A COLLABORATIVE METHOD FOR SCOPING SOFTWARE PRODUCT LINES

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DEDICATION

To my parents José Libardo and Luz Nelly who are my inspiration and taught me that difficulties are opportunities to show strength, and that family is the most important

To my son Juan José my motive, my strength, my pride and my greatest support

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Challenges and dreams are not reached alone. A doctoral thesis is a hard and long work in which many people and institutions helped and supported me; therefore I want to thank them. . .

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RESUMEN

La definición del alcance de líneas de productos software (Scoping SPL) es una actividad clave en el desarrollo de Líneas de Productos Software (SPL), tanto que incide en el exito o fracaso de la línea. Para lograr delimitar el alcance de una línea es necesario diferentes conocimientos que se encuentran dispertos en diferentes tipos de expertos y roles, pero es difícil lograr que personas con diferentes conocimientos e intereses interactúen y acuerden el alcance, y es más complejo aún, si no están claros los resultados que deben obtenerse.

Esta investigación está enfocada en el estudio de un conjunto de enfoques del scoping SPL, y aplicar la ingeniería de método y la ingeniería colaborativa para proponer un método colaborativo para el SPL scoping de tal forma que brinde las directrices concretas para facilitar su aplicación como la identificación de los artefactos a obtener con las plantillas y los pasos específicos que faciliten obtener los artefactos de salida que componen el alcance.

ABSTRACT

The definition of the scope of software product lines (Scoping SPL) is a key activity in the development of Software Product Lines (SPL), both affecting either the success or failure of the line. In order to delimit the reach of a line, different knowledge is needed that is distinct in various types of experts and roles, but it is difficult to obtain people with different knowledge and interests to interact and agree on the scope, and it is even more complex, if the results to be obtained are not clear.

This research is focused on the study of a set of scoping SPL approaches, and applies method engineering and collaborative engineering to propose a collaborative method for SPL scoping in such a way that it provides concrete guidelines to facilitate its application as identification of the artefacts to be developed with the specific templates and steps for obtaining the output artefacts that make up the scope of the SPL.

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Chapter 1

Introduction

"If the need is the mother of the invention, curiosity is her father.
After all, you cannot produce anything that is not interesting
if you are not interested in something before. It is to give and take"
Will Gompertz

1.1 Motivation

Software companies are looking for strategies that allow them to be competitive and stay in the market. These companies must not be limited to create new products and also need to improve their production and marketing processes. Software Product Lines Engineering (SPLE) is a production strategy based on planned reuse of the assets in the development of a set product that shares a set of common characteristics and enough variability to be different products focused on a target market [5]. Some of the potential benefits of adopting the SPL strategy include production cost reduction, improvements in quality products and the decrease in product development time [6].

An essential activity in the development of a SPL is the scoping (SPL-Scoping) [7]. SPL-Scoping specifies the application domain, identifies the product portfolio and the variations between them and plans the reuse infrastructure [8]. The scoping is a difficult activity because of the complexity and the variety of the factors that must be considered.

Many of these factors are unknown by the technical team [8] and as a result, SPL-Scoping requires the participation of non-technical experts who usually do not take part in the development group [9].

The specific practices in scoping require participation from a wide and diverse group of stakeholders. There are risks if there is not enough and adequate stakeholder participation, if one of them is not having the required information to identify the correct products or the proper size of the scope. Another risk is that without sufficient stakeholders' participation in scoping they do not receive the necessary acceptance to achieve the desired downstream results, the impulse and necessary commitment for the following steps in the development of SPL [5].

The scope depends on the knowledge distributed among different participants [10]. However, only some of the scoping approaches provide information on involved roles [11] [12] The diversity of participants is important for the scope definition, but it involves people that represent different areas to participate and agree which is not easy [13] [14], because each one of these participants has different interests [15] and sometimes the objectives can become contradictory [14].

An additional problem when a SPL-S is developed is how to ensure that participants with different interests, concerns and priorities collectively define the scope of an SPL [16] [17]. There are some proposals that involve collaboration in the development of some activities within the construction of software product lines. Normally, product lines are developed from successful products [18] and thus, the available and explicit information is limited [16] [17]. This document proposes a project focused on this problem, setting out the objectives, methodology, and planning that seek to propose a possible solution.

There are some investigations that address communicative and collaborative aspects related to number and diversity of participants required by the SPL scoping. However, there are still several limitations related to the ambiguity of scope specification, how it should be structured and formalized scope, which artefacts make it up and how they should be performed. In this sense, this work seeks to combine the techniques of method engineering and collaborative engineering with the practices and artefacts that have been proposed and tested by scoping approaches.

In general, and taking into account the ideas above, this research attempts to establish a collaborative method for SPL scoping, which describes the steps of each of the practices to be performed, provides information on the roles involved and guidelines for their interaction and encourages collaboration, supporting the development of the outcomes that make up the scope.

1.2 Problem Statement

A SPL is a set of products that share common features, satisfy needs of a specific market segment and are constructed from reusable assets [5]. The set of products that constitutes a SPL is not random, on the contrary, a line is composed of a set of carefully planned products that are developed from reusable assets [7]. The planned reuse seeks to increase the productivity and economic benefits of the developer company [7] [19]. The set of products that are expected to constitute the SPL is called the scope of the product line [7] [8].

The set of products envisioned to be in the SPL is called the product line's scope [7] [8]. One of the discipline that is properly considered for the engineering of software product lines is scoping [11]. All system development involves scoping, but in the conventional development systems, scoping is an inherent activity that is usually done informally and preliminary to the requirements engineering activity; in systems based on planned reuse, it is necessary to consider the variability the design, the reuse domains and its implications in effort and investment [5] [20] [7].

The SPL-Scoping is an activity where the line is delimited, the products that belong to the line are identified, the domain is specified, and some parameters are established for the reuse infrastructure [1] [20]. SPL-Scoping is a critical activity in the development of SPL, if the identified scope is too broad, the usefulness and reuse of the base assets will decrease; but if the scope is too small, the company will obtain a very low return on investment. In addition, an incorrect scope can lead to incorrect products that do not correspond to the target market [7]. The scope determination not only refers to the correct size, but also must identify the correct products according to the market opportunities, the necessary investment and the commercial objectives [20] [7].

There are different SPL scoping approaches, as well as descriptions and reports of experiences of these approaches in the literature [11] [12]. Some of these proposals have focused on the definition of the product portfolio [19] [21] [22]; others in domain analysis [8]

[23] [24] and others in the analysis of reusable assets [25], [15]. The studies of these approaches, their application and analysis have shown that the scoping does not have technical and economic dimensions only, but also a communicative and collaborative dimension [26] [17] [13] because the definition of the scope of SPL is a multidisciplinary activity [13] [20]. Therefore, it is necessary to consider different factors, such as the relevant domains, business goals, market conditions, and technical aspects [8]. Thus, the definition of the scope of SPL requires the participation of various technical and non-technical experts [8].

The SPL scoping depends on the interaction between the knowledge of the target domain (context), the possibilities of development and market conditions [11] [9], therefore, this activity requires the correlation of participants who have partial and different knowledge. None of the scoping participants has all the necessary knowledge and experience [10]. The correct scope of a product line depends on a balanced decision making of the participants [27], therefore the diversity of participants is a key factor that must be combined to achieve an activity that is considered as part of the marketing of the SLP [27], but at the same time as one of the technical management practices of the SLP [5]. The implications of this duality has been analyzed by different authors [14] [26] [17] [13], considered that communication and collaboration between the different participants is fundamental in the definition of the scope of software product lines because, achieving the participation of people from different areas and with different interests is not easy [14] [17] [13]. However, these proposals have not been sufficiently formal as to how companies should reach the scope of a product line, the lack of formality in the scope is evident in the ambiguity of the entries and exits. This makes communication and collaboration of the stakeholders participating in the scoping and who know where, when and how collaborative. The way in which the result of the scope definition is represented is diverse and it is not clear how it should be used in the following stages [28]. Can a method for defining the scope of SPL with a collaborative approach encourage the participation of stakeholders through guidelines that allow to generate, document and validate in a systematic and practical way a useful scope for the following stages of the development of the software product line?

1.3 Objectives

1.3.1 General Objective

To propose a collaborative method for defining a well-defined and useful scope of Software Product Lines based on increasing the effective participation of the stakeholders and facilitating them the decision-making.

1.3.2 Specific Objectives

- To identify the elements of teamwork considered in the different scoping approaches and their possible impact on the scope.
- To establish the tasks in which elements of collaborative engineering can increase the effective participation of team members in the software product lines scoping.
- To propose and organize a method from chunks of scoping approaches, the inclusion of practices collaborative engineering and method engineering guidelines
- To validate the effectiveness and the collaboration factor of the proposed method for obtaining a well-defined and useful scope.

1.3.3 Hypothesis

The hypothesis of the present research work is based on the collaborative work in SPL scoping, referring to the evaluation of a collaborative method for SPL scoping. Thus, the research hypothesis and the null hypothesis are as follows:

Hypothesis: The application of a collaborative method for SPL-Scoping that fosters the stakeholder participation through a descriptive guide of steps and expected outcomes, allowing to obtain a well-defined and useful scope.

Null hypothesis: The application of a collaborative method for SPL-Scoping increases the participation of roles. However, it is not enough for achieving a well-defined and useful scope.

1.3.4 Methodology

To achieve the objectives, the methodology of this project is based on the philosophical framework of Mario Bunge [29] and for the concrete project, this framework has been instantiated by combining methods and specific techniques of software engineering research for some of the determined activities. These techniques are numbered below and can be seen in figure 1.1:

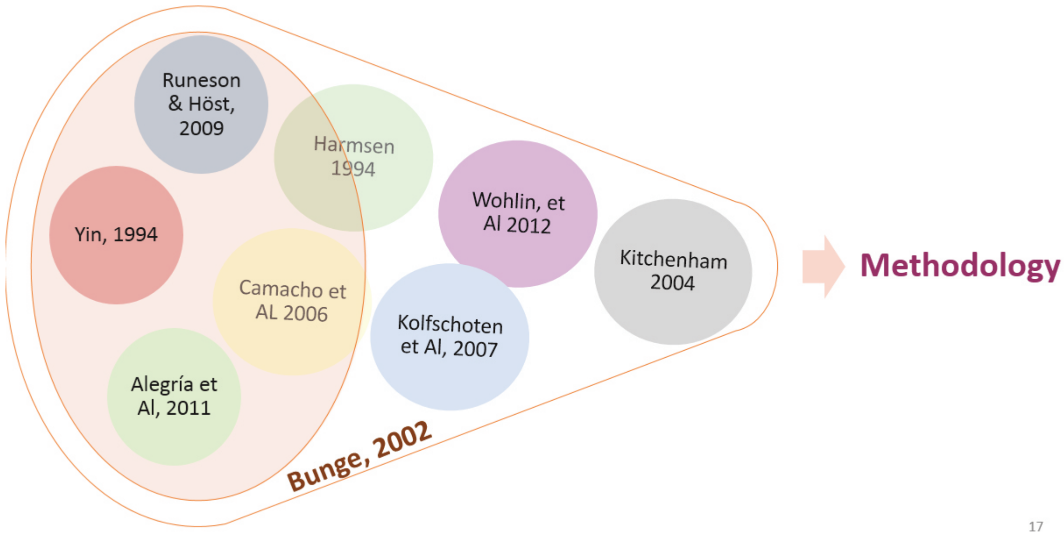

Figure 1.1: Methods, techniques and framework for the methodology

- For the search and revision of the SPL-Scoping approaches, some of the Guidelines and procedures for carrying out Systematic Reviews followed Kitchenham [30].
- To design and propose the method:
  - The Collaborative Engineering Approach for Designing a Collaborative Process [4].
  - The situational approach engineering approaches proposed by Ralyté [31].
  - To validate the elements of the method will be used process engineering guidelines [32] [33]

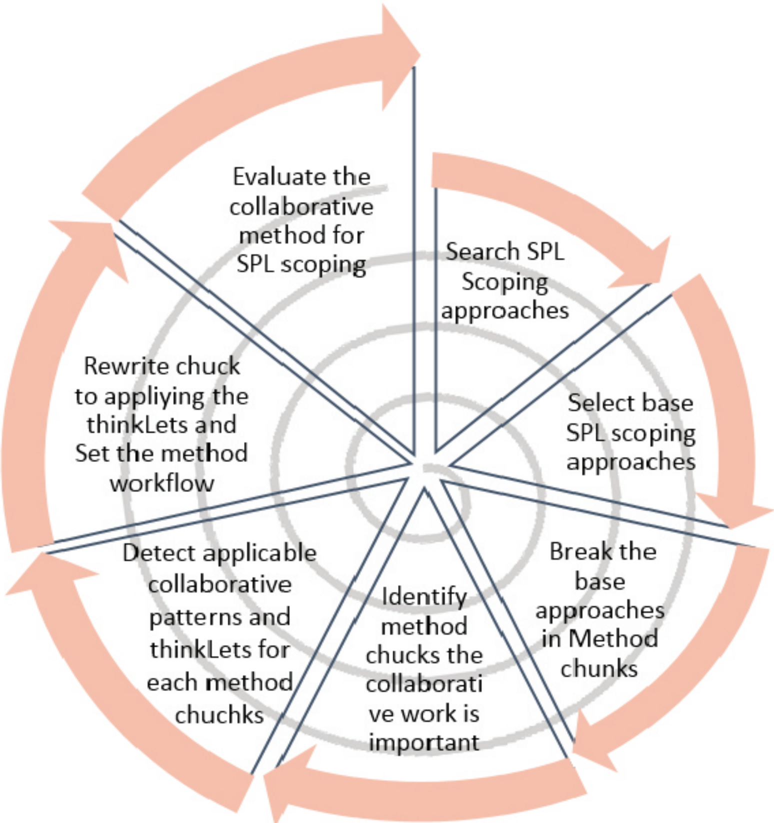

Figure 1.2: Scheme of the project's research methodology

- For the validation of the method, guidelines for carrying out and reporting experiments and case studies in software engineering were used [34] [35] [36]

The combination between the framework, the methods and specific techniques of software engineering research have been instantiated in a set of activities that guided the development of the project, figure 1.2 represents the activities that make up the project methodology and are described below.

Activity: Problem Statement

- Facts recognition: review of the facts, preliminary classification and selection of the relevant facts according to the problem and review of the literature about the SPL-scoping.

- Problems discovery: find a gap or knowledge lacking in the state of the art that identifies a relevant problem. It requires to study the theoretical framework on SPL-Scoping: published methods, techniques, approaches and experiences.

- Problem formulation: establish the problem by focusing a research question according to the available knowledge.

Activity: Construction of the theoretical Model

- Selection of relevant factors: analysis of the different approaches for SPL-Scoping. Revision of the literature about SPL-scoping.

- Formulation of hypotheses: the hypotheses, supposed as a basic argument to address the research work.

- Construction of the proposal: Identify the possible elements of the proposal according to the literature and the results of exploratory studies; construction of the model that constitutes the proposal.

Activity: Validation In this activity, the developed proposal will be evaluated using quasi-experiments, controlled experiments and / or case studies

- Validation design: the validation research question is posed, indicators and metrics are defined and the data collection instruments are created.

- Validation planning: validation planning according to the hypothesis, research questions and available groups or organizations that will make up the population participating in the validation.

- Execution of the validation: the experiment or case study is carried out as planned and the data collection will be carried out using the designed instruments.

- Analysis and report of the validation: the interpretation of the collected data is analyzed from the viewpoint of the theoretical model and the validation report is documented.

Activity: Introduction of conclusions to the theory

- Confrontation of the results obtained with the hypotheses.
- Relevant adjustments to the proposal: analysis of relevant results and necessary adjustments to the proposed model.
- Suggestions for additional work: look for gaps or limits in the theory or empirical procedures, if the null hypothesis is confirmed or if the alternative hypothesis is confirmed, the possible extensions and consequences will be reviewed.

1.3.5 Organization of the document

The organization of the degree work document is divided into five chapters which are briefly described below:

Chapter 1, is the current chapter referring to the introduction, which has been divided into the Problem Statement, the objectives of the project, the solution hypothesis, the methodology and finally the structure of the document.

Chapter 2 presents the theoretical references necessary to understand the information presented in the document and which were the basis for carrying out this project. The theoretical references are divided into groups: The first group includes the concepts of Software product Line (SPL) and scoping. The second corresponds to collaborative engineering and the third group to method engineering.

Chapter 3 will present the study on the SPL scope approaches reported in the literature and the selection of the approaches that were used as foundations for the design of the proposed method.

Chapter 4 presents the specification of the collaborative model for SPL-scoping, this information corresponds to each of the tasks, with their steps, participant roles, inputs and outputs; as well as if collaborative patterns and thinkLets are included in the task

Chapter 5 presents the evaluation of the proposed methodology, Initially presents the experiences collected in the exploratory studies; and then the evaluations of the proposed method that include the design, the description of the participating population, the results obtained and their analysis. Some conclusions about the collaborative method for SPL-scoping proposed are also presented.

Finally, **Chapter 6** presents the conclusions of the results obtained and their articulation with the set of objectives. Additionally, future activities are presented to strengthen the present work.

Chapter 2

Background

"If I have been able to see beyond, it is because I was on the shoulders of giants" Issac Newton

This chapter presents the theoretical framework for this project. The first section introduces the concept of software product line, software product line engineering and SPL scoping activity. After that, the concepts of domain engineering will be introduced. Additionally this chapter introduces some definitions about collaborative engineering. The main topics that are described in this chapter correspond to the conceptual framework that support this project. The figure 2.1 presents the 4 elements that make up this conceptual framework, the scoping of the software product lines engineering, the different proposed SPL scoping approaches, the method engineering and the collaboration engineering

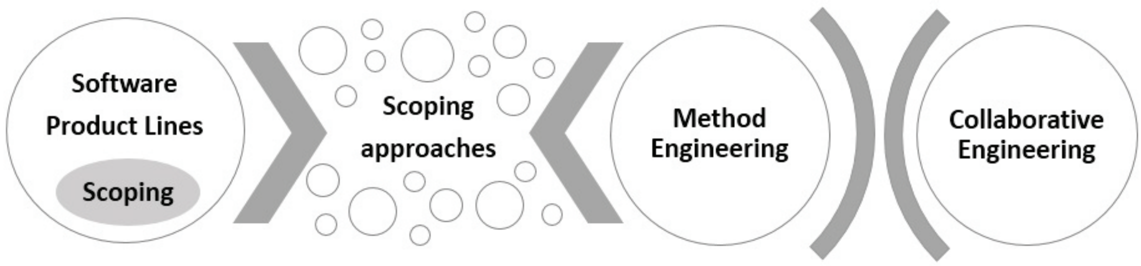

Figure 2.1: Conceptual basis

2.1 Software Product Lines

2.1.1 Introduction to Software Product Lines

A Software product line (SPL) is a set of similar software products sharing common features, differing in some features, and satisfying specific needs related to a particular market segment. The products are developed in a predetermined way from a set of reusable assets [20] [5] [37]. This definition is shown in figure 2.2.

