types of stakeholders, project managers can effectively manage their expectations, address their concerns, and ensure their involvement.

Mitchell et al. [25] highlight the importance of stakeholder identification in the context of new ventures. They argue that identifying stakeholders is crucial for entrepreneurs as it helps them build relationships, gain support, and acquire resources for their ventures. Additionally, the author emphasises that understanding the different types of stakeholders enables entrepreneurs to align their goals and interests, leading to successful project outcomes.

Elneel et al. [26] found that stakeholder identification plays a crucial role in the success of e-learning systems. By involving all relevant stakeholders, such as teachers and students, entrepreneurs can ensure that the system meets the expectations of all parties involved. This leads to higher user satisfaction and increases the long-term success of the e-learning platform. The study highlights the importance of ongoing communication and collaboration with stakeholders throughout the development and implementation process to address any potential challenges and ensure smooth operation of the system. The findings of this study provide valuable insights for organisations and developers looking to create and implement effective e-learning platforms.

D. Stakeholder analysis

Stakeholder analysis involves assessing the level of influence, power, and interest each stakeholder has in the project. This step helps prioritize stakeholders and determine how to effectively engage with them. By analysing stakeholders, project managers can identify potential advocates, blockers, or decision-makers and tailor their communication and engagement strategies accordingly [27]. Overall, stakeholder identification and analysis are crucial steps in the SMP during the requirements elicitation phase. They enable project managers to understand the potential impact and influence stakeholders may have on the project. This understanding allows project managers to allocate resources and prioritise stakeholders based on their level of importance. By effectively engaging with stakeholders, project managers can build strong relationships and ensure their needs and expectations are met, ultimately leading to successful project outcomes. Without proper stakeholder identification and analysis, project managers may face challenges in gaining stakeholder support and may encounter resistance or opposition throughout the project lifecycle.

Kaginalkar et al. [28] highlight the importance of stakeholder engagement in designing a successful data governance ecosystem for smart cities. By involving stakeholders in the early stages of the project, project managers can gather valuable insights and expertise, ensuring that the designed ecosystem meets the needs and expectations of all stakeholders involved. This collaborative approach not only increases the chances of successful implementation but also fosters a sense of ownership and commitment among stakeholders, leading to the long-term sustainability and effectiveness of the governance system. Without the involvement of stakeholders, the project risks becoming disconnected from the realities and needs of the community, leading to potential resistance, conflict, and ultimately, project failure. Therefore, it is crucial for project managers to prioritise stakeholder engagement from the beginning, ensuring a comprehensive understanding of the ecosystem and fostering a collaborative environment for success.

E. Stakeholder prioritisation

Sharpe et al. [29] developed a framework to help project managers prioritise stakeholders based on their level of influence, interest, and impact on the project. By engaging key stakeholders early on, project managers can gather valuable insights, address concerns, and build strong relationships that enhance project success. This approach helps in managing potential resistance and conflict and ensures that the project aligns with the expectations of the community, increasing the likelihood of achieving the desired outcomes. This work suffers from a lack of stakeholder involvement.

Guaita-García et al. [30] describe how stakeholder analysis is a critical tool for understanding the needs and interests of various groups involved in a project. By identifying and prioritising stakeholders, project managers can effectively communicate and collaborate with those who have a vested interest in the project. This ensures that the project aligns with the expectations and goals of the community, fostering a sense of ownership and support. Through stakeholder analysis, project managers can also identify potential conflicts or challenges early on, allowing for proactive measures to address them and minimise negative impacts. Ultimately, this comprehensive approach to stakeholder engagement enhances the likelihood of achieving desired project outcomes and long-term sustainability.

Khatri-Chhetri et al. [31] present a framework to prioritise climate-smart agriculture interventions based on stakeholder preferences and needs. The framework takes into account various factors, such as the potential impact on food security, adaptation to climate change, and mitigation of greenhouse gas emissions. By involving stakeholders in the decision-making process, the framework aims to ensure that the selected interventions are both effective and acceptable to the local community. This approach recognises the importance of engaging stakeholders in sustainable development initiatives and acknowledges their expertise and perspectives. One limitation of the work is that it may be time-consuming and resource-intensive to involve all relevant stakeholders, particularly in large-scale projects. Additionally, there may be challenges in identifying and including marginalised or vulnerable groups who may have limited resources or access to decision-making processes. However, despite these limitations, involving stakeholders in the decision-making process can lead to more informed and inclusive solutions that address the diverse needs and concerns of the community.

Related studies frequently use a number of attributes to prioritise stakeholders, namely type, power, interest, and interpersonal skills were identified as key factors in determining the importance of stakeholders. Khatri-Chhetri et al. [31] found the elements that are used to prioritise stakeholders include their level of influence or power, their level of interest or involvement in the decision-making process, their expertise or knowledge in the relevant subject matter, and their ability to effectively communicate and collaborate with others. Additionally, the author highlighted the importance of considering stakeholders from diverse backgrounds and perspectives to ensure a comprehensive and inclusive approach to decision-making.

Sadiq and Jain [15] propose that stakeholders should be identified and categorised based on their level of influence and impact on the decision-making process. This can be done through various techniques, such as stakeholder mapping and analysis. By understanding the different stakeholders and their unique needs and perspectives, the decision-making process can be more informed. The author emphasise the need for ongoing communication and collaboration with stakeholders to ensure their concerns and ideas are considered. The authors demonstrated the approach by providing an example of a real-world scenario in which stakeholder mapping and analysis were used to inform a decision. In this example, a city government was considering implementing a new transportation system. By engaging with stakeholders such as local residents, business owners, and environmental organisations, the government was able to identify potential challenges and opportunities. This information allowed them to make a more inclusive decision that took into account the diverse perspectives of the stakeholders.

F. Stakeholder interaction

Stakeholder interaction refers to the engagement and communication between an organisation or project and the individuals or groups who have an interest or "stake" in its activities, outcomes, or decisions [32]. Since the interaction with people is so hard to handle, there are few studies that address stakeholder interaction [9]. Stakeholder interaction is essential for understanding the concerns and expectations of different stakeholders. This interaction fosters transparency and trust, ensuring that decisions are made in the best interest of all stakeholders involved. Additionally, stakeholder interaction allows for the exchange of knowledge and expertise, enabling the government to make more informed and effective decisions that align with environmental goals and sustainability objectives.

Chyhryn et al. [33] suggest that involving stakeholders in decision-making processes can lead to more effective and sustainable outcomes. The authors acknowledged the limitations of their research, such as the small sample size and the specific context of their study. They recommend to explore different industries and contexts to provide a better understanding of the impact of stakeholder interaction on decision-making. The authors also emphasised the importance of creating a communicative system that fosters collaboration among stakeholders to ensure the successful implementation of sustainable initiatives. Overall, the research highlights the need for continued development of innovative approaches to engage stakeholders in decision-making processes.