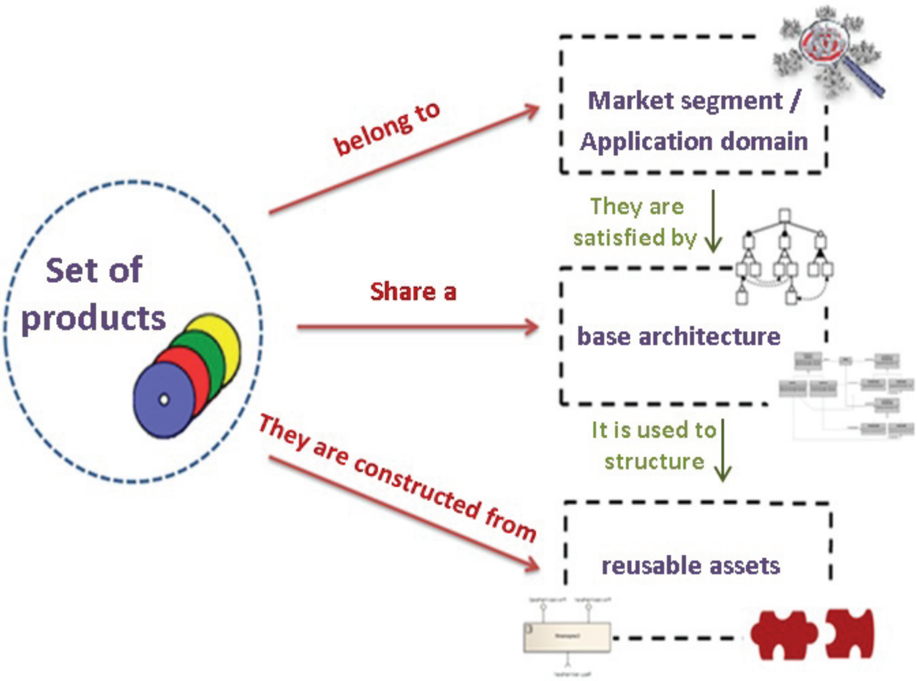

Figure 2.2: Software Product Line

The products belonging to the SPL are conceived, developed and maintained in a pre-established way from a set of reusable assets, instead of being developed individually from scratch or reusing elements or assets in an opportunistic way. A reuse strategy is applied for deriving products belonging to the SPL, using the alternatives features [1].

Some benefits expected by a company that adopts the SPL approach include [20] [38]:

- Increase productivity: products are not built from scratch, but from a reusable base previously implemented and that is reused for developing each product. This benefit occurs when a considerable number of products require to be developed as part of the family.

- Reduced time to market: due to the knowledge about the market and the productivity increased by the planned reuse of assets.

- More efficient use of resources: the development team is not limited to repetitively doing code, which allows them to dedicate their efforts towards engineering, quality and business.

- Increasing product quality: The reuse requires the assurance of the quality of the reusable assets. Each product development requires to test each reused asset although it had been tested before(because each reuse context requires that), therefore the quality filter is higher.

- Reducing risks: counting on an architectural early solution allows to address technical and managerial risks

- Capability to maintain presence in the market: Due to the rapid response to the market, quality and knowledge of the domain, organizations can position themselves in a niche business.

- Increasing customer satisfaction: as a consequence of the other benefits, such as less development time, high quality and fast response to incidences.

These benefits offer software companies several competitive advantages, derived from the reuse of the base assets using a reuse plan [39]. Once the base assets have been developed, there is a direct saving each time they are incorporated into a product. The product line approach enables future market opportunities and reduces the costs and risks associated with the exploration of new products. The lines of products improve the quality, in each new system the defects detected in the previously developed products have already been solved.

Although the approach offers benefits of great impact for an organization, its adoption is not simple and there are some difficulties:

- The company requires a strong organizational structure for the successful execution of the SPL approach [40] [41].
- The Capture and Analysis of requirements in the engineering domain requires balance between both contradictory requirements of different products and common requirements and also needs an overview of production but not individual [42]
- The adoption of the SPL approach requires a specific approach to the development process model determined by a vision of SPL production [42].
- The resources, time and initial investment associated with the SPL approach are greater than those required in the individual developments [41] [20].

2.1.2 Software Product Line Engineering

The difference between traditional development of a single system and software product line engineering is a shift of approach and strategy: from the next-contract vision to a strategic view of a business idea and target market [1].

Software product line engineering includes two processes: development for reuse (domain engineering) and development with reuse (Application engineering). As Figure 2.3 shows, a distinction of software product line engineering from other reuse approaches is the strategically planned assets reuse, so that they can be used in the development of products of the SPL and these assets contain explicit variability that can be applied only for a certain subset of the products [1] [38]. The goal of software product line engineering is to build up similar products that differ inside a defined scope [38].

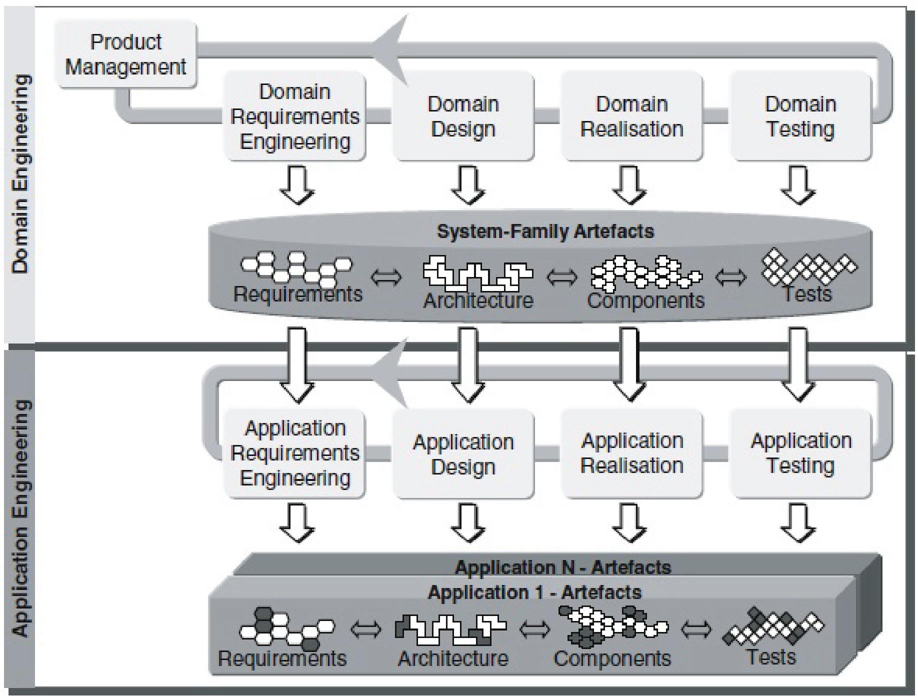

Figure 2.3: Software Product Line Engineering Framework [1]

2.1.3 Scoping Software Product Lines

The scoping activity goal is to determine the boundaries of the SPL. The scoping is a set of limits the aspects and functionalities that are "inside" a system to be developed, and those behaviors or aspects that are “outside“ [20].

The SPL scoping is a crucial step for developing a SPL. This activity may determine the success or failure of the complete product line effort [8]. The product line scope includes the set of products that is part of the line, these products must be carefully selected in order to obtain economic benefits and that they can be efficiently developed from valuable reuse assets [7]. Thus, SPL Scoping is considered as a SPL technical discipline [7].

The scoping allows organizations to define the reuse context and help engineers capture the common aspects and restrict its variability [7] [5]. For instance, a too broad scope could severely threat for the usefulness and cost-effectiveness of the software assets reuse of SPL. However, a too narrow scope will give software organizations a low ROI (Return of Invest). Additionally, an incorrect scope could address toward the wrong products to the real market opportunity [5]. Thus, according as scoping activity is performed, SPL production will be successful or a failure [5], being the most critical activity since it defines a relationship of a multi-set of domains, features, reusable assets and products belonging to a SPL [8]. Three types of scoping can be identified [8]:

- **Product Portfolio Scoping:** identifying the specific features and the individual products that should be part of the product line.
- **Domain Scoping:** it allows to identify and bound the functional areas or domains relevant for reusing assets since they provide sufficient reuse potential and what exactly should be regarded as part of products.
- **Asset Scoping:** it determines specific assets to be developed for reuse and constitutes a basis for the subsequent design of the reuse infrastructure.

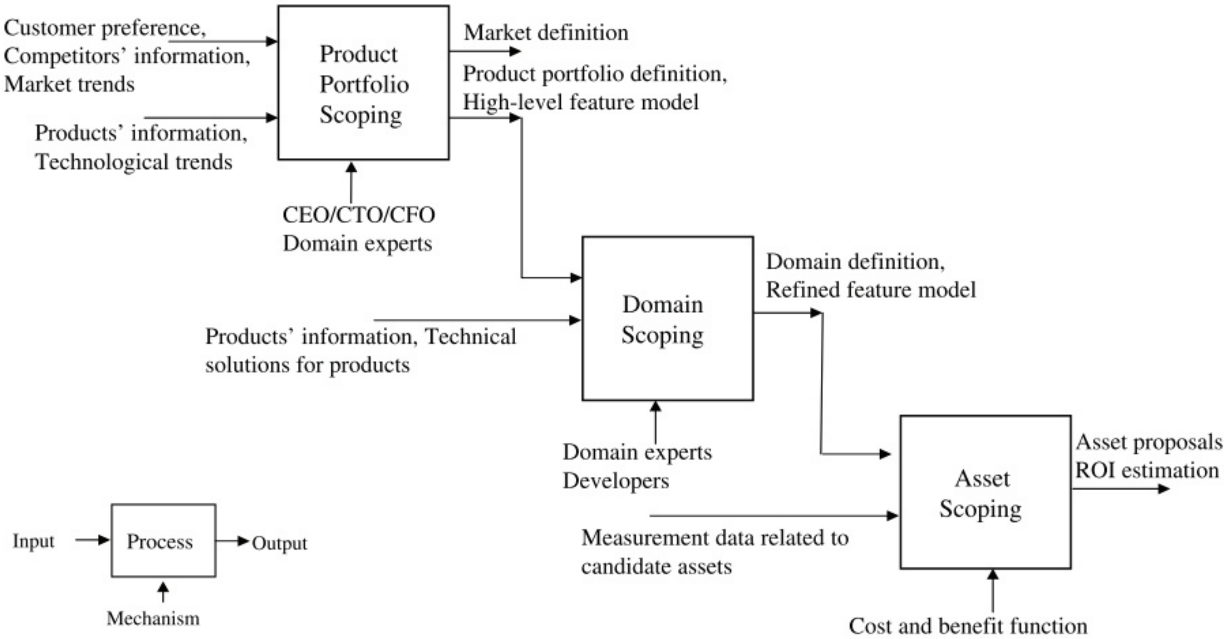

Figure 2.4: Relation of Product line scoping levels in the Unified Approach [2]

Each scoping type is a mechanism for planning reuse. Each one is related with another, each type refines the decisions made in the others. The initial basis for decisions is the product portfolio scoping [43] [11]. The product portfolio scoping is conducted by people who have overall knowledge about products, customer needs, competitors, market trends, and technological tendencies, and also, people in charge of authorizing strategic decisions about the products that will be produced as part of a product line and the used production strategies. The domain scoping takes as a base the product portfolio. During domain scoping, experts of domains who have in-depth knowledge about products, software architects and developers analyze the proposed products and features. The common and variable features are classified in functional areas or domains. The manager's, experts of domains, software architects and developers participate in asset scoping. The product portfolio and classification of features and functional areas could be decomposed according to possible assets. These assets are evaluated to identify which must be developed as reusable [2].

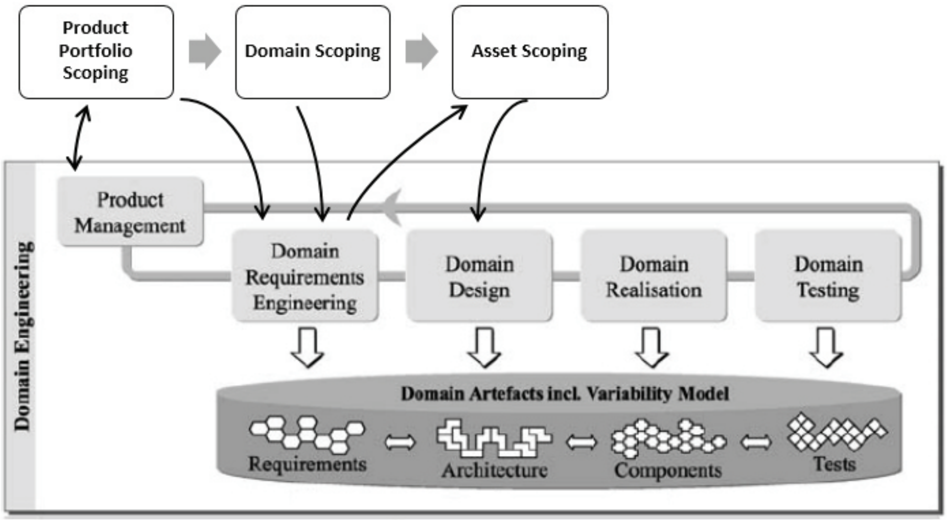

Figure 2.5: Relation of Product line scoping types and SPL development life-cycle

Figure 2.4 depicts a representation of the relations among the three scoping types.

The interconnection of scoping types is enriched at a different stage of the life-cycle of a SPL development [43] as seen in the figure 2.5. In the SPL domain engineering, the Product Portfolio Scoping connects product management and domain requirements engineering areas, usually addressed by market studies and company goals defined by high management. The domain scoping defines the functional areas or domains and precedes the domain analysis. The asset scoping can be executed parallelly or after to domain analysis. The outcome obtained at this scoping type is one of the inputs that should be considered in architectural design during the domain design. [2].

SPL scoping has three distinguished levels to be addressed by domain engineers [8] [43] [11]:

- Identification and description of a scope from a vision or guidelines supplied by experts.
- Assessment of the appropriateness of a scope. This level aims at

identifying those (sub-) domains or functional areas or assets that are the most appropriate candidates for reuse.

- Optimization of the scope, identifying which elements must address during the domain construction. This aims to guide the development in a strategic way.

2.2 Method Engineering

A method provides the instructions that allow the transformation of one or several artefacts into a target artefact, the guidelines are systematic and provide the steps for their execution or allow the deduction of the concrete steps as of the objective and the guidelines [44] [45].The Method Engineering (ME) is the discipline to design, build and adapt these methods. [46] [44].

A method description usually includes activities, roles, specification documents, techniques, and meta-models. An activity is performed by roles (job descriptions or organizational units) with the aim of generating a certain result. The results are recorded in previously defined and structured specification documents. A technique is the detailed instruction for the development of the specification documents and obtaining the results. Finally, the meta-models describe the concepts that make up the method [45].

2.2.1 Method

A method is defined as a sequence of planned and systematic steps to achieve an objective [45]. A method is generally defined as a set of activities, tasks or related techniques described through a sequence of planned and systematic steps that must be followed and the work products that will be generated, used or modified at a certain time; the people involved and the tools required, during the necessary effort to achieve a goal [47]. The attributes of a method are [45]:

- Goal orientation Methods: they give guidance and rules about how to proceed or act in order to achieve defined goals or be able to solve concrete problems.
- Systematic approach: the method must have a systematic structure that allows the deduction of concrete work steps for achieving goals set.
- Repeatability: the method is potentially repeatable to achieve the goals established independently of others factors.
- Principles: Many method specifications are related to general construction guidelines and/or strategies.

A method is described by the elements of activities, roles, specifications, techniques and meta-models. An activity is performed by roles (job descriptions or organizational units) with the aim of generating a specific work product. The work products are recorded in previously defined and structured specification documents. A technique is the detailed instruction for the development of the specification documents and obtaining the results. Finally the meta-models describe the concepts used for defining the method [47] [45].

2.2.2 Method pieces

The literature talks of "method part" using the terms (1) method fragments, (2) method chunks or (3) method components for referring to some pieces of a method. These three different concepts are based on their utilization [48]. The software development methods can be created as well as possible by means of identifying and building small method elements, called fragments or chunks which are selected and strategically joined for running in a specific situation [49].

A “method fragment” is a portion of a meta-model and it could be of two types of fragments: process fragments and product fragments [31]. In general, there are three basic types of meta-modeling fragments: Producer, WorkUnit and WorkProduct used by SPEM of OMG (Software Systems Process Engineering Meta-Model: OMG 2008), in the OPEN process framework (OPF: Firesmith and Henderson-Sellers 2002) and in the international ISO / IEC standard 24744 (ISO / IEC 2007).

The fragments are typically adapted to a single metamodel element. The process fragments are focused on the process or WorkUnit (e.g. a kind of task or technique). The product fragments are oriented to the WorkProduct (a kind of diagram, document or other). [50]. The method fragments are defined separately, process-only fragments or product-only fragments [49].

A method chunk is an autonomous and coherent part of a method, that coupled the process part (work unit) that transforms (construction, modification, etc.) the work product part (artefacts such as documents, models or code) [50] [51].

A method component is a part contained in a method including the rationale and guidelines for transformation from one or more work products into a defined target work products [44]. A method component consists of method elements: goal, artefact, actor role and action. The method component is an artefact centered concept. The input artefacts of a method component are used during the predefined actions and are finally transformed into a deliverable which is the outcome of other components [44].

The three concepts of the "method part" look similar but they have differences. The method fragment references a single concept in the metamodel: a process (work unit), a work product or a produce. The method chunk is a combination of a process-focused fragment and a product-focused fragment. The method component consists of work products (inputs/outputs) and the ‘process’ used to transform the input in the target output. The Method chunks does not describe the producers while the method components consider the producers in the rationale method [48].

2.2.3 Method Building

The method engineering focuses on the construction of methods by selecting components from a repository, or a set of existing methods or a base method [44]. The construction of a method involves three general steps, (1) specification of the method requirements, (2) selection of the method components and (3) the assembly of the selected method components [3].