Kujala et al. [34] outline the importance of understanding the historical context of stakeholder engagement to effectively navigate current and future challenges. By analysing past approaches and learning from successes and failures, organisations can develop more informed methods for engaging stakeholders in decision-making. The authors suggested that future research should focus on evaluating the effectiveness of different stakeholder engagement strategies to identify best practices and improve overall outcomes.

Wood et al. [32] suggest that stakeholder interaction is crucial for ensuring that decisions are made in the best interest of all parties. They argue that involving stakeholders leads to better decision-making and helps build trust among the stakeholders. The authors highlight the need for further research in this area to fully understand the impact of stakeholder interaction on decision-making processes. They used a qualitative research approach to gather data from various stakeholders in a specific industry. Through interviews and focus group discussions, they gained insights into the perspectives of the stakeholders. The findings of their study support the notion that involving stakeholders in decision-making processes can lead to more effective outcomes.

Based on the related work presented above, which is related to the SMP, the FM-SMP looks like a good way to deal with the problems that come up when trying to identify, prioritise, and document the right stakeholders during the SMP. By focusing on identifying and prioritising stakeholder features, this process can help practitioners in the market better understand the needs and expectations of their stakeholders. Using FMs supports the efficiency of the SMP by effectively capturing and documenting stakeholder information. FMs provide a visual representation of stakeholder characteristics, allowing companies to easily identify and categorise stakeholders based on their specific attributes and requirements. This not only enhances stakeholder engagement but also enables companies to tailor their communication and decision-making processes to meet the unique needs of different stakeholder groups.

The FM-SMP offers a comprehensive and efficient approach to ensuring effective stakeholder engagement and ultimately improving software development outcomes. The evolvability feature of FMs enables practitioners in the SMP to adapt and respond to changing stakeholder dynamics. By continuously assessing and updating the FMs, practitioners can identify new stakeholders, understand their priorities, and adjust their strategies accordingly. This ensures that the SMP remains relevant and effective throughout the project lifecycle. Additionally, the evolvability feature of FMs allows for ongoing collaboration and feedback between stakeholders and practitioners, fostering a sense of inclusively and shared ownership in the decision-making process. Ultimately, this approach leads to better software development outcomes and a higher level of stakeholder satisfaction. This FM-SMP has been shown to enhance stakeholder engagement and improve decision-making outcomes. However, further research is needed to validate the effectiveness of this process across different industries and contexts, as well as to explore any potential limitations or drawbacks that may arise.

IV. Feature Modeling-Based Stakeholder Management Process

This section presents the FM-SMP proposed in this manuscript. The FM-SMP uses attributed FMs to document and monitor the involvement of stakeholders in the SMP. This makes communication, collaboration, and decision-making easier and faster. The FM-SMP also supports updates in stakeholder status for the purpose of requirement elicitation in the product development process.

A. Stakeholder lists

A method to identify stakeholders is maintaining checklists using, for example, tables and spreadsheets, as proposed by Pohl [6]. This permits the systematic and targeted engagement of pertinent stakeholders. A different method makes use of the stakeholder database, which is an integral part of achieving the objective of the project and disseminating its findings [35]. If the list of stakeholders is updated too late or insufficiently, it is possible that essential system aspects may go undiscovered, the objectives of the project are missed, or considerable additional expenses are incurred to solve issues.

B. Stakeholders documentation

The stakeholders best suited for requirement elicitation must be chosen due to the limited resources available to interact with them [18]. Some details should be put in tables or spreadsheets to keep track of the people who have a stake in the development process. These details include name, role, and additional personal and contact information; availability in time and space; relevance of the stakeholder; area and level of expertise; and the project-related goals and interests. All these criteria cannot be met because projects must comply with strict deadlines and financial constraints. Thus, to determine priorities, a stakeholder analysis is needed [18]. Managing stakeholders also involves a constant flow of information through regular status updates. This may help the requirements engineer turn people who were only negatively affected by the project into contributors who are well-integrated [6]. In this research, we decided to tackle this problem by using an evolvable artefact called an attributed FM that makes it easier to document and keep track of how stakeholders are involved in the elicitation process.

C. Stakeholder types

Stakeholders could be positive, negative, or neutral factors for the development of a product. Key stakeholders are those who have a considerable interest in or influence over a given project. These are the people who require the most attention and commitment. The stakeholders may be subdivided into four types: primary, secondary, external, and extended [18], [19], [24]. Definitely, primary stakeholders are more essential than secondary stakeholders, since they are directly affected by the development of the product. Thus, the primary stakeholders should be included due to their considerable impact on the product. The importance of primary stakeholders comes from their control, authority, and responsibility over the resources [19].

Secondary stakeholders are people who indirectly benefit from the product success. Although they are less significant than primary stakeholders, their interest in the product should be effectively managed. External stakeholders are those outside the product development team who have expectations for it. It is essential to recognise the contributions they can make to the product. External stakeholders are people who aid others in achieving their visions. Based on the above description, *the FM-SMP visually represents the stakeholders of a product as features, with the primary stakeholders depicted as mandatory features and the other types of stakeholders as optional features*. The FM-SMP helps project managers and requirements analysts document the relevant stakeholders for requirements elicitation based on their characteristics during the SMP. The FM-SMP has two uses for the attributed FM:

1) It serves as a repository to document the identified stakeholders in a reference artefact. This is performed via a document called a stakeholder FM.
2) It serves as an evolvable artefact that helps to continuously monitor all the stakeholders identified in the FM and update their statuses.

In this work, we use an attributed FM, in which each partner can fill in her desired stakeholders in a standard way.

D. Information to collect in the stakeholder FM

Based on the investigation of studies related to the selection of appropriate stakeholders [4], [9], [18], we decided to include the following factors in the stakeholder FM:

1) Role of the stakeholder.
2) Area of the stakeholder.
3) Extent of expertise of the stakeholder.
4) Goals of the stakeholder.
5) Interests of the stakeholder regarding the project.
6) Personal and contact data of stakeholders, including Name, Telephone, and Email.

Table I shows the main attributes of each stakeholder that the FM-SMP uses to build the stakeholder FM, including all types of stakeholders. The table shows the relationship between the features of the FM and each attribute of the stakeholder. Each row relates an attribute of the stakeholder to its corresponding feature design in the model. In the stakeholder FM, for example, the "Product Name" attribute is shown as a root feature, and the "Area" attribute as a parent feature. Furthermore, "Area" classifications is presented as child feature. The details of "Personal and Contact Data," like "Name," "Phone," and "Email," are represented as attributes.

E. Design the stakeholders FM

Based on the factors that influence stakeholder identification (i.e., attributes of stakeholder), the proposed process designs the stakeholders FM as shown in Fig. 5. The FM-SMP visually represents the stakeholders of a product as features. The primary stakeholders are depicted as mandatory features (i.e., stakeholder 1 of the stakeholder FM presented in Fig. 5) and the other types of stakeholders (i.e., secondary, external, and extended stakeholders) as optional features (i.e., stakeholder 2 of the stakeholder FM presented in Fig. 5). For

TABLE I
INFORMATION OF THE STAKEHOLDERS USED TO BUILD THE CORRESPONDING FM.

feature	stakeholder information
root feature	product name
parent feature	role
child feature	role $1 \dots n$
parent feature	area
child feature	area $1 \dots n$
parent feature	experience
child feature	experience $1 \dots n$
parent feature	goal
child feature	goal $1 \dots n$
parent feature	interest
child feature	interest $1 \dots n$
parent feature	personal and contact data
attribute 1	name
attribute 2	phone
attribute 3	email
attribute 4	priority
attribute 5	key stakeholder

each stakeholder FM, the root feature shows the "Product Name", the parent features hold the stakeholder information (i.e., factors/attributes) regarding the project, such as "Role", "Area", "Experience", "Goals", and "Interests", as well as "Personal and Contact Data." The child features of each parent feature show further information about the stakeholder's attributes. The "Personal and Contact Data" feature makes use of feature attributes/parameters to represent the stakeholder's "Name", "Phone number", and "Email address", as well as its "Priority" and whether (s)he is a "Key" stakeholder. The starting point for stakeholder elicitation is often the suggestions of relevant stakeholders that are made by management or by domain experts, for example. On the basis of these suggestions, relevant stakeholders can be identified, documented, and monitored to guarantee their successful involvement in the product development process.

V. Running Example

To clarify the proposed process, we present a running example, namely, the Health Care Mental Patient Management System (HCMPMS). This system is used to keep records of patients who are receiving treatment for issues related to their mental health. Following the FM-SMP, we propose that the requirement engineer has to **(1) identify the stakeholders** in the HCMPMS. The following list identifies individuals who could be considered stakeholders in HCMPMS.

- **Patients** whose information is stored in the database.
- **Doctors** who diagnose and treat patients.
- **Nurses** who organise doctor visits and carry out some treatments.
- **IT staff** who are responsible for the IT system, namely its installation and maintenance.

Using the FM-SMP, the software engineer has to **(2) capture and document the stakeholders** in a reference document, namely the stakeholder FM. Fig. 5 depicts the attributed FM for HCMPMS. To build the stakeholder FM, the software engineer needs to determine the priority of each stakeholder and then **(3) analyse and classify** them. The priorities are given on a scale from 1 to 3, where 1 is the highest priority, 2 is medium priority, and 3 is the lowest one. The software engineer may use the stakeholder FM (e.g., presented in Fig. 6)

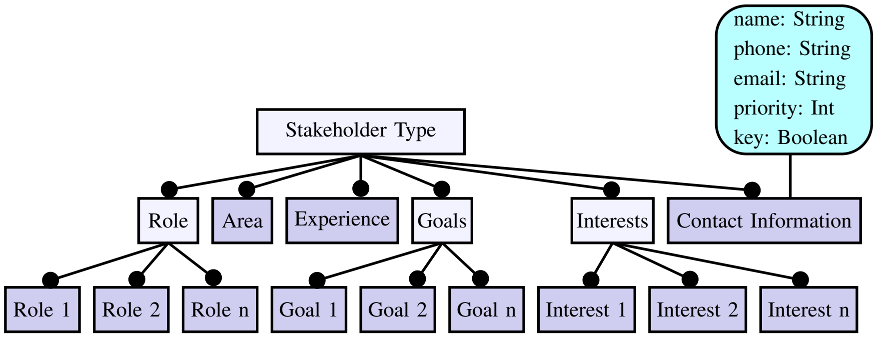

Fig. 5. Abstract view of the FM of the stakeholders.

to **(4) engage each stakeholder** in order to maximise the quality of the product development process. The engagement phase of the process focuses on determining the optimal frequency and method of communication with each individual. Using the proposed process the software engineer can use the information presented in the features and attributes of each stakeholder (e.g., the "Contact Information" feature and the "phone" attribute in Fig. 6) to support communication with stakeholders. As mentioned earlier in this manuscript, stakeholder management is an ongoing, iterative process that continues throughout the product development process. Thus, software engineers can identify, document, analyse, classify, plan and implement engagement from the beginning of the product development process until the end of the process. Following the FM-SMP, the software engineer can use the stakeholder FM for continuous **(5) monitoring and updating of the stakeholders**.

Ongoing monitoring of the stakeholders implies a continuous update of the their information. Thus, the software engineer may need to update the information stored in the stakeholder FM. In order to refine the stakeholder FM to reflect the new status and updated information of the stakeholders, the FM-SMP adopts the following operations on the stakeholder FM:

1) Refactor the FM.
2) Insert a new stakeholder.

Refactoring: In case a software engineer needs to perform a transformation to the stakeholder FM by keeping or improving its configurability (e.g., adding a new role to a specific stakeholder), he/she can apply a set of sound refactorings for FMs, as presented in the catalog proposed by Alves et al. [36]. The refactorings guarantee configurability improvements. For example, a software engineer can extend the role of the doctor to include "View Consultation", by applying Refactoring 12 (add optional node) of the catalog and then applying Refactoring 2 (collapse optional and or) on the stakeholder FM presented in Fig. 6. The stakeholder FM after refinement includes a red asterisk placed close to the refactoring point. A complete explanation for FM refactoring is presented in [36], where the authors offer a list of sound FM refactorings, which were verified by automatically examining the properties of the resulting FMs. The authors also provide a catalog of refactorings that is accompanied by examples to demonstrate their use.

Insertion: Software engineers can change the stakeholder lists, namely when they want to add a new stakeholder (i.e., installers). This addition can be represented by a sub-tree (i.e., sub-FM). The software engineer can use the insertion operator proposed by Acher et al. [37] to insert this sub-FM into the stakeholder FM in a specific position (i.e., a target feature in the stakeholder FM) that is specified by the requirement engineer. In the stakeholder FM, for example, the stakeholder list can be expanded to include a Non-Governmental Organisation (NGO) stakeholder. Fig. 7 depicts the stakeholder FM after inserting the NGO sub-FM in a specific position (i.e., the HCMPMS root feature) of the stakeholder FM.