2.3 Collaborative Engineering

Collaborative Engineering (CE) is an approach to the design and implementation of collaborative processes that include collaborative work practices in recurrent activities where teamwork is a relevant success factor [52] [53]. The term collaboration denotes "to work with". Thus, collaborative efforts are joint, not individual. The collaborative efforts must be directed toward a group goal. This means collaboration involves multiple individuals who combine their knowledge and efforts to achieve a mutual proposed goal. Therefore the collaboration is defined as the joint effort towards a group goal [52].

2.3.1 Patterns of Collaboration

Patterns of collaboration characterize the ways in which “group’s activities” can move to “team’s activities” focusing on a common goal. These patterns allow to classify team activities based on the changes they produce [52]. The basic patterns are [52] [54]:

- Diverge: move from having fewer concepts to having more concepts shared by the participants' group.
  - Gather: Collect known concepts individually and share them with the other members of the group.
  - Create: Produce and share new ideas that were not previously known by group members.
  - Elaborate: Add details to concepts shared by the group, either decomposing a concept or expanding it by adding details.
- Converge: Move from having many concepts focusing on a few concepts deemed worthy of further attention and dedication.
  - Select: Choose a subset of existing concepts.
  - Abstract: Derive more general concepts from specific instances from the existing set.
  - Summarize: Capture the essence of the concepts.
- Organize – move from less understanding to more understanding of concepts and the relationships among used concepts.
  - Classify: Arrange concepts into labeled clusters.
  - Structure: Organize arrangements among concepts to represent their relationships
- Elaborate: Move from having concepts expressed in less detail to having concepts more detailed.
- Abstract: Move from having concepts expressed in more detail to having concepts expressed in less detail.
- Evaluate: Move from less understanding of the value of concepts to more understanding of its value.
  - Poll: Assess the group opinion with respect to a set of concepts.

  - Rank: Identify an order of preference among concepts.
  - Assess: Specify and elaborate the value for a set of concepts

- Build Consensus: Move from having less agreement to having more agreement among stakeholders.

  - Measure: Assess the degree to which stakeholders agree on a concept or concept value.
  - Assess: Specify and elaborate the value of concepts.
  - Diagnose: Seek understanding of the underlying causes of discrepancy.
  - Advocate: Seek to persuade others to adopt and accept a position, the concept or a specify concept value.

2.3.2 ThinkLet

To propose a collaborative process, building blocks or designing units called thinkLets are used. A thinkLet is a predictable pattern of interactions among people working together to achieve a goal [55] [56], whereby a thinkLet is a predictable pattern of collaboration, a known, proven and reusable solution for similar work situations in teams [53] [57]. A thinkLet is a named, packaged facilitation technique that creates a predictable, repeatable pattern of collaboration among people working towards a goal [55] [55].A collaborative process is a series of activities carried out by a team to achieve a common goal, at the same time it is a sequence of thinkLets that create patterns of collaboration among the members of the team [56].

2.3.3 Gamestorming

Gamestorming methodology considers the use of games in the resolution problem by a people group, where presenting the problem in a game format eludes the conventional meetings and frees the participants to think creatively. The Gamestorming application want that all participants of the team be aligned towards a goal, and that everyone understands what they are doing and achieving an active and dynamic work form [58] [59].

Gamestorming brings together a set of strategies and practices that have been called games, specific games with the aim of exploring and examining business challenges, improving collaboration among the members of a team and generating new approaches and possibilities of situations or products. The gamestorming raises the essential elements be considered in a game. It also classifies the games in four types according to the objective that is sought to achieve basic games, opening games to start an activity, games to explore concepts or proposals by the participants and closing games to conclude an activity [58].

2.3.4 Chapter Summary

To address a research project, it is necessary first to discuss and agree on the key concepts that will form the conceptual framework of the project. We first address what a software product line is, and what the activity of scoping mean does in the engineering of software product lines. After the method engineering was approached and the related terminology was discussed, such as the definition of method and method component. Finally, we included important aspects of collaboration engineering such as collaborative pattern and thinklet, basic design units for a collaborative method.

Chapter 3

Literature Review on Software Product Lines Scoping Roles and Its Interactions

"Great ideas come from the unconscious.
But the unconscious has to be well informed or
that idea will not be relevant to us" David Ogilvy

This chapter presents the main SPL scoping approaches representing the state-of-the-art, and analyzes the characteristics related to the roles required and the interaction among them. The searches and revisions of the literature were made across the different research stages, some of the related works were identified as advanced research.

3.1 Introduction

The diversity aspects of the participants in SPL Scoping are as necessary as the technical, administrative, organizational, market and sale aspects during SPL planning. However, gathering a group of people does not mean working as a team [60]. Teamwork requires the existence of an activity that must necessarily be carried out with a group of people to achieve a common objective [61]. SPL Scoping requires people with different knowledge, representing different interests according to an organizational unit or the performed role [16]. Teamwork is to cooperate in an organized way in order to achieve a common goal, and it requires to manage the interaction and the inter-dependencies among the participants; each team member brings skills, knowledge and experience, techniques are required in order to achieve a common goal [62].

3.2 Planning of Review Process

Literature Review is performed like a secondary study. it proposes to identify, analyze and interpret relevant primary studies related to a specific research question [30] [63].

3.2.1 Planning of Literature Review

This section presents the Planning of Literature Review about SPL Scoping approaches, which includes the protocol definition and the research questions specification and structure. The protocol of Literature Review defines the research objectives and how the review will be conducted, which includes the research question definition and the planning about how the sources and studies selection will be carried out. The research questions guide the design of the review process.

3.2.2 Research Questions

The general objective of this study was to analyze and understand how the existing approaches address interaction and the work among the participants. This was divided into four research questions in order to have a detailed research to identify the suitable roles (including interactions), guidelines and practices proposed for encouraging collaboration and communication. In this part, this study starts to define the research question as follows:

Question 1: Which are the roles defined in the SPL Scoping approaches?

It allows to identify approaches specifying the roles that should be involved in the SPL Scoping, and the detail level in which these are described.

Question 2: Which are the elements of the teamwork considered by the studied SPL Scoping approaches?

It allows to determine elements that improve the teamwork in the SPL Scoping approaches (knowledge, responsibilities and interdependence between role guidance).

Question 3: How SPL Scoping approaches consider aspects promoting communication or collaboration among the participants?

Identifying how each approach indicates inter-dependencies among roles during the scoping tasks, and if it describes elements or techniques to help the participating roles to communicate or collaborate into task execution or building artefacts.

3.2.3 Types of Review

In the literature, there are some reviews on SPL, and specifically there are two studies that identify and characterize the SPL Scoping approaches. Thus, in order to identify the SPL-Scoping approaches, the studies were divided into two groups, the former ones are studies from 2000 to 2009, referred in other studies, making an Umbrella review, and the last are the approaches identified from a search in the literature reports after 2010, it can be seen in figure 3.1.

Figure 3.1: Literature review

3.3 Review Process: Umbrella review, A first group of SPL Scoping approaches

The umbrella review specifically refers to a review compiling evidence from other reviews into one accessible and usable document for a new research [64]. For this particular case, we started with the previous revisions to identify the existing SPL Scoping approaches before 2010.

In 2009, two studies were conducted on SPL Scoping approaches: Moraes et al [12] and John and Eisenbarth [11], who characterized the SPL Scoping approaches. Both studies focused on process and technical aspects. Although, they included some questions about the required roles, the analysis did not consider aspects such as role interaction. For this research, these two studies were used as a basis to identify a first group of approaches and some of their characteristics. Moraes' study identified 11 approaches and John's study recognized 16 approaches, with 8 common findings between these two studies. We reviewed 18 of the 19 approaches identified, two identified approaches did not find the base referenced document.

The table 3.1 presents the SPL Scoping approaches identified by each of the studies, those common to both studies and those reviewed in this research are indicated, in the second row the number of approaches of each study is presented, the common approaches (C) ones and those approaches that we review in this study (R).

3.4 Review Process: Literature review,The second group of SPL Scoping approaches after 2010

Search Strategy

To identify the SPL Scoping approaches proposed between 2010 and 2017, a review of the literature was made. From the research questions formulated, were extracted keywords that were used to search the sources of the primary study: “scoping”, “scope”, “planning” and "scope definition". These terms were combined with "Software Product Line" in order to build the search string using the boolean “AND“, and “OR“ operator to join the different alternatives, so the search string was defined as:

(scoping OR scope OR planning OR scope definition) AND
(software product line OR product line)

Data Sources

The main data sources of the review were conference proceedings and journal articles. The initial steps were considered in the interactive platforms ACM Digital Library, IEEE Xplorer and Springer. The search range time was articles published between 2010 and 2017. Some books and technical reports were also collected.

Inclusion and Exclusion Criteria

As inclusion criteria, articles related to software engineering, computer science or software development were considered, in which they described the SPL Scoping activity. Exclusion criteria: articles that only name the SPL Scoping activity but its main theme was another SPL

	John y Eisenbarth [11]	**Moraes at al [12]**	**Approaches**	**Year**	C	R
1	Bandinelli and Sagardui [23]		Business Analysis of Domain	2000		x
2	Chastek et Al [9]		Practical Introduction	2001		x
3	Riebisch et Al [15]	Riebisch et Al [15]	Feature Scoping	2001	x	x
4	Kang et Al [25]		Marketing and Product Plan	2002		x
5	Kishi et Al [65]	Kishi et Al [65]	S-DM Method for Scoping Based on a Decision-Making Framework	2002	x	x
6	Schmid [43]	Schmid [43]	PuLSE-Eco ((Product Line Software Engineering – Economic Scoping)	2002	x	x
7		Northrop and Clements [20]	Scoping in SPL Practice Framework	2002		x
8	Geppert and Weiss [24]		Goals for Domain Assessment	2003		x
9	Rommes [16]	Rommes [16]	People Oriented Approach	2003	x	x
10	Fritsch and Hahn [66]		PLPA (Product Line Potential Analysis)	2004		x
11	Taborda [21] [67]		Release Planning	2004		x
12		Lee et Al [68]	Feature-Based Approach	2004		x
13	Helferich et Al [69] [70]	Helferich et Al [69] [70]	QFD-PPP (Product Line Portfolio Planning using Quality Function Deployment)	2005	x	x
14	Niehaus et Al [71]		scoping in Product Management	2005		x
15	Park and Kim [72]	Park and Kim [72]	Process for Scoping Core Assets	2005	x	x
16		John et Al [27]	Practical Guide to scoping	2006		x
17	Noor et Al [18] [13] [73]	Noor et Al [18] [13] [73]	Collaborative Approach to Scoping	2006	x	x
18	Ullah and Ruhe [22]		RP-PL(Release planning for software product lines)	2006		x
	Inoki and Fukazawa	Inoki and Fukazawa,		2007	x	No

Tabla 3.1: SPL-Scoping approaches (before 2010)

Source	Findings	Repeated suppression	Filtered results
ACM	65	49	7
IEEE Xplorer	21	14	6
Springer	7	6	2
Scopus	20	16	1
SPL Scoping approaches identified			15

Tabla 3.2: Sources and findings

development activity, and therefore it did not discuss aspects of SPL Scoping or propose tools for systematization of some of the scope artefacts. Initially only studies written in English language were considered.

Studies Selection

Both the selection and search process were conducted with the objective of identifying the proposed SPL Scoping approaches. The first stage was initiated with the approaches identification using the defined search string applied to the title and abstract. The found papers were analyzed according to the inclusion and exclusion criteria to identify the approaches. For each selected primary study, a brief analysis of the following elements was applied: title, abstract, keywords, and conclusion. After the repeated proposals in different sources were excluded. The result of this stage is presented in the table 3.2.

SPL Scoping approaches identified between 2010 and 2017

In this second group, proposals for the optimization of the scope were found, but they do not propose an approach of how to define the scope. These start point is a defined scope which is analyzed in order to maximize the objective of the SPL, thus these proposals are excluded from this study.

The SPL Scoping approaches identified in the literature review are presented in chronological order in the table 3.3.

N	Proposed by	Approaches	Year
19	John [74]	Cave (Commonality And Variability Extraction)	2010
20	Cvetković and Nešković [75]	Approach to Defining Scope in SPL for the Telecommunication Domain OSS/BSS	2010
21	Ullah et al [28]	Method COPE+ (Customer Oriented Product Evolution)	2010
22	Lee and Lee [76]	A Framework for Product Line Scoping Product	2011
23	Müller [77]	VB-PO (Value-Based Portfolio Optimization)	2011
24	Balbino et al [78]	RiPLE-SC An agile scoping process for SPL RiPLE (RiSE Process for Product Line Engineering) RiSE (laboratory of Reuse in Software Engineering)	2011
25	Hu et al [79]	Value-Based Portfolio Scoping	2012
26	Nöbauer et al [80]	Lightweight Product Line Scoping	2012
27	da Silva [81]	SPL Scoping Agile Process	2012
28	Gillain et al [82]	Product Portfolio Optimization	2012
29	Ianzen et al [10] [83]	Semi-automatic scope	2012
30	Capilla [84]	Variability Scope	2013
31	Cruz et al [85]	Hybrid Approach to Generate PPS	2013
32	Alsawalqah et al [86]	PPSMS (Product Platform Scoping Method for Software Product Lines)	2014
33	Vale et al [87]	The Portfolio Planning phase of SPLICE (Software Product Line Integrated Construction Environment)	2014

Tabla 3.3: SPL-Scoping approaches (after 2010)

Unifying the two groups of SPL scoping approaches identified in the umbrella type review carried out by other authors (18) plus those identified in the search and revision carried out by us (15), a group of 33 approaches was finally identified.

3.5 Review results: Roles in Scoping approaches

A role is understood as the function performed by a person within the group, each person occupies a specific position as part of a working group. A role defines a set of expected behavior patterns and assigned responsibilities [61].

A role defines the behavior, skills, competences and responsibilities of a person or several people as part of a group that works on the whole to achieve a common goal. Individual members of the development organization can perform different roles and a role to be played by several individuals [88].

Question 1: What are the roles defined in the SPL Scoping approaches?

In order to answer this question, we identify which approaches consider some role in their description. Table 3.4 presents which of the 33 Scoping SPL approaches consider any role in their description and which do not. Figure 3.2 indicates the proportion of approaches that considers roles. The number of approaches that include roles is almost the same as those who do not consider them.

The main concern of most of the approaches of the first approaches group (before 2010) was to propose the necessary activities in scoping more than establishing the roles involved. The concerns that are recognized in the approaches in the second group (after 2010) is to improve the definition of the scope in aspects related to the process, the tools used, the optimization of the scope obtained and some in the communication required during this activity.

N	Approaches	year	consider roles?
1	Business Analysis of Domain	2000	no
2	Practical Introduction	2001	yes
3	Feature Scoping	2001	yes
4	Marketing andProduct Plan	2002	no
5	S-DM	2002	no
6	PuLSE-Eco	2002	no
7	Scoping SPLP Framework	2002	yes
8	Goals for Domain Assessment	2003	no
9	People Oriented Approach	2003	yes
10	PLPA	2004	no
11	Release Planning	2004	no
12	Feature-Based Approach	2004	no
13	QFD-PPP	2005	yes
14	Scoping in Product Managemen	2005	yes
15	Process for Scoping Core Assets	2005	no
16	Practical Guide to scoping	2006	yes
17	CollaborativeApproach to Scoping	2006	yes
18	RP-PL	2006	generally
19	Cave	2010	yes
20	Approach Scoping Telecommunication Domain	2010	no
21	COPE+	2010	no
22	Framework for Scoping	2011	no
23	VB-PO	2011	yes
24	RiPLE-SC	2011	yes
25	Value-Based Portfolio Scoping	2012	no
26	Lightweight Scoping	2012	yes
27	Scoping Agile Process	2012	yes
28	Product Portfolio Optimization	2012	no
29	Semi-automatic scope	2012	yes
30	Variability Scope	2013	no
31	Hybrid Approach to Generate PPS	2013	no
32	PPSMS	2014	yes
33	SPLICE	2014	yes

Tabla 3.4: Approaches that consider roles

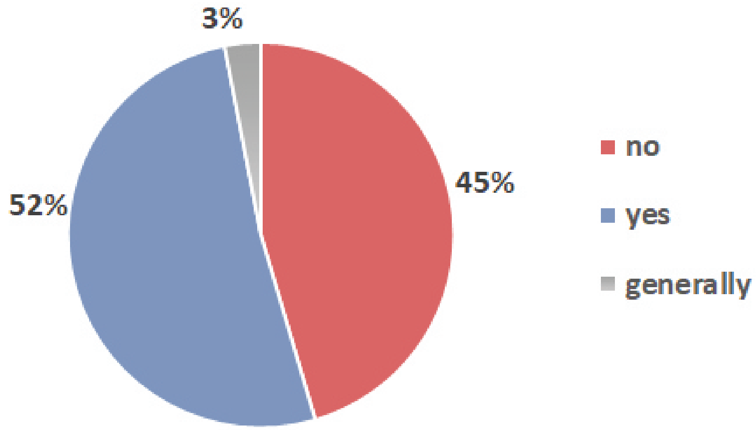

Figure 3.2: Approaches that consider roles

Table 3.5 only includes the 17 approaches that have considered roles. This table presents the number of roles proposed by each approach and their names. It can be seen that there is a diversity regarding the considered considered, as well as the number of roles that each approach considers (see figure 3.3), it should be noted that those approaches mentioning only one or two roles do not indicate that they are the only ones, but they are the roles that the proposal considers as the most important instead.

The table 3.5 allows to visualize the number of times a role has been proposed by SPL scoping approaches, we have grouped synonymous names. The study of the roles considered by the approaches (table 3.5, and table 3.6) show that most approaches are in line with the diversity of disciplines and knowledge required.

The most repeated roles in the approaches are customers, domains experts, developers and system architects; followed by management, product line manager, and marketing/sales personnel.