VI. Case study evaluation

A case study is one of the most common approaches for evaluating software engineering methods [38]. In this section, the FM-SMP is applied and evaluated in a practical case study to investigate its applicability in a real-world setting.

A. *Case study context*

Home automation refers to the automatic control of household features, and appliances. In practical terms, it means that one can easily control the utilities and features of the home via the Internet to make life more secure and convenient and to spend less on household bills. Home automation projects usually span across various domains. In recent years, smart homes have become a popular subject of scientific and technological research and development. Typically, microprocessors are utilised to control everyday technological appliances. With the advent of home automation, these devices are connected to a network, enabling them to coordinate and perform complex tasks without human intervention. Smart homes boast intuitive user interfaces that make their functionality easy to access. The evolution of smart homes is influenced by diverse fields, such as *web technology*, which permits remote access to home operations over the Internet.

B. *Stakeholders of the smart home*

The design, installation, and operation of a home automation system involve various stakeholders. It is crucial to consider the interests of all stakeholders when developing and operating a home automation system to ensure that the system meets their expectations. As Fig. 8 shows, the different stakeholders and their interests are presented below.

The **residents** are the primary users. They have specific requirements based on their lifestyle, habits, and preferences.

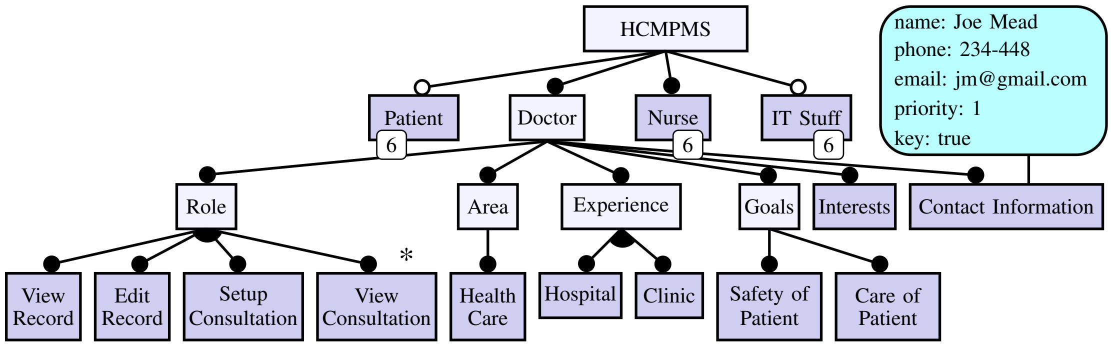

Fig. 6. FM of the HCMPMS.

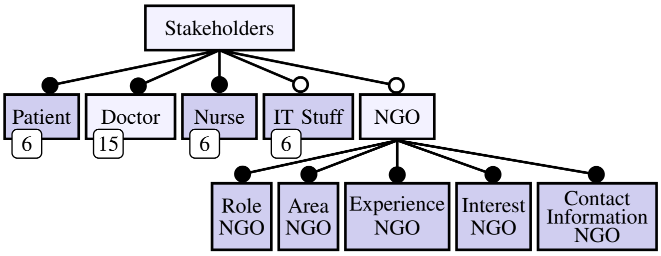

Fig. 7. FM of the HCMPMS stakeholders, after using the insertion operator.

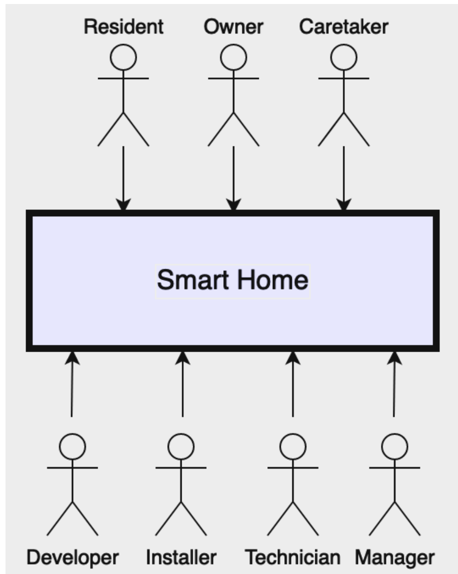

Fig. 8. Stakeholders of the smart home domain.

They usually desire a smart home system that is easy to use, provides security, energy efficiency, and convenience.

The **building owner** has an interest in the smart home system that adds value to the property. He may want a system that is reliable, efficient, and cost-effective. He may also want a system that is easy to maintain and upgrade.

The **caretaker** is responsible for the administration and accounting of the residence. They have an interest in the smart home system that is easy to manage, monitor, and control. They may also want a system that is secure and provides reliable data for billing purposes.

The **managers of the company** that seels the smart home system to the market have an interest in the features of the product, its functionality and marketability. They want a system that is innovative and competitive in the market.

The **developers** have an interest in creating the smart home system that meets the requirements of users while being technically feasible and cost-effective. They want to create a system that is scalable, secure, and easy to maintain.

The **installers** have an interest in installing the smart home system correctly and efficiently. They want a system that is easy to install, configure, and integrate with other systems.

The **maintenance personnel** has an interest in ensuring that the smart home system operates at peak performance. They want a system that is easy to diagnose and repair.

C. Participants

The participants in the case study are software engineers, who were chosen based on convenience and divided into two groups. Group 1 represents six software engineers who are students taking the Software Engineering course at Al-Bala' Applied University (Jordan). They were students in their final year of study. They had prior knowledge and experience in software development and were eager to apply their skills in a real-world setting. The six software engineers in Group 2 are from a company (Pioneers Company, Jordan). They were professionals with years of experience in the industry. These two groups allowed for a comprehensive and well-rounded evaluation of the FM-SMP in a practical context.

D. Ethical considerations

To conduct the case study, we addressed the ethical considerations of the research. Firstly, we ensured that all participants were fully informed about the purpose and potential risks of the study, and we obtained their written consent before proceeding. Additionally, we guaranteed the confidentiality and anonymity of all participants by assigning them identification numbers instead of using their names in any documentation or analysis. Further, the university and the company both gave their approval for the study, ensuring that any research involving human subjects abides by strict ethical standards. We conducted the study in accordance with ethical issues principles outlined by Singer and Vinson [39], who safeguard the well-being and rights of individuals participating in research. We also provided participants with the opportunity to withdraw from the study at any time without facing any negative consequences. Our commitment to ethical standards and participant protection was paramount throughout the entire research process.