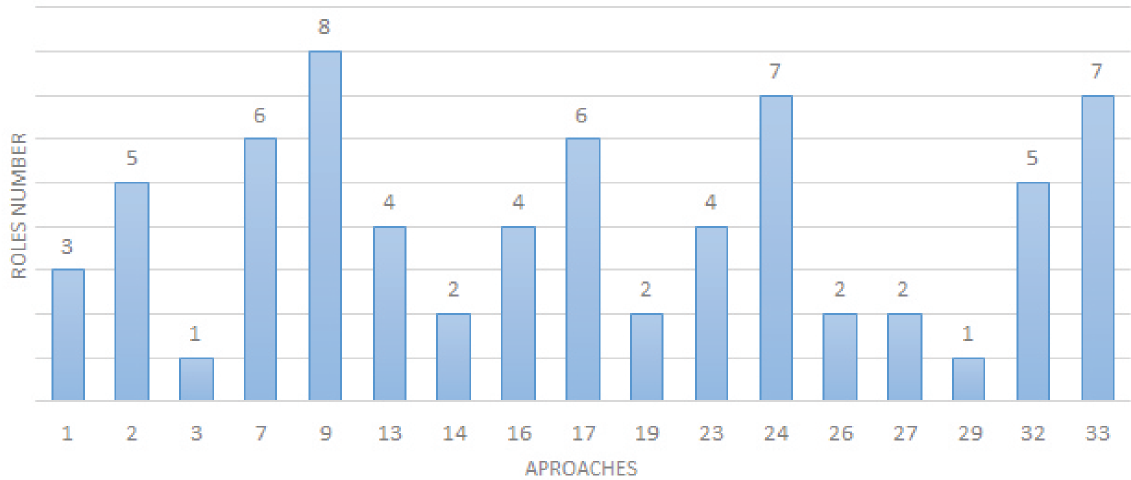

Figure 3.3: Number of roles considered in the approaches

N	Approach	Roles	Roles names
1	Business Analysis of Domain	3	software Department representative, systems Department representative, marketing/sales department representative
2	Practical Introduction	5	Organization's executives, Product end users Product line analysts, Designers, Implementers
3	Feature Scoping	1	Developers
7	Scoping in SPL Framework	6	Management, Developers, Methodologists, Customers, Users, Subject-matter experts
9	People Oriented Approach	8	Management, Product managers, Users, Sales persons, Customers, System architects, Developers, Suppliers
13	QFD-PPP	4	Developers, Software architects Existing customers, Potential customers
14	Scoping in Product Management	2	Product managers, Customer

N	Approach	Roles	Roles names
16	Practical Guide to scoping	4	Scoping expert, Product line manager Domain experts with technical knowledge Domain experts with marketing knowledge
17	Collaborative Approach to Scoping	6	Senior management, Customers Marketing and sales, Developers, Software architects, Maintenance personnel
18	RP-PL	-	stakeholders
19	Cave	2	Product line engineers, Domain experts
23	VB-PO	4	Analyst, Manager, Sales person Software engineers
24	RiPLE-SC	7	Scoping expert, Customer, Architect, Domain expert, Market analyst, Developer, Product line manager
26	Lightweight Product Line Scoping	2	Customer, Domain expert
27	SPL Scoping Agile Process	2	Stakeholders, Domain expert, Customer
29	Semi -automatic scope	7	Potential customers, Domain experts Product developers, Domain analysts Marketing personnel, Project managers Product manager
32	PPSMS	1	domain experts
33	The Portfolio Planning phase of SPLICE	5	Business Expert, Scope Owner Product Expert, Legacy Systems Developer

Tabla 3.5: Roles considered in SPL scoping approaches

Roles	Number of times proposed
organization's executives/ management / Senior management	5
product end users /users	3
developers / Legacy Systems Developer /implementers /product developers /software department representative	10
customers/existing customers /potential customers	9
methodologists / scoping expert	3
domain experts with marketing knowledge /Domain experts /subject-matter experts	9
Product managers / product line manager / project manager	5
Sales persons/ Marketing and sales / market analyst /Business Expert /marketing personnel /marketing and sales department representative	6
systems department representative	1
System architects / domain experts with technical knowledge / designers	7
Maintenance personnel	1
Suppliers	1
Product line engineers / Software engineers	2
Analyst / domain analysts /product line analysts	3
Product Expert	1
SPL Expert	1
product manager	1
Scope Owner	1

Tabla 3.6: roles proposed

3.6 Results of the literature review: the teamwork in scoping approaches

Question 2: What are the elements of teamwork considered by the SPL scoping approaches?

That a SPL scoping approach mentions the participating roles, and it does not mean they work as a team. In order to promote the teamwork, it is necessary to describe enabling aspects, for instance, each role must know the objective of their participation, the knowledge and skills they contribute to the whole task of SPL scoping. The tables 3.7 analyzes these three aspects in each of the approaches that indicate roles in their specification.

According to the results obtained (see table 3.7) half of the approaches considering roles are limited to mentioning them. However, these do not provide information about the objective of their participation, only the 27.3% of the identified approaches provide descriptions of the roles they propose, allowing to know the objective of their participation.

Collaboration of the members of a work team requires that each one contributes with different and complementary knowledge and skills; To conform the work team, it is necessary to know what knowledge and skills each role should contribute. Only the 24.3% of approaches takes into account the knowledge and skills that each role must provide.

Another aspect that improves the collaboration between members of a team is to know their responsibilities. A 21.2% of approaches describes, in a general way, the responsibilities of the roles and only 9.1% indicates the specific tasks where each role participates.

When the manager of a project does not know the role specification (objective, skills and knowledge), there is a high possibility selecting the wrong person, additionally as a result we have a person who plays an unsuitable role, because he/she does not know his/her objective in the project, the knowledge that she/he must contribute, their responsibilities or specific tasks in which the person participates.

Question 3: Do the SPL Scoping approaches consider aspects helping to improve communication or collaboration among the participants?

Identifying if the approaches exhibit inter-dependencies between roles in the scoping tasks, and if it describes techniques or practices oriented to the roles to communicate or collaborate as scoping activity advance.

N	description	knowledge	Responsi-bilities	associated with tasks
1	only mentioned	yes	no	generally
2	view that the role has of the LP	yes	no	no
3	only mentioned	only technical	Effort estimation	no
7	describes the risk that the required roles do not participate	no	no	no
9	describes in which aspects of the scope it influences and why	yes	no	no
13	general description of what they contribute to scoping	yes	yes	yes
14	only mentioned	no	no	no
16	general description of what they contribute to scoping	yes	generally	generally
17	general description of their interests and participation	yes	generally	no
18	For this approach, stakeholders are very important, and propose a way in which stakeholders prioritize the features, but it does not specify who the stakeholders are.	no	no	no
19	general description of what they contribute to scoping. this proposal seeks to reduce the time required to accompany the domain expert	no	no	no
23	general description of what they contribute to SPL	no	no	no
24	description of what they contribute to scoping	yes	yes	no
26	only mentioned	no	only for a role	no
27	only mentioned	no	no	no
29	only mentioned	yes	yes	no
32	general description of what they contribute to scoping. this proposal seeks to reduce the time required to accompany the domain expert	no	no	no
33	general description of what they contribute to SPL	yes	yes	yes

Tabla 3.7: Description of roles in SPL scoping approaches

Deciding which products belong to the SPL, indicate the functional domains and analyze and features regarding their potential reuse. It requires considering and negotiating aspects from different perspectives [9], these perspectives are represented by the roles. The table 3.8 shows how each approach presents the relationships between the roles for exchanging information from their vision and knowledge, and how they negotiate among scope concerns. The 51% of the approaches studied do not show where or how the interactions among the roles proposed should be carried out. Some of the approaches expose the risk derived from a unappropriated participation of the roles. the 9% of the approaches generally presents the interaction of the roles, and the 18% gives some indications about the interaction in some specific tasks. Only one of the approaches presented the roles they participated by each of the proposed tasks.

The concern for the dependence that scoping has with the different knowledge is reflected in how the approaches have raised aspects and techniques to achieve mixed different knowledge and experiences, with tendency to scope optimization. The table 3.9 presents the aspects or techniques that have been proposed by each approach in order to encourage communication or collaboration among the participating roles. In this analysis software tools have not been considered, because the objective was only to analyze teamwork during scoping.

N	Approaches	consider interdependencies between roles
1	Business Analysis of Domain	As a risk
2	Practical Introduction	generally
3	Feature Scoping	Any
4	Marketing and Product Plan	Any
5	S-DM	Any
6	PuLSE-Eco	Any
7	Scoping SPLP Framework	As a risk
8	Goals for Domain Assessment	Any
9	People Oriented Approach	between roles belonging to different dependencies and possible conflicts
10	PLPA	Any
11	Release Planning	Any
12	Feature-Based Approach	Any
13	QFD-PPP	in some tasks gives clues
14	Scoping in Product Management	Any
15	Process for Scoping Core Assets	Any
16	Practical Guide to scoping	in some tasks gives clues
17	Collaborative Approach to Scoping	generally and possible conflicts
18	RP-PL	regarding the prioritization of features
19	Cave	Dependence with experts and how to decrease it
20	Approach Scoping Telecommunication Domain	Any
21	COPE+	Any
22	Framework for Scoping	in some tasks gives clues
23	VB-PO	in some tasks gives clues
24	RiPLE-SC	in some tasks gives clues
25	Value-Based Portfolio Scoping	Any
26	Lightweight Scoping	Any
27	Scoping Agile Process	generally
28	Product Portfolio Optimization	in some tasks gives clues
29	PPSMS	Any
30	Semi-automatic scope	Any
31	Variability Scope	Any
32	Hybrid Approach to Generate PPS	Describe who contributes each stakeholder in each task
33	SPLICE	in some tasks gives clues

Tabla 3.8: Inter-dependencies between roles

The 39.4% of the approaches propose some aspects or technique to improve communication or collaboration between roles. The proposals are diverse and in most cases are considered aspects for specific tasks. The use of workshops, interviews and punctuation techniques is frequent. The interviews or surveys seek to capture the contributions of the external participants for the development group considering that one of the main drawbacks is the lack of availability to participate or the lack the synchronized work schedules among the different roles.

Another repeated aspect are the artefacts constructed in a cooperative way, where the different roles contribute to their vision. Artefacts such as user scenarios written collaboratively, evaluation matrices or prioritization of features must be analyzed by each stakeholder in order to asses it according to their knowledge. Some of these artefacts consider the relative importance of each stakeholder. The artefacts are specific and correspond to maximum one or two per approach, so they do not cover all the artefacts that make up the scope.

Four of the approaches (12%) have proposed techniques that enclose more than one task or artefact. The work of Noor that we have identified as a collaborative approach scoping, proposes the combination of collaborative practices and agile principles with scoping practices. This is one of the most related works to this proposal and it will be analyzed in the section 3.8 of this chapter. The proposals RiPLE-SC, Scoping Agile Process and SPLICE have combined principles and agile practices with the practices of scoping, some of them encourage communication and collaboration among the participants. For corresponding works close to this proposal, they will be analyzed in the section 3.8.

N	Approaches	Do consider elements or techniques to encourage communication or collaboration among participants?
1	Business Analysis of Domain	It proposes a risk analysis workshop scoring different issues
2	Practical Introduction	no
3	Feature Scoping	no
4	Marketing and Product Plan	no
5	S-DM	no
6	PuLSE-Eco	no
7	Scoping SPLP Framework	no
8	Goals for Domain Assessment	interviews, evaluation criteria and scoring for candidate domains
9	People Oriented Approach	writing and collective selection of user scenarios
10	PLPA	structured interview, criteria for the applicability
11	Release Planning	no
12	Feature-Based Approach	no
13	QFD-PPP	QFD provides a systematic but informal way of communication between customers and developers. HoQ (House of Quality) is an instrument of QFD, it is the matrix which analyzes customer requirements and translates them into the developers' language.
14	Scoping in Product Managemen	no
15	Process for Scoping Core Assets	no
16	Practical Guide to scoping	no
17	CollaborativeApproach to Scoping	CE (Collaboration engineering) practices as thinkLets. the technique EasyWinWin, Use of Tools Group Support Systems (GSS), and adopting agile principles.
18	RP-PL	prioritization model by feature voting, considering the relative importance of each participating stakeholder
19	Cave	no
20	Approach Scoping Telecommunication Domain	no

N	Approaches	Do consider elements or techniques to encourage communication or collaboration among participants?
21	COPE+	Customers vote on the features using a 9-point Likert scale (1: least desired to 9: extremely desired). the number of features under consideration is in the order of up to 100
22	Framework for Scoping	no
23	VB-PO	no
24	RiPLE-SC	RiPLE-SC uses the workshops because it is a fundamental resource from agile methodologies for maintaining the integration in a team, that allows that the project stakeholders discuss several aspects and expressing their viewpoints. Also, it proposes review meetings to obtain customers' feedback.
25	Value-Based Portfolio Scoping	The practice value-based portfolio scoping, punctuates the features by priority, coupling, and effort, customers and developers participate
26	Lightweight Scoping	no
27	Scoping Agile Process	pre-scoping Workshops, stakeholders understand the SPL concepts and goals. Onsite interaction session agile practice and collaboration engineering patterns applied in the workshops of each task
28	Product Portfolio Optimization	no
29	PPSMS	no
30	Semi-automatic scope	no
31	Variability Scope	no
32	Hybrid Approach to Generate PPS	A questionnaire with criteria for prioritizing major features by Scope Owner and Product Expert
33	SPLICE	Prioritization major features using classification criteria relevant for reuse, Domain Potential Assessment using a set of criteria applied through a questionnaire, the Scope-Backlog generated from the ranking of the major features and assessment criteria technical and non-technical aspects.

Tabla 3.9: Elements for communication and collaboration between roles

3.7 Analysis and conclusions of the revision of scoping approaches

Deciding which products belong to a SPL and which of them should build depends of business goals, market trends, technological feasibility, of the experience and organization of the company. There are many sources of information to be considered and many negotiations, agreements, and trade-offs to be made [9]. In order to achieve the gathering of the different expertise, it is necessary to find people with the availability and they must meet certain conditions, but in addition they must be able to work as a team in order to achieve a common objective instead of particular interests.

A SPL stakeholder could play one or more roles according to systems involved in or affected by, the effort and investment required in the development of a product line. These stakeholders include the organization's executives, product end users, and product line analysts, designers, implementers among others. Furthermore, a single resource may play the role of more than one stakeholder (e.g., designer and coder) and vice-versa a role can be played by several resources [9]. Most SPL scoping approaches recognize the need for diversity of participants because different perspectives must be taken into account, and these view points do not come from a single area of knowledge requiring the expertise of different stakeholder types [23]. Each stakeholder has a particular view point of the product line and a particular set of expectations and interest regarding it.

The importance of the scope in the engineering of product lines is evident in the amount of proposals and research works that are carried out in this area. The first works focused on defining the tasks that must be done whereas the last works focuses on the scope optimization; However, there are still gaps in the definition and formalization of process/method elements such as artefacts and roles, and there are gaps at the tasks level to be sufficiently prescriptive for the deduction of specific steps that must be carried out.

The interdisciplinary nature of this activity that is proposed by the different approaches requires approaches that facilitate communication and collaboration between the participating roles; there are works that have addressed this approach but do not provide or do not have available the details about the method and the artefacts works in order to facilitate their actual application by part of companies and development units that want to focus its production on following a SPL approach.

3.8 Related work

Some of the scoping SPL approaches reviewed have considered techniques or elements to improve communication or collaboration between the participating actors, these works are considered the related to this research. By analysis of these related works, new sources were taken into account as from the literature review, other articles by the authors, their thesis documents, and some of their references were searched.

People Oriented Approach

Rommes [17] [16] proposes an artefact-based approach called "usage histories or use scenarios" that must be developed jointly with all participants, using a common language. The work of Rommes is a basis for the method we propose because it recognizes the importance of the diversity of participants in SPL Scoping, a diverse group is able to observe the problem from different perspectives, however, it also warns about the risks involved in massive participation, endless debates, lack of agreements on details, absence of clear points for decision-making, bureaucracy and loss of efficiency. However the Rommes work does not present proposals to reduce these risks, additionally the information in this proposal is limited which makes difficult its replication. This proposal focuses only on one of the tasks to be performed in scoping, thus, it does not clearly show how the information inside the artefacts is related.

Reconciling marketed and engineered software product lines

This article analyzes two perspectives of the product lines, both the marketing perspective and the SPL engineering [14]. The scoping is the first point of union between product line engineering and marketing where both visions are important and it has been considered the need to consider both perspectives. However, the authors consider that the integration is far from perfect. The article exposes the benefits of improving this integration as they are better back in the selection of the market segment, and making decisions regarding the marketing of the line.

Scoping Agile Process: RiPLE-ASC

The proposal of Da Silva is a process that combines the Scrum process with SPL Scoping [81] [89]. RiPLE-ASC is part of the RiSE process for product line engineering proposed by the software engineering reuse laboratory (RiSE Labs), the part corresponding to SPL Scoping activity. RiPLE-ASC includes in the process Scrum practices such as daily meetings, workshops and frequent feedback at the end of the iterations and proposes artefacts such as the Scrum dashboard that contributes to the roles being informed during the development of the iterations. The proposal suggests the use of collaborative practices, but does not focus neither provide detailed information about them.

RiPLE-SC

RiPLE-SC is a systematic and agile process for SPL Scoping [78] [90], it is also part of the RiSE process for the engineering of product lines proposed by Balbino and other researchers. It provides guidance for the project team, specifying the tasks to be performed and the guidelines to make possible the agility in the execution of the tasks. In RiPLE-SC, most of SPL Scoping activities are carried out in workshop formats that are a resource of agile methodologies to maintain team integration, these workshops must be guided by an expert in SPL Scoping and agile practices. However, from the available information, the process is not described in a concrete way, particularly it does not describe how the collaboration between participants occurs and how the practices are used to achieve it, the thesis document details more information about the method than the published article. However, it is not a document intended for companies to use it as a guide document, but it is a research document.

SPLICE

This approach is a Lightweight Software Product Line Development Process combining SPL scoping and agile practices, addressed to small and medium Size Projects [87]. The information of the proposal includes the main elements of a process, but it does not give details of the practices or techniques to apply as model storming or the evaluation of domains or the questionnaire of evaluation of features. In the article, it is mentioned that the most detailed information of the process is available in the website http://tassiovale.com/splice, however its url keeps down.

Product Line Planning Game

This propose adapts the agile practice “planning game” to product line context [26]. This propose adapts the agile practice “planning game” to product line context. The planning game is used in the application engineering phase to perform the customization of a product for a specific customer. A customer representative shares the customer point of view on what features the product needs and power makes changes or includes new requirements. This approach proposed an artefact that encourages communication and feedback, the "Product Line Planning Game" is a strategy to introduce a lightweight feedback process from application engineering to domain engineering. The scope of a product line can vary according to the changing requirements of the customers of the products derived from the SPL infrastructure. This proposal presents an alternative for performing technical feedback of the components from the application engineers representing particular clients to the domain engineers who represent the business interests of the whole SPL. The approach uses the "stories of reuse" as a means of information exchange, in a similar way to "user stories" which include suggestions for components improvement, which are evaluated and prioritized by teams of engineering applications

Unified Approach by Product line scoping

Lee and other researchers compared and analyzed three of SPL scoping approaches to deduce the essential components and developed a unified approach that could be easily referenced and used by companies [2]. This work concludes that existing product line scoping approaches used diverse terminology and representation for the same concepts, in a similar way, they also used differently defined tasks and artefacts. The differences of these elements of the process denote the lack of formalization of scoping whereas focus on the communication and collaboration between the roles.

A collaborative approach for reengineering-based product line scoping

Noor and others [18] [13] [73] proposed a collaborative proposal for SPL scoping based on product reengineering. This approach introduces the practices of scoping patterns and collaborative thinkLets, and also applies agile principles. This proposal seeks that all team members build together and therefore share a common vision about the project and its scope.

The proposal is particularly focused when the SPL is derived from successful legacy systems, one of the three possible scenarios of adoption and production of SPL, although it is the most common one, this is only focused on the product portfolio and some activities of the scoping of domains, because it considers that a company that starts its production from the line of successful legacy systems, has extensive knowledge of the target domain, and that during the development of these products it has already identified functional domains and designed the reusable base architecture. Therefore, low effort is required to define domain scoping or asset scoping. This work is the most similar to our proposal and serves as a basis.

An industrial case study the Software product line scoping in a small and medium-sized enterprise

Da Silva and other researchers presented empirical evidence in which they characterized the weaknesses discovered in the scope and requirements disciplines of SPL, specifically when it is applied by medium and small companies [91]. Communication and collaboration factors are defined as the interactions among the team members and how these interactions contribute to the development of the tasks. The process employed in scoping discipline was RiPLE-SC [78]. The scoping participants belonged to two groups, the roles of the company (domain expert, domain analyst, architect) and the roles of the SPL team (product line manager, scoping expert, developers, risk manager).

The communication and collaboration weaknesses identified in the study case: The lack of availability of some stakeholders affected communication and collaboration. The company employees were busy with other projects and paid little attention to the SPL project; inappropriate managerial strategy for the project; the SPL team did not have any contact with the company customers, whereby volatility in customer features could have been hidden, there were many change requests for adaptations and corrections. The lack of specific templates and misconceptions regarding the specification caused inconveniences in communication and collaboration. In terms of communication and collaboration, the bottlenecks identified are long time iterations; few interactions among the participants; feedbacks mostly occurred during the validation meeting, and the lack of face-to-face communication among the stakeholders, it was replaced by an improvised way: emails exchange. The authors propose possible communication and collaboration improvements as the use of collaboration patterns. In the SPL scoping context, it can be the key factor for supporting the stakeholder's involvement.

Comparative between related approaches

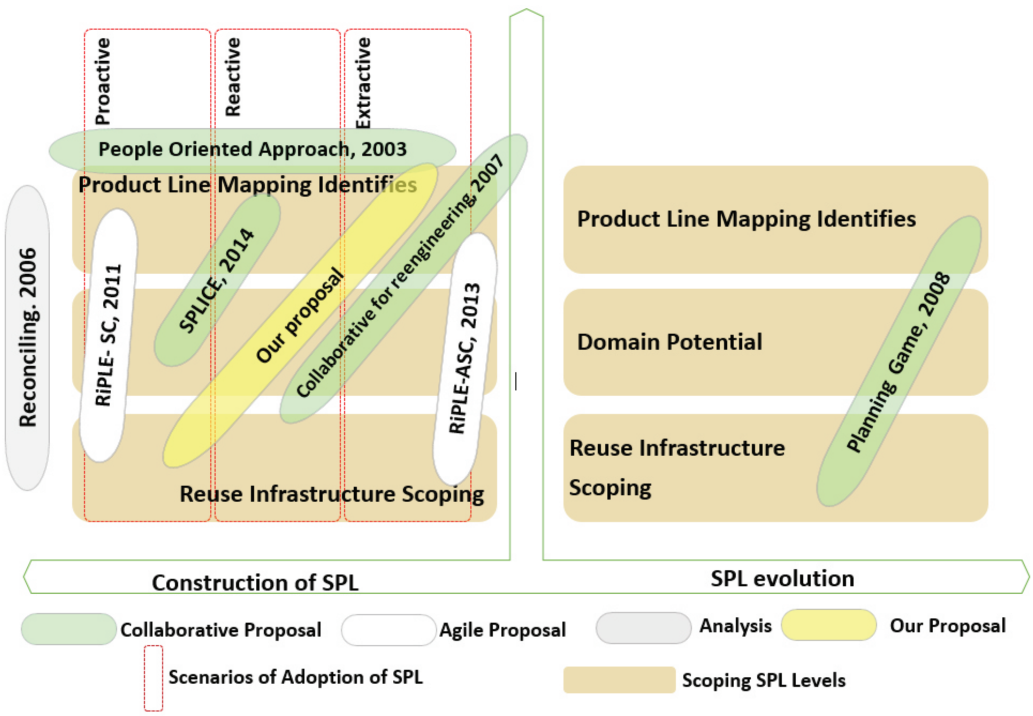

Figure 3.4: relatedApproache

In Figure 3.4 shows seven approaches related to communication and interaction among stakeholders participants in the realization of the

SPL scoping. The related proposals are located in two regions, six in the region that corresponds to the scoping as the first task in the development of a SPL and one approach in the second region that corresponds to the applications engineering and the scope update. On the left region that corresponds to the construction of the SPL, they have been divided horizontally the three scope levels proposed by Schmid have stated: Product line mapping identifies the potential domain and the reuse infrastructure scoping [8], also the vertical axis have been divided three columns representing the strategies for SPL engineering adoption [92]: extractive, reactive, and proactive. In the region of construction of the product line, the five SPL scoping proposals have been located, indicating which levels of coverage they contain and in which strategy of adoption they are located, similarly, our proposal has also been located, which allows to show the differences between the different proposals, related to the adoption strategy and the types of addressed scope levels.

Table 3.10 and 3.11 presents a comparison of SPL Scoping proposals that seek to improve communication and collaboration between the actors, considering the type of scope considered, the additional practices, the roles and artefacts considered.

	People Oriented Approach	**Collaborative Approach to Scoping**	**RiPLE-ASC**
Type of scope	Scope of product portfolio	Scope of product portfolio Scope of functionality domains	Scope of product portfolio Scope of functionality domains
Additional practices to the techniques	Collaborative practices applied to a specific artefact	Collaborative practices Agile practices	Agile practices Scrum
Availability description of the approach	Published article	Partial in published article	Partial in published article Doctoral thesis in web repository repositorio.ufpe.br/
Artefacts	Description, does not include template	only names them	Description, templates for some artefacts
Number of artefacts	1 additional	5	18
Roles	describes in which aspects of the scope it influences	general description of their interests and participation	description of what they contribute to scoping
Number of roles	8	6	2

Tabla 3.10: Comparative between the related works 1 part

	RiPLE-SC	SPLICE	Product Line Planning Game
Type of scope	Pre-Scoping Scope of product portfolio Scope of functionality domains Scope of reusable assets	Scope of product portfolio	Scope of product
Additional practices to the techniques	Agile practices	Agile Software Development (ASD)	agile practice “planning game”
Availability description of the approach	Partial in published article Doctoral thesis in web repository repositorio.ufpe.br/	Partial in published article Supposedly available on the website, but the link does not load	Partial in published article
Artefacts templates	Description and only names them	only names them	
Number of artefacts	12	4	2
Roles	only mentioned	general description of what they contribute to scoping	only mentioned
Number of roles	7	5	4

Tabla 3.11: Comparative between the related works 2 part

The approaches that combined the agile practices with the scoping SPL seek to improve communication and collaboration between roles with the application of agile principles such as face-to-face communication, the constant participation of clients, feedback. However, these principles are not explicit in steps or descriptions of tasks, this makes it difficult in practice to actually take place. The information on most of the related approaches is limited. The information presented in the articles about “A collaborative approach for reengineering-based product line scoping" indicates that the approach has a complete description of the tasks, artefacts, and roles, and that also most of the artefact templates exist, in the article (for reasons of space) only one of the tasks is presented in detail. However, there is no reference to a website, repository or printed publication where the entire process can be consulted. In the case of RiPLE-ASC and RIPLE-SC the document of the doctoral thesis project is available on the Reuse in Software Engineering Laboratory page, but these documents are not referenced in the published articles, neither it is a document intended to guide a company to apply their proposals. Our proposal for a collaborative method for SPL scoping seeks to contribute at the level of the description of the tasks to facilitate that the companies can follow concrete steps, instantiating defined practices, integrating components from collaboration engineering and method engineering for scoping a SPL. These collaborative practices are carried out for building specific artefacts that are described by means of templates and steps to be followed. The method has been published on a website and expects to be hosted also in an academic site and to ensure its continuity.

3.9 Chapter Summary

The study of the approaches proposed for SPL scoping, allowed us to identify that the first concern was to define the necessary tasks to perform the delimitation. Smith identifies three types of scope, most proposals focus on some of them, presenting the tasks to be performed; Later, the proposals focused on systematizing some of the scoping tasks and optimizing the scope. Software product line engineering similar to traditional software engineering has neglected aspects related to the human factors involved in the development of a software system, and that this system development be a social collaboration activity. Software is developed by people and for people. Besides, the interdisciplinary is a mandatory aspect for producing software in general. The SPL scoping activity is one of the main examples of this reality, the human factor has a big impact on planning and development efforts of a software product line. Although, there are some proposals that we identify in this chapter related to communication and collaboration between the roles participating in SPL scoping, the availability of these proposals is limited, some proposals have been biased to a single artefact or type of scope, and in other proposals the level of granularity does not facilitate the applicability. We consider that addressing the aspects related to the participants and their interactions from a collaborative approach and at method level, considering the artefacts that should be developed will facilitate to achieve a well formed and useful SPL Scope.

Chapter 4

Method Engineering and Collaboration Engineering for Building a Collaborative Method for Scoping SPLs: The CoMeS-SPL Method

‘Combinatory play seems to be the essential feature in productive thought”
Albert Einstein

4.1 Introduction

This chapter presents the way as Method Engineering and Collaboration Engineering approaches for the construction of a Collaborative Method for Scoping of Software Product Lines (CoMeS-SPL) was used.

4.2 Why integrate method engineering in SPL scoping?

Based on the review of the literature carried out, it can be seen that there are several proposals for SPL scoping approaches, it is important to emphasize that there is no "best approach", all of them have strengths and weaknesses that a company should consider to select which of them they should apply. However, one of the limitations that has been reported in different scoping reviews is the lack of formality, evidenced by the lack of clarity in which the scope makes up a product line, and that causes the obtained scope not to be so used in the following line development activities [91].

Although there are different SPLS proposals, for many companies that adopt the product line strategy, it is still unclear how to obtain the scope or how it is formed [12], because the SPLS is one of the least formalized activities of the SPLE [2]. In addition, most of the proposals do not show the activities clearly, the guidelines are described at a high level, which makes these guidelines not easy to apply, nor to instantiate concrete steps [12]. The low formalization is evidenced in the discrepancy of proposed activities [91], the use of different names for the same concepts and the heterogeneity of artefacts suggested in the proposals [12]. This lack of clarity causes ambiguities and doubts which does not help the participating actors to communicate and collaborate with each other during the SPLS.

Method engineering focuses on work products (artefacts) and the description of the guidelines seeks to guide participants how to build the artefacts, this would allow the proposal made in this project to facilitate the applicability of scoping.

4.3 Why integrate collaboration engineering into an SPL scoping method?

A good part of the tasks that make up the SPL scoping activity depends largely on the knowledge and experience of the participants [8] [16] [91], it is important to take into account that knowledge and experience required is dispersed among different required roles. The complexity and diversity of the aspects that should be considered in scoping is one of the factors that makes this activity complex and difficult to perform in practice. The literature review presented that there have been projects [16] [78] [81] [18] that have sought to improve communication and collaboration between the roles involved seeking to take advantage of the agile principles or collaborative work. The collaborative work between the different scoping roles increases the probability of including most features in the product catalog specification and improving the relevance of these features to the target market, obtaining a more complete and correct product description, in addition to an analysis of products, features and domains from different perspectives, techniques, marketing, business and from the objective domain, which can result in a more useful scope in the following stages of product line development.

However, the documentation available on the application of collaborative engineering in the activity of SPL scoping is limited (we could not find it complete), the problem of the diversity of knowledge and experience required remains latent.

4.4 Applying Method Engineering

Method engineering is the engineering discipline to design, construct and adapt methods, techniques, and tools for the development of software systems [48]. A method can be defined as an approach to perform a software system development project, based on a specific way of thinking, consisting of guidelines, rules and heuristics, structured systematically in terms of development activities, with corresponding development, work product and developer's roles [48]. The design and construction of methods based on method engineering is made from parts of methods as a building unit that can be fragments of method, method chunks or method components [46] [48]. In this research method components were used as basic units. A method consists of one or more method components [44], a method component has

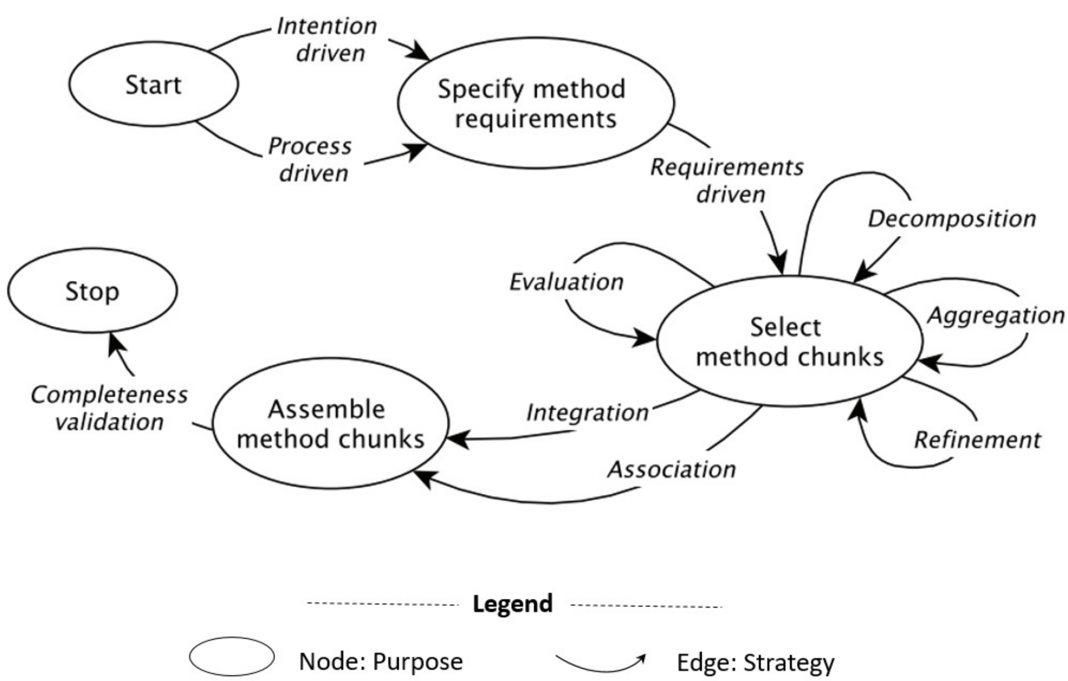

Figure 4.1: Process model for assembly-based method engineering [3]

a focus on artefacts (input/output artefacts), denominated work products, and the process used to transform the input work products into output work products [48]. All fragments or components of a method are related to one or more goals. If a fragment is part of a method, it should have at least one reason to be there [48].

Method engineering focuses on the construction of methods by selecting components from existing methods or from a repository called the base method [44]. The construction involves three general steps: specification of the method requirements, selection of the method components and assembly of the selected method components [3], as it can be seen in figure 4.1.

The process model for assembly-based method engineering was adapted to use method components instead of method chunks, considering the input and output work products for each method fragment.

Although systems development is a social collaborative activity, it is often a neglected aspect in current method-engineering approaches because the method engineering is focused on the artefacts, this is often criticized for being a rigid view on methods [44]. However, through grounding and combination of external theories, it is possible to incorporate other aspects in existing method engineering theories and constructs and hence to address other aspects. The collaboration among the roles participating in scoping is the fundamental concern in this research, whereby we combine method engineering with collaboration engineering in order to include human factors such as communication and collaboration.

4.5 Applying Collaboration Engineering

Collaboration Engineering is an approach to the design and implementation of collaborative processes that include collaborative work practices in recurring activities where teamwork is a relevant success factor [52].

A methodology for the design of collaborative processes is proposed by Kolfschoten and others [4] is depicted by Figure 4.2. This methodology proposes to evaluate the activities of a process, identifying what type of collaborative objective is searched, such as generating ideas, concluding proposals or classifying ideas, which allows to identify and employ in an activity as a pattern of collaboration or a thinkLet. A thinklet is a predictable pattern of interactions between people who work together to achieve an objective and therefore it is a known, proven and reusable solution for similar work situations in teams [55].

One key factor to consider in a collaborative process is related to the participants, each participant represents a role that will be described by a name and the objective function in the process. Each activity or task of the process must indicate which of the roles participate, the thinkLets providing guidelines for the interaction of the roles during the activities, and the rules describing actions and restrictions that should be considered. [56].