For confidentiality issues related to company where we conducted the case study, we hid the name of the company and any identifiable information of the participants. All data collected during the study was treated with the utmost confidentiality and stored securely to ensure that no unauthorised access could occur. Additionally, when presenting the findings of our research, we used pseudonyms instead of real names to further protect the identity of the participants.

E. Case study design and planning

To assess the **ease of use**, **usefulness**, **effectiveness** and **efficiency** of the FM-SMP, we performed a case study, according to the guidelines presented by Runeson et al. [40][41]. Despite this being its first evaluation, the obtained results have shown the FM-SMP to be a promising solution. In order to conduct the case study, we need to plan and outline the specific steps and procedures that will be followed. First of all, we **identified the objective**. Thus, we stated the goal of the case study as follows: to analyse the proposed FM-SMP for the purpose of evaluating it with regard to **ease of use** and **usefulness** from the viewpoint of a set of software engineers in the context of a smart home project during the SMP. Furthermore, the case study aims to evaluate the performance of software engineers using the proposed FM-SMP and assess any potential challenges they may face. Additionally, it seeks to measure the impact of the FM-SMP on the overall success of projects by examining key metrics such as **effectiveness** and **efficiency**. This comprehensive analysis will provide valuable insights for stakeholders and decision-makers to make informed decisions regarding the adoption and implementation of the proposed FM-SMP in future projects. Secondly, we **identified the case of the study** (context). The context of the study is the FM-SMP during product development. The selected product is called smart home; see Subsections VI-A and VI-B. To fulfil the objective of this study, three research questions (RQa) were next presented:

RQ1: What is the impact of the FM-SMP on the performance of software engineers in the SMP?
RQ2: What is the impact of the FM-SMP on usability of the software engineer in the SMP?
RQ3: How does the ease of use and usefulness of the system change over time as software engineers become more familiar with the proposed strategy?

Based on the study design, there is one treatment, the FM-SMP, presented in this research. The study includes two subjective dependent variables: ease of use and usefulness.

- **Ease of Use:** The degree to which a software engineer believes the FM-SMP is easy to use is a subjective assessment of how challenging it is to learn and operate.
- **Usefulness:** The degree to which a software engineer believes the FM-SMP achieves its stated objectives represents a perception of its effectiveness.

We prepared a usability survey to assess both variables after implementing the FM-SMP in a real-world setting. The required data related to evaluation and case study is available at https://github.com/karamignaim/SMP. The survey consisted of questions regarding ease of use, ease of learning, fatigue, simple preference, and other questions that were relevant to the FM-SMP that was being used. In accordance with the recommendations for conducting an effective survey that are detailed in [41], we adopted the NASA TLX (Task Load Index), with some adjustments so that it better reflects our approach.

The NASA-TLX is a widely used subjective measure for evaluating the workload and task demand associated with a particular task or activity. The NASA-TLX usability questionnaire uses six questions to assess different aspects of task demand, including physical demand, mental demand, temporal demand, performance, effort, and frustration:

1) How mentally demanding was the task?
2) How physically demanding was the task?
3) How hurried or rushed was the pace of the task?
4) How successful were you in accomplishing what you were asked to do?
5) How hard did you have to work to accomplish your level of performance?
6) How insecure, discouraged, irritated, stressed and annoyed were you?

Each question is rated on a scale of 1 to 7, where 1 represents the lowest task demand and 7 represents the highest. This allows the respondent to rate different aspects of the task demand according to their perceived level of difficulty or effort required. The overall TLX score is calculated as the sum of the six scores, providing a single score that represents the overall perceived workload and task demand associated with the task or activity. The NASA-TLX is widely used in a variety of contexts, including aviation, healthcare, and human factors research, to evaluate the subjective experience of task demand and workload.

Our study has two hypotheses related to the **ease of use** and **usefulness** of the FM-SMP. In the following, we formulate the null hypotheses (He0 and Hu0) and the alternative hypotheses (He1 and Hu1) to assess the two subjective dependent variables:

- He_0: The proposed FM-SMP is difficult to use.
- He_1: The proposed FM-SMP is easy to use.
- Hu_0: The proposed FM-SMP is not useful.
- Hu_0: The proposed FM-SMP is useful.

In the study, we also define a correct key solution for the tasks of the study. The aim is to compare solutions of the software engineers with the key solution to analyse the degree to which the software engineers applied the FM-SMP effectively and efficiently.

To initiate the study, we prepared the case study design (refer to Table II). This design was implemented in both sessions: the Software Engineering course and the Pioneers Company. Each group (the Software Engineering course and Pioneers Company) required two days, totalling three hours and 30 minutes per day, to execute the case study for each session. On the initial day, a one-hour training session was conducted, encompassing a presentation on the proposed FM-SMP and a practical exercise to apply it. On the following day, the case study was executed. In the first 15 minutes, software engineers were asked to complete a form with background information. Subsequently, they were tasked with performing the three assignments using the FM-SMP. Following task completion, the software engineers from both groups responded to a survey regarding their experience with the FM-SMP.

As case study instrumentation, several documents were created: slides for the training session, an explanation of the tasks, and a questionnaire (i.e., the NASA TLX survey). These documents were utilised by software engineers who were queried about their experiences in the field. The results indicated that each of them possessed prior experience in this context. Consequently, we did not categorise software engineers based on their familiarity with the SMP. The first session included six undergraduate students from Al Balqa' Applied University (BAU). Six software developers from Pioneers Company also participated in the second session, bringing the total number of participants in the empirical investigation to 12. For training on the FM-SMP, we presented the software engineers with a running example explained in Section IV, where the stakeholder FM of the HCPMS was created. This FM comprised 32 features. Following the FM-SMP training, the software engineers were tasked with performing three tasks.

In **Task 1**, the software engineers were required to build the stakeholder FM for the smart home (refer to Section VI (B)). **Task 2** involved updating the information of the stakeholders by applying FM refactoring to the stakeholder FM. Finally, in **Task 3**, the software engineers were asked to update the information of the stakeholders by applying an insertion operator over the same FM.

Before commencing the actual study, participants were required to fill out a form providing background information. The form consisted of five questions aimed at gathering information about the software engineers' experiences in various areas relevant to the study, including stakeholder management, FMs, and requirement elicitation. Upon completion of the study, the software engineers were asked to participate in the NASA TLX survey, a widely used tool for measuring mental workload. This survey included six questions eliciting the opinions of software engineers regarding the FM-SMP used in the study.

In this case study, we **performed data collection** before, during, and after the empirical study. To perform the data collection, we have used the following.