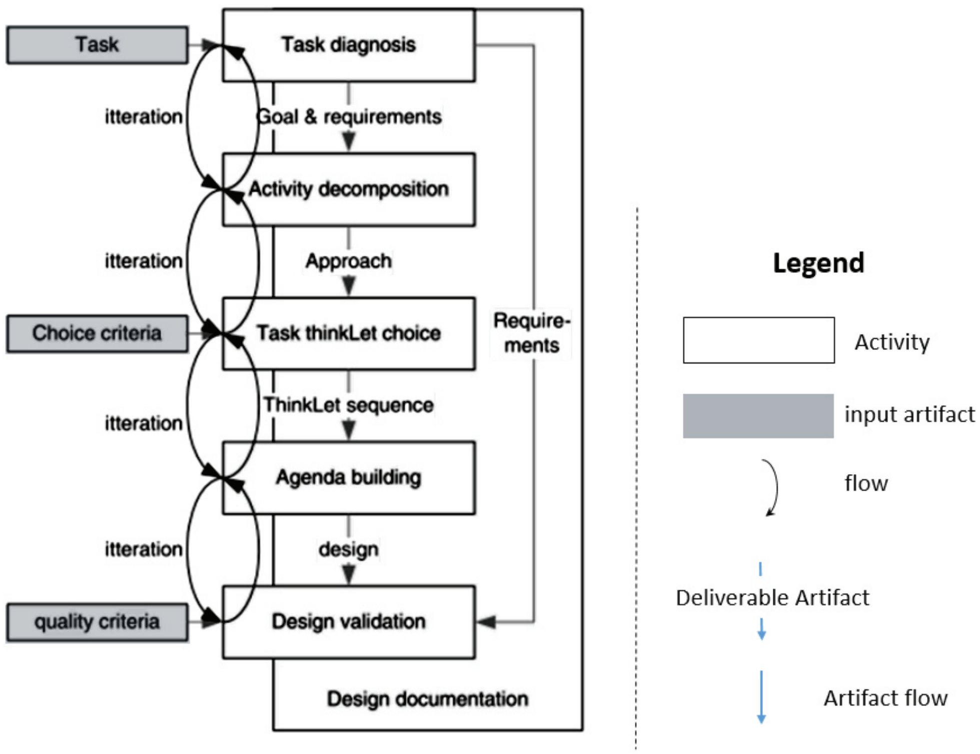

Figure 4.2: Overview of the Collaboration Engineering design [4]

4.6 Combining Method Engineering and Collaboration Engineering

To define the CoMeS-SPL method, elements of Method Engineering [3] [50] and Collaboration Engineering [4] were combined, giving rise to a collaborative method design approach, where the first stages are directed by method engineering, the second stage by collaborative engineering and the final stage combines the two approaches for final integration. The proposal for the construction of collaborative methods iterative follows the coming activities:

- Selection of SPL scoping approaches to be used as base methods
- Identification of the method components
- Selection of method components
- To complete the method components description as of the comparison of different base components
- Diagnosis of the method components by the relevance of collaborative factors
- Selection of thinkLets applicable to method components
- Assembling method components
- validate the proposed method

Figure 4.3 presents the proposal for the construction of collaborative methods, in which the activities to be carried out can be observed, and that the proposal follows an iterative and incremental life cycle. Each cycle of the spiral implies a progression that addresses the same sequence of steps but generates a new version of the collaborative method, each iteration includes a validation step carried out through empirical studies, in addition to preparing the next cycle, which allows feedback between different activities and iterations [93].

Figure 4.3: Proposal for the construction of collaborative methods

4.7 Applying the proposal for the construction of collaborative methods

For the selection of base methods, the criteria that were considered according to the proposed goals were: The first objective was to cover the three types of scope identified by Schmid [8], the definition of the product portfolio, the scope of the domain and the scope of the assets. The second objective was to consider the involved roles and the collaborative methods in their proposal; and the third objective was to look for the formalization of scoping elements.

For which the proposals have been selected:

- **A practical guide for PuLSE-Eco [27]**
  The PuLSE-Eco approach proposed by Schmid [8] [43] has been the basis for the definition of the other approaches. According to the authors of the framework of the SEI, PuLSE-Eco is perhaps the most referenced approach for scoping a software product line [5]. The 92.8% of the approaches reviewed in this research references to the proposal of Schmid. This proposal identifies the three types of scoping. The practical guide of Jhon's Pulse Echo as the name implies to provide a manual that modularizes the approach by the types of scoping and identifies for each type the activities and the artefacts (inputs and outputs), it also presents in a general way the rationale of each kind of approach. However, this guide does not present the roles that participate, nor even templates that allow to know what information makes up each artefact, or how the transformation of an input artefact must be carried out to become an output artefact.

- **The unified approach for SPL Scoping [2]**
  The authors of this approach compared and analyzed the three approaches which they considered as the main scoping proposals. they deduced the components of these approaches, then they compared them and finally used them to propose a unified approach, this goal of unified approach was that companies could use it easily. This work provides the components of the work that I consider as the most important and its proposal, identifying and unifying elements such as tasks and artefacts, which is an entry for our work to identify the method components.

- **A collaborative approach for product line scoping [13] [18]**
  This work is the most similar to ours, combining scoping practices with collaborative engineering, however the information is limited, the available articles only have some of the tasks of the approach, but the proposed process could not be found published in its entirety, so that there is no guide easily followed by a company that wishes to use it, there are no templates of the proposed artefacts so that companies could not deduce what information they require.

- **RiPLE-SC [78]**
  This proposal is a systematic and agile process, which combines the potentials of product lines and agile methods. IT is essential to provide guidance for the project team, specify direct tasks to be executed and guidelines to make possible the agility. According to the authors, it employs some of the agile principles that encourage collaboration such as face-to-face communication and consider people more important than tools, however, these principles are not instantiated in concrete ways that really allow collaboration, but If you describe the required roles and clearly indicate which ones participate in each task.

These base proposals were studied to identify the method components, then they were compared to recognize similarities and differences between the components of the different proposals, and to obtain the components with the highest level of completeness including: task (description of the objective), role (responsibilities or organizational units), specification document (artefacts), technique (detailed instructions for the development of a certain type of specification documents) and meta-models (concepts). The elements of methods resulting from the decomposition and equivalence of the base proposals were called base method components.

To apply the collaboration engineering, the base method components were analyzed to identify in which the collaborative work is relevant, the latter group was called collaborative method components, according to the type of stakeholder interaction needed, a thinkLet was selected to use and write or rewrite the collaborative method component by applying the thinkLet selected in the description of the method component guidelines. These components were then assembled to conform the flow of the method, verifying the consistence between the input and output artefacts among connected tasks. One way of ensuring compatibility between method parts was to review the consistence based on the traceability among inputs and outputs from the different components.

4.8 Chapter Summary

The construction of a method based on components of identified methods is a strategy form of method engineering. For CoMeS-SPL it was simple due to the fact that some of the basic approaches were modular, which means that it facilitated the identification of method components because they already raised the approach divided into parts, these parts could or do not consider components according to the description of elements such as input work products, output work products, roles, guides, concepts. In order to become a method as collaborative, applying thinkLets for re-defining the tasks was the key strategy. The relationship between method component and thinkLets was done one by one, this increased the number of sub-tasks that the CoMeS-SPL method finally described at a detailed level.

Selecting more than one approach as the base method increases the work of identifying the method components, but it also helps to integrate different denominations for the same element, and to complement the description of a method component.

To assemble the method components, the workflow, traceability and consistence of the artefacts were considered, which led to an overlap between the scope of the product catalog and the scope of domains.

Chapter 5

A Collaborative Method for Scoping Software Product Lines

"I have gathered a posy of other men's flowers,
and nothing but the thread that binds them is my own"
Montaigne

5.1 Introduction

This chapter presents a Collaborative Method for Scoping of Software Product Lines (CoMeS-SPL). A method is an approach to perform a software development project or one part of this, the method consisted of guidelines and rules, structured in activities, with corresponding work products that are produced and participating roles [48]. This chapter includes a general description of the method CoMeS-SPL, its hierarchical structure and composition, including its tasks, artefacts and participant roles framed by workflows.

5.2 Overview CoMeS-SPL

CoMeS-SPL (**Co**llaborative **Me**thod for **S**coping - **S**oftware **P**roduct **L**ines) is a method for scoping software product lines which applies collaborative patterns in the tasks that must be performed with the purpose of improving the contribution of the participating roles and gets a more useful and complete scope. This method is aimed to guide the actors involved in the execution of scoping by describing systematic steps for obtaining the scope artefacts. CoMeS - SPL seeks to obtain a more tangible, described and composed SPL scope from a defined and structured specification of artefacts. Additionally, these steps include guidelines to encourage and strengthen the collaboration among the different roles involved during its elaboration.

For the representation of the method we used the extended HAMSTERS notation (Human-centered Assessment and Modeling to Support Task Engineering for Resilient Systems), used for the modeling of collaborative processes proposed by Solano and others [94] [95]. This notation has been selected because it allows us to represent collaborative activities, graphically shows the relationships (concurrency, iteration, among others) among the tasks to achieve an objective, generates a hierarchical graphic representation of the goals and tasks of the method, and it also indicates the types of interaction among the participants, representing detailed information about the collaborative activities and the participants (roles) that perform these tasks.

5.3 Metamodel of the CoMeS-SPL method

The CoMeS-SPL method is formed by units of work, roles, and work products, also applies a thinkLet by task and provides a template for each work product. It is depicted in the figure 5.1.

The tasks are units of work composed by steps or actions to be executed in order to delimit the scope, the tasks have been redesigned applying the thinkLets recommended from collaboration engineering in order to achieve collaboration between the participating roles. Roles are the set of related responsibilities and skills to perform a task. The role concept does not represent an individual person but responsibilities. Work products are the artefacts produced, modified, or read dur-

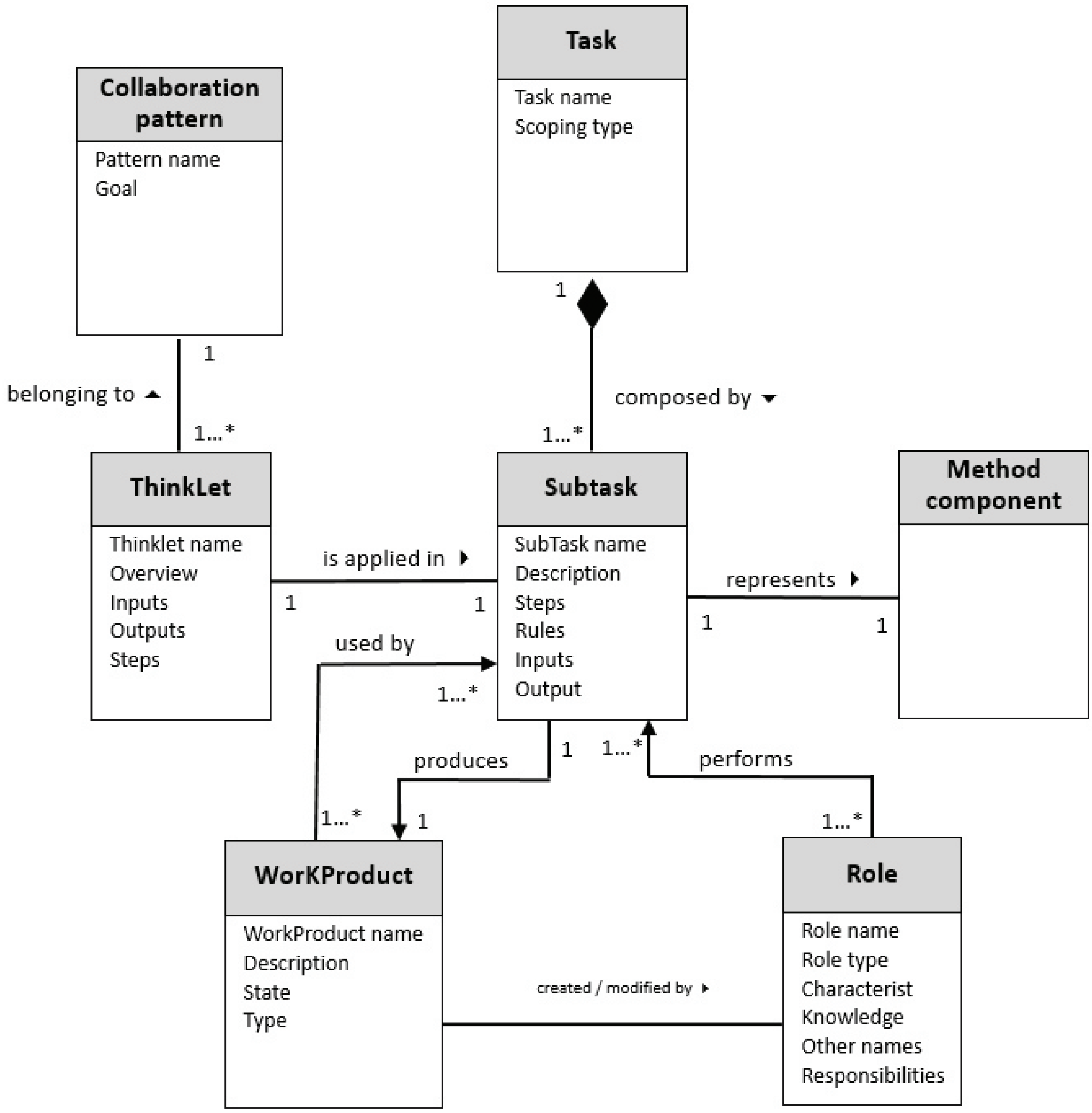

Figure 5.1: Metamodel of CoMeS-SPL

ing the tasks execution, the SPL scope is the set of artefacts resultant from carrying out CoMeS-SPL into practice. The tasks have been divided into sub-tasks in such way that each task is associated with a collaborative pattern and a thinkLet (a one-to-one relationship).

The parts of CoMeS-SPL are described in the following sections of this chapter, for those interested in this method the complete and detailed method components (concepts, templates, steps, guidelines, tasks, activities, roles, and artefacts) can be browsed through the website `https:comesspl.com` (check the appendix B).

5.4 Method hierarchy

The figure 5.2 shows the hierarchical structure of CoMes-SPL, and presents the main goal of the method "To define the software product line scope", it is represented as the top node of a top-down tree of nodes. This goal has been divided into 6 sub-objectives, four of which correspond to the three scope types defined by Smith [43], for differentiating visually the goals of the tasks, the first ones are black colored. This sub-goals are decomposed into tasks.

5.5 Description of the tasks of method CoMeS-SPL

A task is a Method Content Element that indicates a Work Definition, work being performed by Roles and that transforms input work products into output work products [88]. A Task is small-grained work unit: this task focuses on what must be done in order to achieve given purpose, this is generally associated by one or several artefacts [96].

For the description of a task the following elements were taken into account:

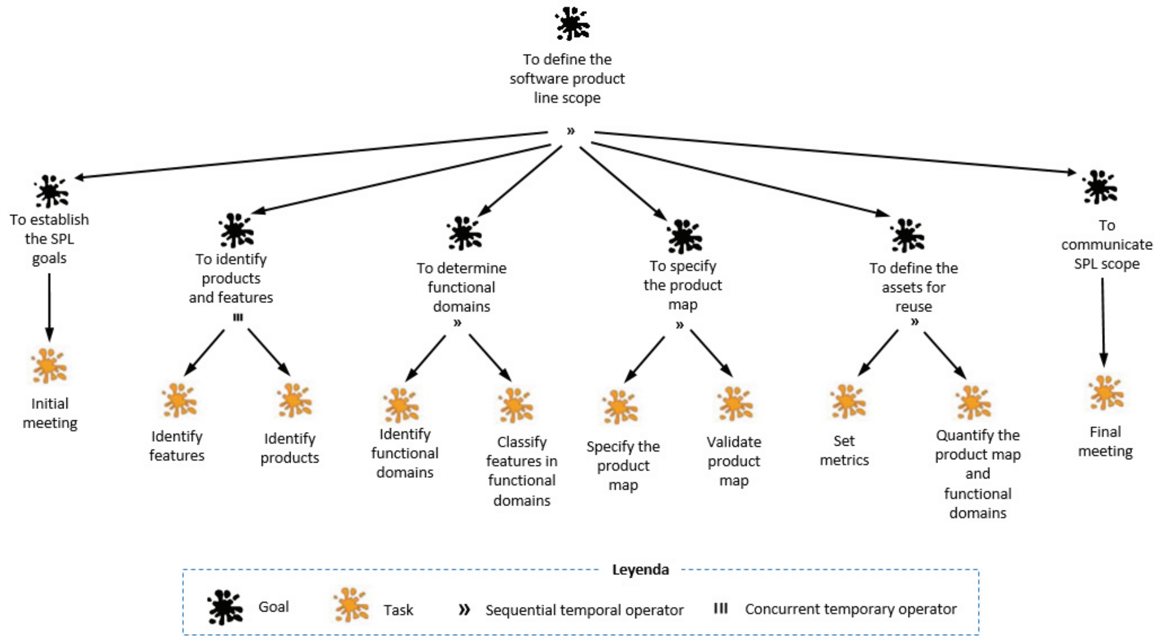

Figure 5.2: Method hierarchy

- Task
- Description
- Artefact (input and output)
- Steps
- Rules
- Collaborative pattern
- ThinkLet

We have used the Collaboration Engineering Approach for Designing Collaboration Processes to define a collaborative method for SPL scoping [4]. This approach recommends to use a Facilitation Process Model (FPM) to graphically represent the flow of the method process and other elements of collaborative activities. An MFP basically consists of representing a set of activities or tasks to achieve a goal [94].

CoMeS-SPL was modeled using the extension of the HAMSTERS notation [94]. HAMSTERS (Human-centered Assessment and Modeling to Support Task Engineering for Resilient Systems) is a notation for collaborative tasks, Solanos proposal extended this notation and it allows to represent in an MFP elements such as: relationships between tasks / activities, input / output of information, collaborative activities detailed, among others [95]. The figure 5.3 shows the representation of a task, using the extension of HAMSTERS notation.

The method elements are graphically represented using this notation, see the figure 5.4

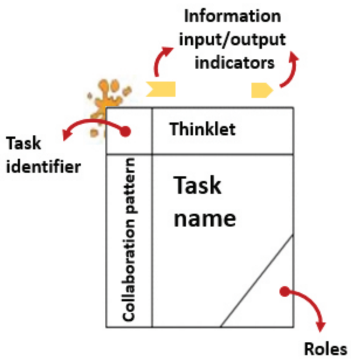

Figure 5.3: Representation of an task in the MFP, using HAMSTERS elements

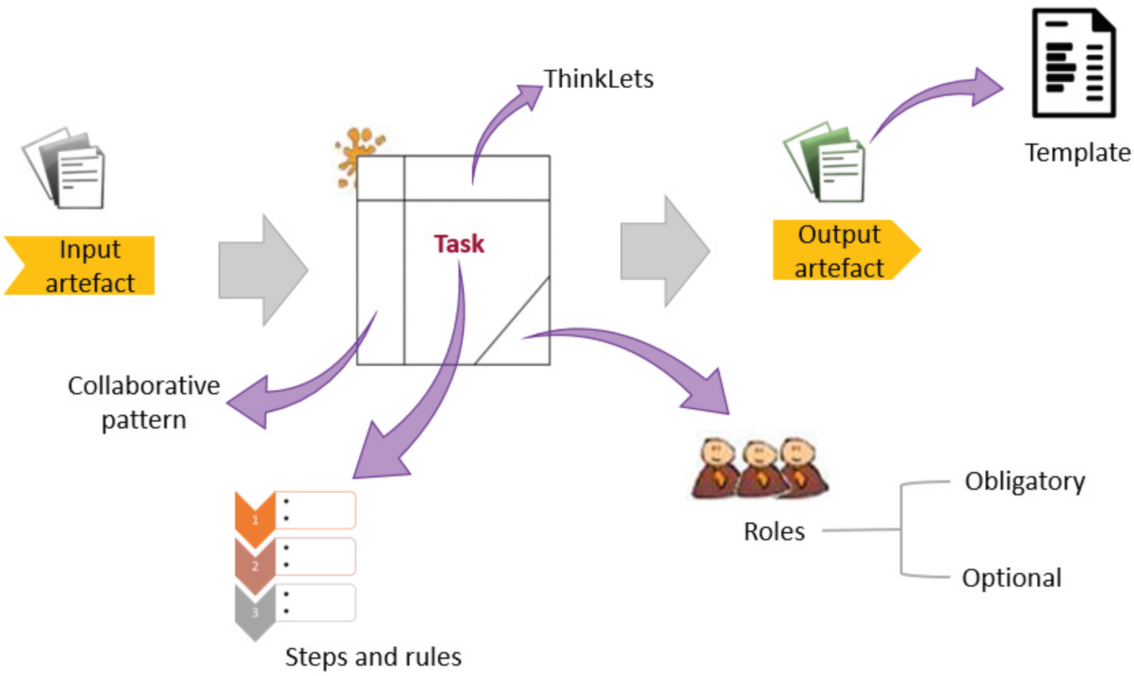

Figure 5.4: Association of elements to a method task

The extension of HAMSTERS notation represents detailed information about collaborative activities such as group decision making (consensus), data analysis, among others. The figure 5.5 presents the images that can be used to represent the steps that make up a collaborative task, these steps correspond to the steps defined in the thinkLet used in each task.

Symbol	Steps
	Cognitive Analysis
	Share information
	Collaborative cognitive activity (analysis or decision making)
	Input data to the system
	Collaborative input data to the system

Figure 5.5: Graphical representation of collaborative activities

The CoMeS-SPL method is composed by six (6) tasks and twelve (12) sub-tasks. The tasks and sub-tasks of the CoMes-SPL method are:

- Initial meeting
  - Assemble the profile of the line
  - Baptize the line
- Identify features
  - Explore existing products
  - Propose features
  - Analyze features
  - Concert features
- Identify Products
- Identify functional domains
- Classify features in functional domains
- Tabulate products and features
- Validation product map
- Set metrics
- Quantify product map and functional domains
- Final meeting

The table 5.1 presents the necessary tasks to achieve the objectives of scoping, and the patterns and thinkLets that have been associated with each one of them. As modeling and practice result, this table relates the hierarchical model of the CoMeS-SPL method presented in the figure 5.2 with the tasks, sub-tasks and the collaborative patterns and associated thinkLet. The CoMeS-SPL method is composed by 6 tasks and 12 sub-tasks.

The full description of each task of CoMeS-SPL can be seen in the Appendix A of this document denominated Guide to the CoMeS-SPL. The description of the method can also be found on the website `https://comesspl.com` (check the appendix B).

Sub-Goal	Scope type	Task	Sub-task	Collaborative pattern	ThinkLets
To establish the SPL goals		Initial meeting	Assemble the profile of the line	Gamestorming	Empathy map
			Baptize the line	Gamestorming	Voting by points
To identify products and features	Product Portfolio Scoping	Identify features	Explore existing products	does not apply	does not apply
			Propose features	Generate	Free Brainstorm
			Analyze features	Convergence	Garlic Squeezer
			Concert features	Gamestorming	Voting by points
		Identify Products		Generate	OnePage
To determine functional domains	Domain Scoping	Identify functional domains		Organize	Theme Seeker
		Classify features in functional domains		Organize	Popcorn Sort
To specify the product map	Product Portfolio Scoping	Tabulate products and features		Evaluation	StrawPoll
		Validation product map		Evaluation	Bucket Walk
To define the assets for reuse	Asset Scoping	Set metrics		Convergence	DimSum
		Quantify product map and functional domains		Gamestorming	Voting by points
To communicate SPL scope		Final meeting		Gamestorming	Matrix who-what -when

Tabla 5.1: CoMeS-SPL tasks

5.6 Collaborative description of the tasks of the method CoMeS-SPL

This chapter presents two sub-tasks of one of the tasks of the method, with the objective of illustrating how the tasks of the method were described and modeled.

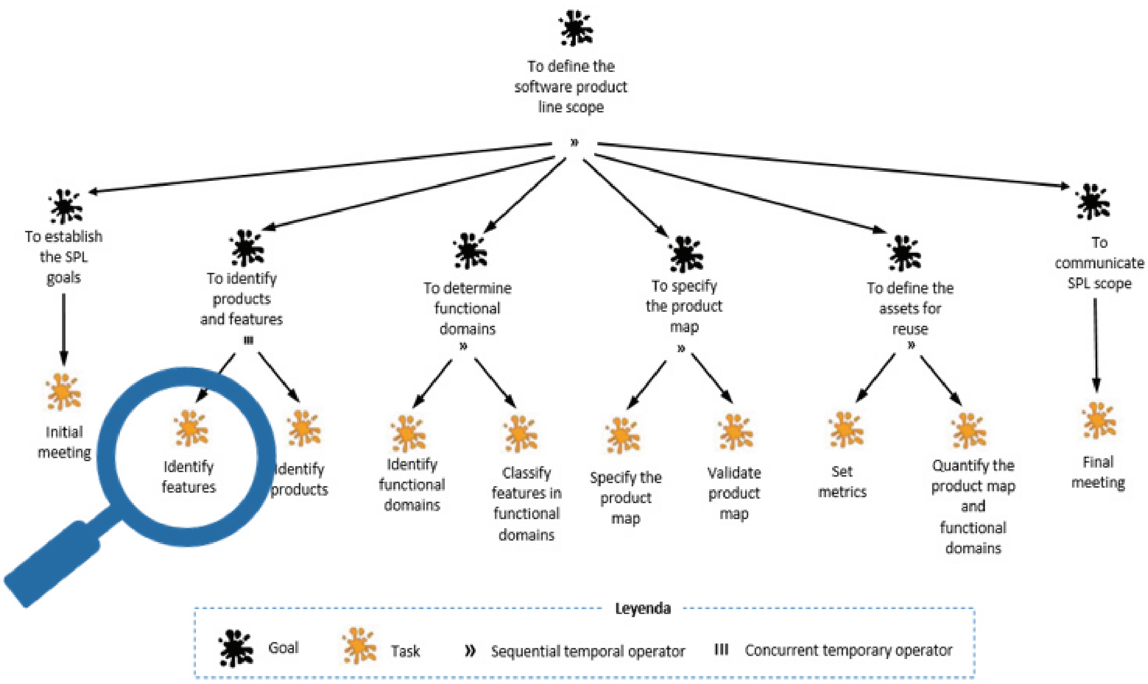

Figure 5.6: Selection of the task to be described

The selected task is **Identify features**, this task is composed by four sub-tasks:

Identify features

- Explore existing products
- Propose features

- Analyze features
- Concert features

5.6.1 Combining Method Engineering and Collaboration Engineering in the description of CoMeS-SPL method tasks

The description of each sub-task is made with two elements, the first one model and the second one table.

The table addresses the different elements considered in method engineering such as the name of the task, the input work products and the output work product, the description of the task that corresponds to the rationale of the component and the guidelines that are the steps to be taken to obtain the target artefact. The collaborative pattern and the associated thinkLet, the mandatory and optional participating roles, have been included from the collaborative engineering. In addition, the guidelines include two aspects, the first is to indicate who does the action, aspect from the collaborative engineering that marks the interaction of the participants, and the indications to obtain the objective artefact, aspect from the engineering method that focused on the output artefacts.

The graphic representation of a task is a model. In this model, the task is represented by a rectangle (divided into 5 sections) used in the Facilitation Process Model (FPM) traditionally defined for HAMSTERS notation. Thus, the task/sub-task name will be accompanied by the identifier, thinkLet and collaboration pattern. Additionally, participants of the activity are indicated using an acronym with the first letters of the role name, also if there is the work product of inputs/outputs (The names of the artefacts have been included in each of these symbols used). And the extension of HAMSTERS notation is used to represent the collaborative way of the task, the guidelines which correspond to the steps should be done to obtain the objective artefact that are proposed, applying the thinkLet and collaborative pattern selected to achieve the effective participation of the roles involved in the task

The specification of the task **Identify features** is presented by its sub-tasks, the graphic representation of the first sub-task **Explore existing products** can be seen in the figure 5.7 and the description of the sub-task is made in the table 5.2.

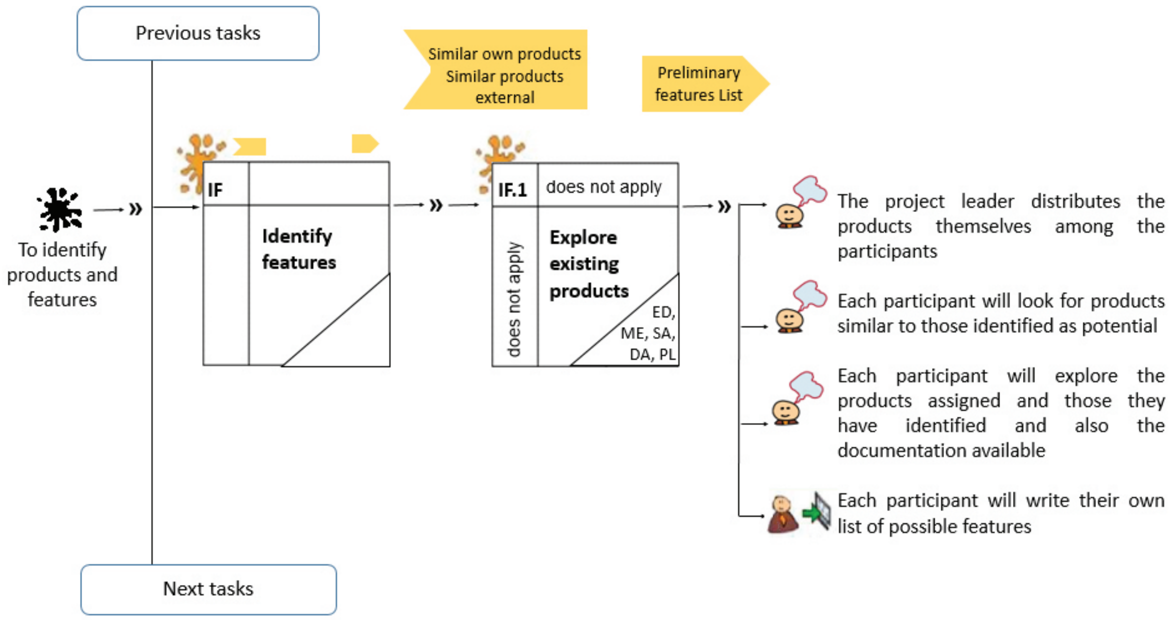

Figure 5.7: Explore existing products

This model allows us to show first that in this sub-task a thinkLet is not applied, this means that it is not done collaboratively. This characteristic can be observed in the upper section of the rectangle of the sub-task and in the steps modeled in the right part of the figure, where all the symbols correspond to a single person.

The textual description of the sub-task performed in the table5.2 confirms that the sub-task is not collaborative, and indicates in the identifier that it is an optional and not mandatory task.

Sub-task	***Explore existing products***
Task	Identify features
id	IF1 (optional)
Description	The objective of this task is to assign a name to the line among all the participants.
Collaborative pattern	does not apply
ThinkLet	does not apply
Mandatory roles	Expert Domain of application (ED) Business Administrator (BA) Software Architect (SA), SPL Project Leader (PL) Marketing expert (ME) Domain analyst (DA),
Optional roles	Potential Customers (PC) Sales staff (SS) Technical expert (TE), SPL Expert (LE) Teamwork Advisor (TA)
Input artefact	Similar own products Documentation of similar products Similar products external
Output artefacts	Preliminary features List
Steps	1. The project leader distributes the same products among the participants. 2. Each participant will look for products similar to those identified as potential. 3. Each participant will explore the products assigned and those they have identified and also the available documentation 4. Each participant will write their own list of possible features

Tabla 5.2: Explore existing products

Propose features corresponds to the second sub-task of task. Identify features, figure 5.8 presents the model of this sub-task, unlike the first sub-task, this is collaborative, and it can be noted because in the upper section of the rectangle the associated thinkLet is indicated and in the lower left section the collaborative pattern is shown. The representation of the steps in the right section of the model, indicates which steps are performed by the entire group of participants, and what are the contributions of each of the roles.The specification of this sub-task is completed with the textual description of the table 5.3

Sub-task: Propose features

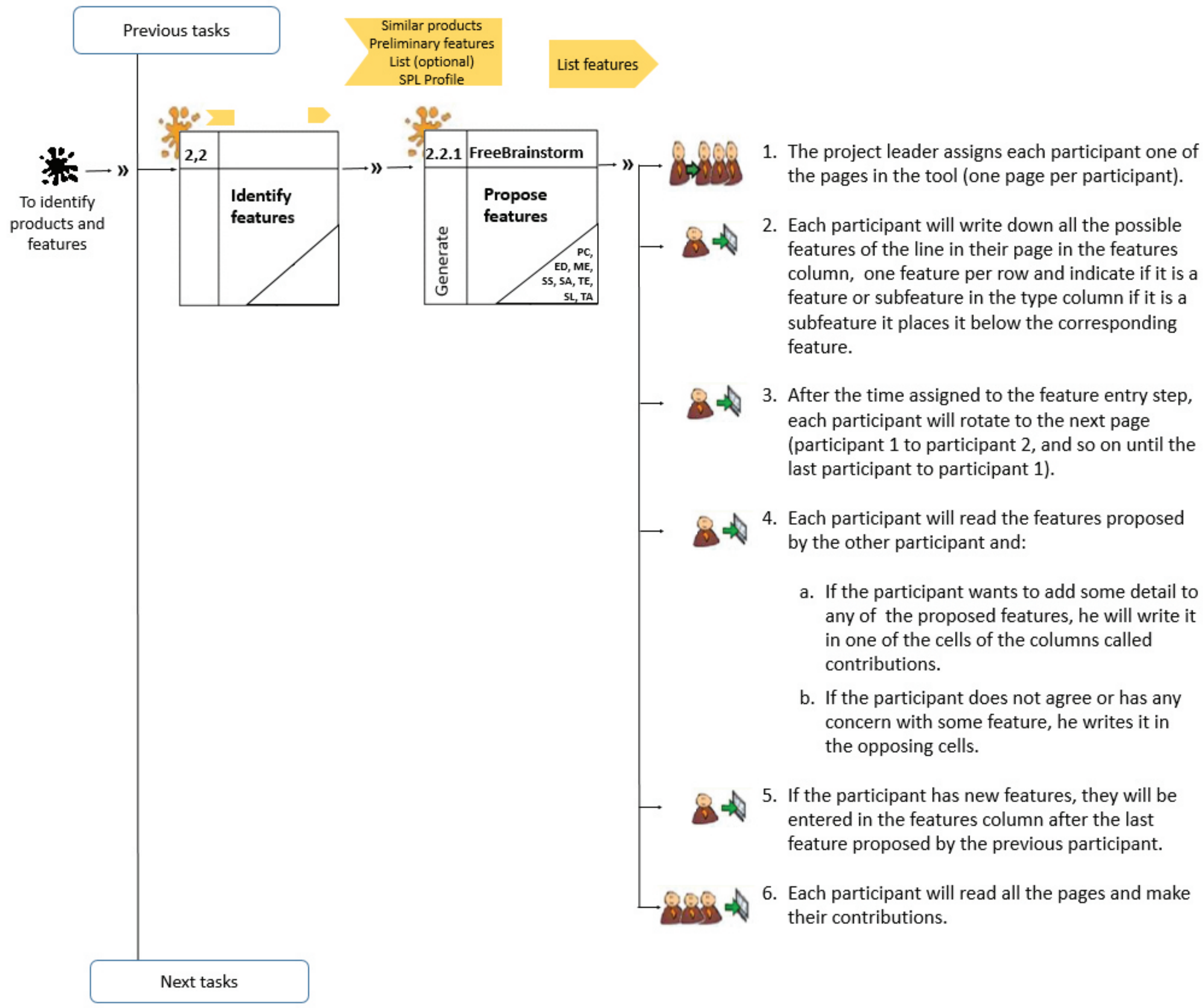

Figure 5.8: Propose features

Note: This sub-task can be done using Electronic Brainstorming, or worksheets online or manually.

Sub-task	***Propose features***
Task	Identify features
id	IF2
Description	The objective of this sub-task is to identify the features that are part of the line, using a brainstorm that allows participants to propose the greatest number of features, taking into account the profile of the identified line and similar products.
Collaborative pattern	Generate
ThinkLet	FreeBrainstorm
Mandatory roles	Expert Domain of application (ED) Software Architect (SA), SPL Project Leader (PL) Marketing expert (ME)
Optional roles	Business Administrator (BA) Potential Customers (PC) Sales staff (SS) Technical expert (TE), SPL Expert (LE) Teamwork Advisor (TA) Domain analyst (DA),
Input artefact	Similar own products Documentation of similar products Similar products external Preliminary features List (optional) SPL Profile
Output artefacts	List features
Steps	1. The project leader assigns each participant one of the pages in the tool (one page per participant). 2. Each participant will write down all the possible features of the line in their page in the features column, one feature per row and indicate if it is a feature or sub-feature in the type column if it is a sub-feature it places it below the corresponding feature. 3. After the time assigned to the feature entry step, each participant will rotate to the next page (participant 1 to participant 2, and so on until the last participant to participant 1).