Background Form: It took around 15 minutes for each session (BAU and Pioneers Company) to collect information about the software engineers' experience with SMP, requirements engineering, and FMs. Most of the software engineers at BAU knew what SMP and requirement engineering are, and, in general, they have less than 1 year of experience with them. Moreover, the majority of the software engineers at Pioneers Company also knew what SMP and requirement engineering are, and they have between one to five years of experience in those topics. Unfortunately, software engineers from both groups have no previous knowledge or experience with FMs. Therefore, we offered them an intensive presentation session.

Empirical Study: It took us around 3 hours and 30 minutes for each session (BAU and Pioneers Company) to collect the answers of the software engineers about the SMP for the smart home. Data was collected for each of the following tasks. **Task 1 - Design the FM of the stakeholders of the smart home.** Once the SMP for the smart home is identified, we asked software engineers to design its stakeholder FM (Task 1). For this task, we provided them with Fig. 8 and its related explanation; see Subsection VI-B. We gave the software engineers a duty to design the stakeholder FM using the proposed process. It was expected from them to capture and document the stakeholders of the smart home in the stakeholder FM. **Task 2 - Update the stakeholder FM using FM refactoring.** In this task, we asked software engineers to perform a transformation that improve the configurability of the stakeholder FM (e.g., adding a new role to the "Owner" stakeholder, such as allowing the home owner to send a request about the door lock status via a mobile phone). The software engineers are required to include new features in the stakeholder FM (Task 2). The new feature (new role) has to be associated with the stakeholder FM using FM refactoring. **Task 3 - Update the stakeholder FM using Insertion Operator.** In the second update, the software engineer needs to perform a modification to the stakeholders FM to capture changes in the stakeholder lists, including adding a new stakeholder and their related information (Task 3). In the stakeholder FM of the smart home, the stakeholder list can be expanded to include the "Installer," "Technician," and "Security" stakeholders using the insertion operator.

Survey: The collection of survey information took approximately 15 minutes per session (BAU and Pioneers Company). From the NASA TLX survey, we learned that software engineers perceived the study FM-SMP as having several steps that depended on FMs. This finding suggests that there may be a need for tool support to facilitate the use of the FM-SMP. Additionally, while the concept of the FM was reported as difficult to understand, software engineers noted that the steps of the FM-SMP were well explained and easy to follow, providing a systematic way to manage stakeholder engagement in product development.

After completing the data collection, we started the data analysis, including both qualitative and quantitative analysis.

F. Qualitative analysis

The first analysis was qualitative and focused on the effectiveness, observed during the execution of the tasks. This analysis aimed to identify any deficiencies in the FM-SMP and improve the quality of the report in a qualitative manner. For this purpose, we defined three objective dependent variables (see Table III) and the following hypotheses:

- **Hp0**: The proposed FM-SMP does not improve the performance of software engineers.
- **Hp1**: The proposed FM-SMP improves the performance of software engineers.

Table IV displays the qualitative analysis of the case study. Regarding Task 1, which involved identifying design scenarios, the effectiveness of the software engineers in this task was measured as the quotient of the number of correct design scenarios that the software engineers identified by the total number of design scenarios in the key solution (Effectiveness-Design). The reported result shows that the software engineers were able to correctly identify 77.7% of the total evolution scenarios in Task 1. To determine the effectiveness of Task 2, we compared the correct updates in the stakeholder FM that the software engineers performed using FM refactoring with the ones in the key solution (Effectiveness-Ref-Update). The results for this variable indicate that the software engineers were able to correctly evolve 80.5% of the total requested updates.

For assessing the effectiveness of Task 3, we compared the correct updates in the stakeholder FM that the software

TABLE II
CASE STUDY DESIGN.

first day	strategy training	• introduce the strategy (30 min.) • apply a practical example (30 min.)
second day	collect softw. eng. feedback	• apply background questionnaire (15 min.)
	conduct the case study	• identify tasks (30 min.) • perform tasks (60 min.) • check tasks (60 min.)
	collect softw. eng. feedback	• apply NASA TLX survey (15 min.)

TABLE III
OBJECTIVE DEPENDENT VARIABLES OF THE CASE STUDY.

Effectiveness-Design is the ratio between the number of correct designs of the stakeholder FM identified by the software engineer and the total number of correct designs.
Effectiveness-Ref-Update is the ratio between the number of right updates to the stakeholder FM that the software engineer performed (using FM refactoring) and the total number of right updates to the stakeholder FM.
Effectiveness-Ins-Update is the ratio between the number of right updates performed by the software engineer in the stakeholder FM (using the insertion operator) and the total number of right updates performed in the stakeholder FM.

TABLE IV
RESULTS OF THE OBJECTIVE DEPENDENT VARIABLES FOR BOTH MEAN AND STANDARD DEVIATION.

dependent variable	mean (%)	std. deviat.
Effectiveness-Design	77.7	0.164
Effectiveness-Ref-Update	80.5	0.172
Effectiveness-Ins-Update	86.1	0.172

engineers performed with the updates written in the key solution (Effectiveness-Ins-Update). The results indicate that the software engineers were able to correctly address 86.1% of the total updates in the stakeholders FM.

These results suggest that the software engineers had a moderate level of proficiency in updating the stakeholder FM using both FM refactoring and insertion operators. Further analysis is needed to determine if the performance of the participants was affected by any other factors, such as prior experience or training in updating the stakeholder FM.

Task-performance measurement is only meaningful when compared to the reference process. Thus, we conducted two measurements between the nominal (i.e., SMP) and the proposed process, applying statistical analysis to identify any meaningful and significant differences between the two measurements. We repeated the analysis for the same tasks to estimate the efficiency of the software engineers while using the SMP, which is typically adopted in product development.

The results indicate that the software engineers took approximately 30 minutes to complete Task 1, with an Efficiency-Design value of 0.16. For Task 2, the software engineers required about 7 minutes, resulting in an Efficiency-Ref-Update value of 0.30. Finally, for Task 3, the software engineers took approximately 8 minutes, yielding an Efficiency-Ins-Update value of 0.41.

Fig. 9 compares the FM-SMP with SMP in terms of efficiency, while the software engineers perform the tasks related to the empirical study. The software engineers from both groups (BAU and Pioneers) performed the tasks related to the FM-SMP more efficiently than using the FM-SMP. Table IV and Fig. 9 offer answers to RQ1 and RQ2. The results enable the null hypothesis (Hp0) to be rejected and the alternative one (Hp1) to be accepted.

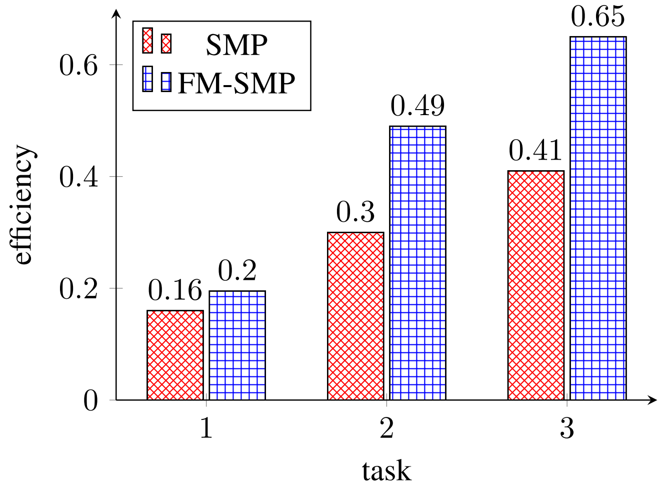

Fig. 9. Efficiency for the SMP and the FM-SMP strategies.

G. Quantitative analysis

The second analysis is quantitative and presents a case of task-performance measurement related to an urgent request from Pioneer Company to engage a new stakeholder in the software product. We asked the software engineers to engage the stakeholder using both the SMP and the proposed FM-SMP. Subsequently, we computed the completion time for each software engineer. Task completion times for adding a new stakeholder during the test trials were recorded for more detailed post-analysis. Since task-performance measurement is only meaningful when compared to the SMP, two measurements were taken between the SMP and the proposed FM-SMP. Statistical analysis was then applied to identify meaningful and significant differences between the two measurements. For accuracy purposes, both types of experiment trials were run over an extended period to assess ease of learning. Furthermore, task performance was measured over weeks to observe how quickly users recalled how to operate the FM-SMP and achieve higher performance.

Fig. 10 illustrates the task completion time for engaging a new stakeholder using the SMP and the FM-SMP. The bars in each trial represent the time taken (in minutes) to add a new stakeholder using both the SMP and FM-SMP. Across all trials, the bars that represent the SMP registered significantly higher completion times than those that represent the proposed FM-SMP. This indicates a clear difference in efficiency, which gives a clear indicator that adopting the proposed process can substantially reduce the time required for adding new stakeholders to the SMP. The analysis of Fig. 10 reveals that software engineers completed jobs faster using FM-SMP when compared to SMP. The reduction in time resulting from the proposed process can lead to improved productivity. FM-SMP reduces task completion time compared to the SMP, indicating that the proposed process can improve the efficiency of stakeholder engagement in software development.

The result of the task performance assessment supports the answers to RQ1, RQ2 and RQ3.

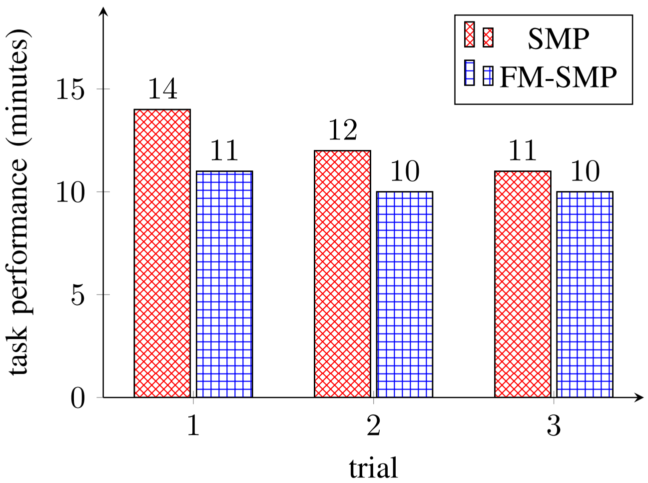

Fig. 10. Time to add a new stakeholder to the smart home using the SMP and the FM-SMP strategies.

In the survey, we asked software engineers to complete the NASA TLX questionnaire, rating it on a scale from 1 (very low) to 7 (very high), and not the original 21-point Likert scale. The TLX was then determined by averaging these scores (last column of Table V).

This information was quantitatively analysed to ascertain perceptions of the software engineers with respect to the ease of use and usefulness of FM-SMP. As shown in Table V, the scores were all positive and closer to the optimal answers. The scores (four instances of 2 and two instance of 1 for question 1) were attributed to some difficulties in adapting to FM concepts by software engineers. The scores (three instances of 3, two instances of 2, and one instance of 1 for question 2) and (three instances of 2, two instances of 3, and one instance of 4 for question 5) were due to clear demands from software engineers for a tool that supports the FM-SMP. The scores on the remaining questions (i.e., questions 3–6) provided an indicator that the software engineers performed well using the proposed FM-SMP. The scores offer valuable insight into whether the proposed FM-SMP is easy to use and useful. The NASA TLX values for each question were generally favourable, indicating that they were close to the optimal score of 1. Thus, we reject both null hypotheses (He_0 and Hu_0) and accept the alternative hypotheses (He_1 and Hu_1), which indicates that the proposed FM-SMP is perceived as easy to use and useful. By conducting both qualitative and quantitative analyses, we obtained a more

TABLE V
THE STAKEHOLDERS INFORMATION USED TO BUILD THE STAKEHOLDERS FM.

soft. eng.	mental dem.	phys. dem.	temp. dem.	perfor-mance	effort	frus-tration	TLX
#1	2	2	2	1	1	2	1.67
#2	3	3	2	2	3	1	2.33
#3	3	3	3	3	2	2	2.67
#4	2	4	1	2	1	2	2.00
#5	3	3	2	2	4	2	2.67
#6	3	3	1	3	3	1	2.33
#7	2	2	3	1	3	2	2.17
#8	2	3	1	2	3	2	2.17
#9	3	2	2	2	2	1	2.00
#10	2	2	2	1	2	3	2.00
#11	4	2	2	3	2	1	2.33
#12	3	4	1	1	1	1	1.83

comprehensive understanding of the effectiveness of FM-SMP and the software engineers' satisfaction with it.

VII. Discussion

This research highlights the potential benefits of incorporating FMs into the stakeholder management practices in the software development industry. We propose FM-SMP, which is evaluated with a population of 12 participants from academia and industry. The results show that using FMs in the SMP can significantly improve communication and collaboration with stakeholders. The participants reported that the FMs helped them have a better understanding of stakeholder requirements and priorities, leading to more effective decision-making and problem-solving. However, it is important to evaluate the FM-SMP in other software development domains to determine its applicability and effectiveness in different contexts. Conducting the study with a larger population may help to further validate the findings and ensure the generalisability of the results.

There are other limitations of the current study that should be addressed in future research. Firstly, the proposed FM-SMP focuses on monitoring and updating activities in the management process. Software engineers must fully understand feature modelling and refactoring to adopt the FM-SMP. This may constitute an important limitation. Secondly, the interviews mostly covered stakeholders who had direct involvement in the project, which can be subjective and may not capture all relevant stakeholders. It would be advantageous to incorporate the viewpoints of external stakeholders, such as regulatory agencies or community representatives, to provide a more comprehensive analysis. This would have yielded a more comprehensive comprehension of the project impact and potential obstacles. Additionally, the attributed FM may not effectively capture the dynamic nature of stakeholder involvement throughout the product development process. It is important to continuously reassess and update the model to ensure all stakeholders are adequately represented and their involvement is accurately documented.

The sample size was relatively small, which might have influenced the statistical results of the study. A larger sample size could result in more reliable results. The study only examined the short-term effects of the FM-SMP, and it would be beneficial to investigate its long-term impact. These limitations provide opportunities for future researchers to expand upon the current study and contribute to a more comprehensive understanding of the FM-SMP effectiveness. The case study could also benefit from a control group, which would allow for a direct comparison between the outcomes of the FM-SMP and those of a traditional development approach. This would provide a stronger basis for drawing conclusions. Conducting follow-up interviews with the developers involved in the case study could offer valuable insights into their experiences and perceptions of the FM-SMP. Future research can get a better idea of the pros/cons of using this FM-SMP in software development.

The strengths of this study are as follows: (1) using FMs in the SMP helps in identifying and prioritising stakeholders' requirements, providing a clear understanding of the features to be developed, and enabling effective communication and collaboration among stakeholders. (2) FMs can assist in managing changes and updates in the software development process, ensuring that stakeholders' needs are met throughout the project lifecycle. Utilising FMs in stakeholder management can enhance the efficiency and success of software development projects. (3) the evolvability of FMs allows for easy adaptation and customisation of the SMP. With FMs, practitioners can invest in the evolvability to respond to changing stakeholder's needs, ensuring that their management strategies remain effective. (4) The adaptability of FMs enables organisations to tailor their stakeholder management approaches to specific industries or contexts, optimising outcomes and ensuring maximum stakeholder satisfaction. The combination of stakeholder engagement, enhanced decision-making, and evolvability makes this approach suitable for improving stakeholder management. Finally, (5) the case study offers insights into how FMs can be used in real-world scenarios. By analysing the specific challenges faced by the companies in the case study, developers can gain a better understanding of how to tailor FMs to their own projects. This practical application of FMs enhances stakeholder management and helps in making informed decisions about prioritising features and allocating resources effectively.

VIII. Threats to Validity

This section addresses the validity of the study, which indicates how reliable the findings are and how much they are unaffected by the researchers' subjective viewpoint. We discussed validity in the analysis stage, but also in all earlier stages of the study. Validity is presented in three aspects: construct validity, internal validity, and external validity.

Construct Validity: This aspect of validity reflects the extent to which the operational measures studied accurately reflect what the researchers had in mind and what is being investigated in accordance with the research questions. For example, the fact that the interview questions of the case study are not interpreted in the same way by the researchers and the software engineers is a threat to construct validity. To avoid this threat to validity, in our study, we interviewed 12 software engineers that have experience with the context of this study, specifically the SMP and requirement engineering. To the best of our knowledge, these software engineers possess the ability and domain knowledge necessary to mitigate the threat further, and those who are unfamiliar with the field have already been excluded.

Internal Validity: This aspect of validity is of concern when investigating causal relationships. When the researcher is investigating whether using the proposed FM-SMP affects the performance of the software engineers, there is a risk that the investigated factor is also affected by the intrinsic backgrounds or interests of the software engineers. A few provisions can be made to reduce such biases; since it was difficult to use a large number of subjects (e.g., more than 30 people), we used a seven-point scale to answer the questionnaire. While the same danger exists with respect to environmental biases, we mitigate this by choosing subjects from two different working environments (software engineers at BAU and Pioneers Company).

External validity: This aspect of validity examines the extent to which it is possible to generalise the findings of this research as well as the extent to which the findings are relevant to software engineers outside the case study. To mitigate this kind of validity, the researchers analysed the applicability of the findings to other cases. For that, the researchers apply a random selection for the participant in the case study from a fair sample population of software engineers that satisfies the conditions of the research work. Moreover, the authors plan to evaluate the FM-SMP in other software development domains and with a larger participanting population.

IX. Conclusions and Future Work

The SMP aids in maintaining beneficial relationships with those who have the most influence over product development. Effective communication with each individual can play a vital role in keeping people efficiently engaged in the development of the software product. In this manuscript, FM-SMP has been proposed to support a systematic SMP. FM-SMP is mainly based on feature modelling for capturing, documenting, and monitoring the involvement of suitable stakeholders during the SMP. This involvement is based on the characteristics of the stakeholders, such as the Area, Experience, Role, Goal, and Interest. FM-SMP uses an evolvable artefact called the stakeholder FM that stores and presents the potential stakeholders and their attributes for a specific software product. These attributes are identified based on a review of the literature on the effective selection of stakeholders. The attributes were conceptualised as features of the stakeholder FM, and attributes of features are used to support the best methods of communication with the stakeholders. The evolvability of the stakeholder FM is implemented using two basic operations defined for feature modelling: refactoring and the insertion operator.

To evaluate the proposed process, we have conducted a case study in the smart home domain. The results reveal that the FM-SMP has a significant influence on the quality of the SMP. There are still many aspects of our FM-SMP that could be improved, like the how a stakeholder FM can be used to deal with conflicts.

Acknowledgment

We thank the students of BAU and the development team of Pioneers Company for their support and cooperation in the case study.

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Karam Mustafa Ignaim received the B.Sc. degree in Information Technology from Al Balqa Applied University, Jordan, the MSc. degree in Computer Science from Al Balqa Applied University, Jordan, and the Ph.D. degree in Software Engineering from the University of Minho, Portugal. Her research interests include software product lines, feature modeling, software reuse, requirement engineering, cyber security, and software maintenance and evolution.

João M. Fernandes is a Full Professor at Universidade do Minho, Portugal. He conducts his research activities in software engineering, with a special interest in software modelling, requirements engineering, software business, and bibliometrics. He was invited professor/researcher at U. Bristol (UK, 1991), Åbo Akademi (Finland, 2002–03), ISCTEM (Mozambique, 2003), U. Algarve (Portugal, 2004-06), U. Århus (Denmark, 2006–07), and UFSC (Brazil, 2013). He is the main author of the book "Requirements in engineering projects" (Springer, 2016). João has been involved in the organisation of various international events, including ACSD 2003, DIPES 2006, GTTSE 2009, PETRI NETS 2010, ACSD 2010, the MOMPES workshops series (2003-2012), and ICSOB 2015.