Sub-Task	***Propose features***
Task	Identify features
Steps	4. Each participant will read the features proposed by the other participant and: 4.1 If the participant wants to add some detail to any of the proposed features, he will write it in one of the cells of the columns called contributions. 4.2. If the participant does not agree or has any concern with some feature, he writes it in the opposing cells. 5. If the participant has new features, they will be entered in the features column after the last feature proposed. 6. Each participant will read all the pages and make their contributions.
Rules	The participants will start from the profile of the line and similar products No participant can eliminate features proposed by others

Tabla 5.3: Propose features

The fourth sub-task of the task Identify features is Concert features, the graphic representation corresponds to the figure 5.9, and the textual description to the table 5.4, in which it can be seen how the interactions are presented using the name of the role that performs them, in such a way that facilitates that each participant knows their responsibilities and knows in what steps they participate, with what knowledge and experience they contribute in the production of the objective artefact

Sub-task: Concert features

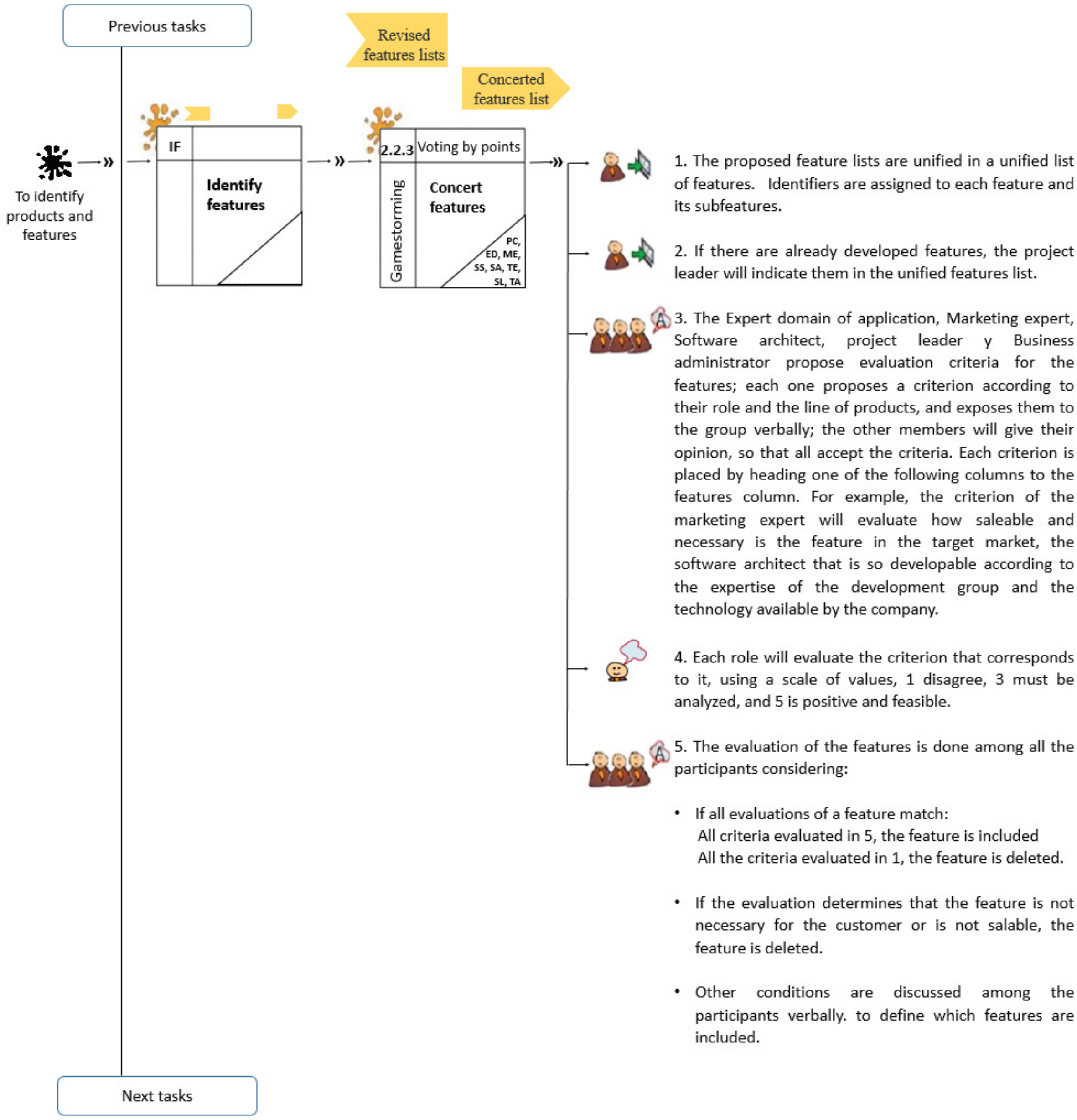

Figure 5.9: Concert features

Sub-task	***Concert features***
Task	Identify features
id	IF4
Description	The task objective is to make a quick evaluation of the proposed features considering important criteria for the company, and obtain a concerted features list.
Collaborative pattern	Gamestorming
ThinkLet	Voting by points
Mandatory roles	Expert Domain of application (ED) SPL Project Leader (PL) Software Architect (SA), Marketing expert (ME), Business Administrator (BA)
Optional roles	Potential Customers (PC) Sales staff (SS) Technical expert (TE), SPL Expert (LE) Teamwork Advisor (TA) Domain analyst (DA),
Input artefact	Revised features lists
Output artefacts	Concerted features list
Steps	1. The proposed feature lists are unified in a unique list of features. Identifiers are assigned to each feature and its sub-features. 2. If there are already developed features, the project leader will indicate them in the unified features list. 3. The Expert domain of application, Marketing expert, Software architect, project leader and Business administrator propose evaluation criteria for the features; each one proposes a criterion according to their role and the line of products and exposes them to the group verbally; the other members will give their opinion so that all of them accept the criteria. Each criterion is placed by heading one of the following columns to the features column. For example, the criterion of the marketing expert will evaluate how saleable and necessary is the feature in the target market, the software architect evaluates if the feature is developable according to the expertise of the development group and the technology available by the company.

Sub-Task	***Concert features***
Task	Identify features
Steps	4. Each role will evaluate the criterion that corresponds to it, using a scale of values, 1 disagree, 3 must be analyzed, and 5 is positive and feasible. (voting method) 5. The evaluation of the features is done among all participants considering: - If all evaluations of a feature match: All criteria evaluated in 5, the feature is included All the criteria evaluated in 1, the feature is deleted. -If the evaluation determines that the feature is not necessary for the customer or is not saleable, the feature is deleted. -Other conditions are discussed among the participants verbally. to define which features are included. The list of characteristics will be cleaned so that only those that have been selected in the evaluation remain
Rules	The participants determine the number and criteria, but it can not be more than one criterion per participant

Tabla 5.4: Concert features

5.7 CoMeS-SPL workflow

The flow of the method is graphically represented using a Facilitation Process Model (FPM) [4] combining with the extended HAMSTERS notation [94] used in this document. A FPM focuses attention on the logic of the flow of the method from task to task.

The different tasks/sub-tasks that make up the method are evidenced in the workflow represented in figure 5.10. Using HAMSTERS elements (see Figure 3) it is possible to identify different types of relationships between activities and if there are workproduct of inputs/output. And it uses temporary operators to indicate the relationships among the tasks, in the figure the operator is $\gg$, This operator indicates that the tasks are performed sequentially.

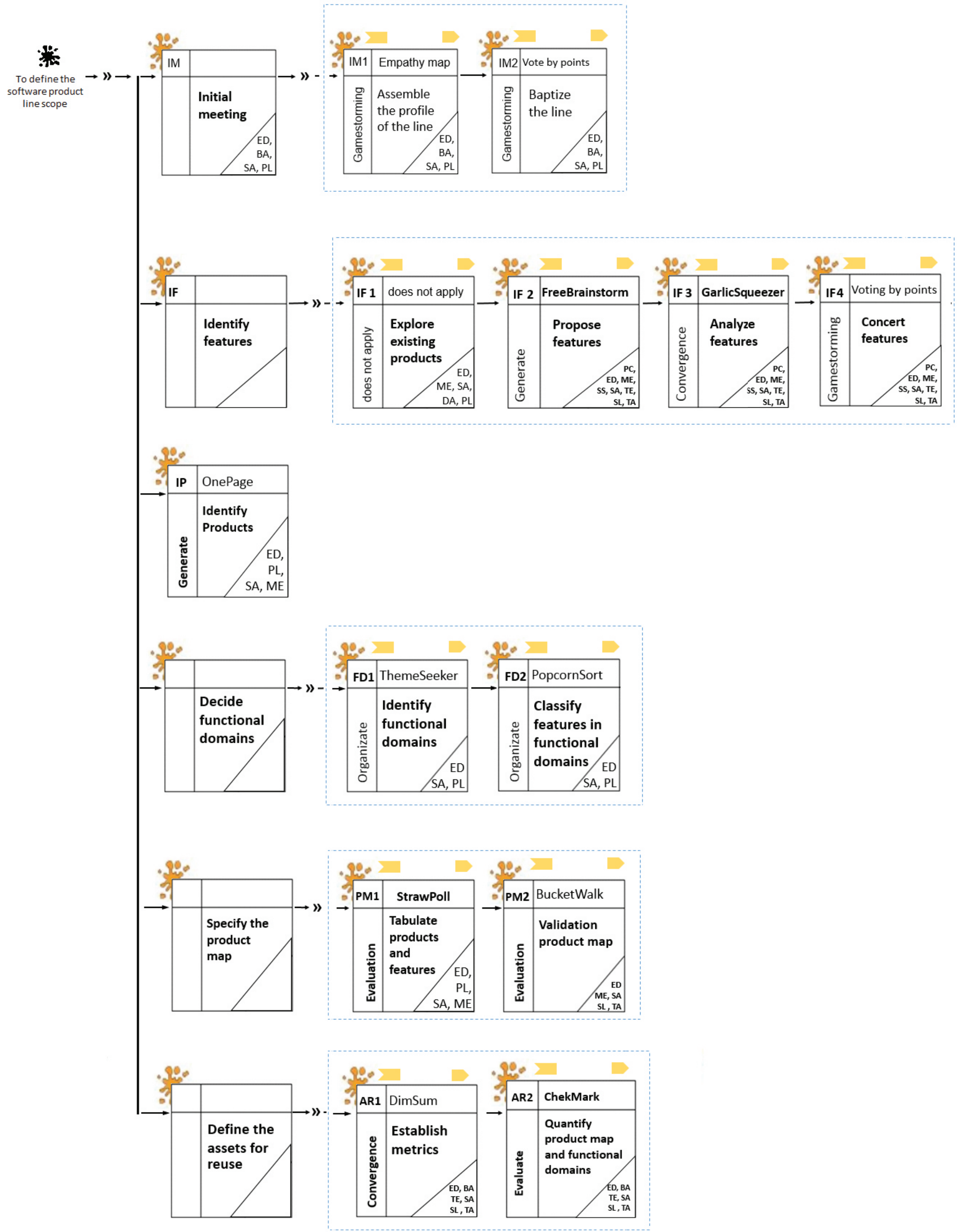

Figure 5.10: CoMeS-SPL workflow

The CoMeS-SPL workflow is represented in the figure 5.10. Each task is represented as a five-field rectangle. The top left field is the task identifier. The top right field is the name of the associated thinkLet. The field on the left is the primary pattern of collaboration to be used in the task. The largest field contains the task name. Finally, the lower right triangle contains the acronyms of the mandatory participants.

As indicated earlier in this same chapter, the full description of CoMeS-SPL method can be seen in Appendix A of this document denominated Guide to the CoMeS-SPL, and also the description of the method is available on the website `https://comesspl.com` (check the appendix B).

5.8 CoMeS-SPL Artefacts

One of the aspects with low standardization for Scoping SPL is the artefacts that describe the scope. Scoping SPL results are quite diverse, with different names and representations [11]. Some of the artefacts are defined differently although the objective is the same [2]. The low standardization of the artefacts that make up the scope of an SPL was one of the reasons for using method engineering, using method components focused on the artefacts. also the templates proposed for the different artefacts were identified and compared. The table **??** shows the templates proposed by the base approaches used to propose CoMeS-SPL.

For the construction of the CoMeS-SPL artefacts, the artefacts were identified and compared in the base approaches, identifying: the necessary steps to perform the required transformations, the facility for creating/modifying the artefacts, evaluating the consistence among inputs and outputs, the level of collaboration required and the utility.

The tasks of CoMeS-SPL express how the transformation of one or more artefacts (inputs) is done in a defined artefact (outcome).The method steps indicate how the participants build or change the output artefacts. By CoMeS-SPL method formulation, the traceability and consistence between input and output artefacts was reviewed. The figures 5.11 and 5.12 present the relationship between the required input artefacts and the product map artefact in the CoMeS-SPL method.

<table>
<tr><th>Artefact Name</th><th>Template</th><th>Approach</th></tr>
<tr><td>Matrix of features and products</td><td>
<table>
<tr><th>Subdomain</th><th>No.</th><th>Feature</th><th>Automotive</th><th>LIMS</th><th>PRISMA</th><th>Professional</th><th>Web module</th><th>Future products</th></tr>
<tr><td>Logistics chain</td><td>76</td><td>Real-time process control</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td></td><td>77</td><td>Order management</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td></td><td>78</td><td>Order generation</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>Manufacturing</td><td>79</td><td>Supply chain logistics</td><td></td><td>X</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td></td><td>80</td><td>Customer service processes</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>81</td><td>Integral quality mangement</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
</table>
</td><td>Practical Guide to Product Line Scoping [27]</td></tr>
<tr><td>Product portfolio</td><td>
<table>
<tr><th>Products features</th><th>Keypad-based door lock</th><th>Fingerprint-based door lock</th><th>Iris-based door lock</th></tr>
<tr><td>Keypad</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Fingerprint_scanner</td><td>—</td><td>✓</td><td>—</td></tr>
<tr><td>Iris_scanner</td><td>—</td><td>—</td><td>✓</td></tr>
<tr><td>Authentication</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Open/Close Sensor</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>
Note: ✓: required feature
</td><td>Unified approach to SPL Scoping [2]</td></tr>
<tr><td>Product map</td><td>No template found for this artefact</td><td>Collaborative Approach to Scoping [13]</td></tr>
<tr><td>Product map</td><td>
<table>
<tr><th>Features</th><th>Sub-Features</th><th>Sub-Sub-Features</th><th colspan="4">Product</th><th>Scope</th></tr>
<tr><td></td><td></td><td></td><td>P1</td><td>P2</td><td>P3</td><td>P4</td><td></td></tr>
</table>
</td><td>RiPLE-SC [90]</td></tr>
<tr><td>Product map</td><td>
<table>
<tr><th>Feature</th><th>Sub-features</th><th>Product 1</th><th>Product 2</th><th></th><th>Product n</th><th>Type</th><th>Priority</th><th>priority value</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td><td>CoMeS-SPL</td></tr>
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Tabla 5.5: Method base artefact templates

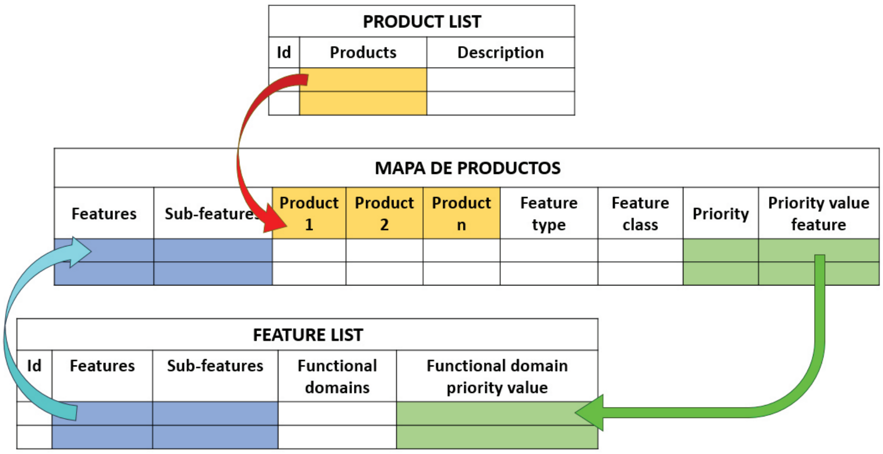

Figure 5.11: Relationship between artefacts

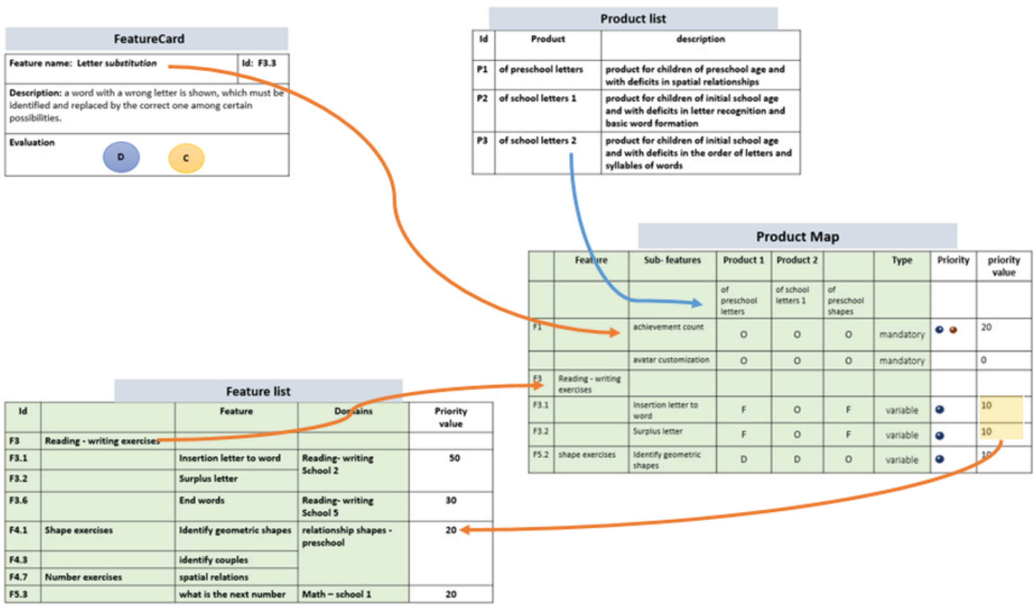

Figure 5.12: Relationship between artefacts 2

This research proposes a method that, from using method engineering and method components, presents in the description of the tasks/sub-tasks the necessary steps to obtain each one of the artefacts that make up the scope, these steps or directors are described in the specification of each task, the steps also describe how the different roles contribute collaboratively to obtain each of the artefacts. Figure 5.13 presents the template adapted and included in the CoMeS-SPL method for the product map and the relationship with the steps included in the textual description of the task table Specify product map.

The templates for artefacts of the CoMeS-SPL method can be found in Appendix A of this document. it has been located in the specification of the task that produces the template artefact, and also the description of the method is available on the website `https://comesspl.com` (check the appendix B).

5.9 Participating roles in CoMeS-SPL

A role defines the behavior, skills, competences and responsibilities of a person or several people who are part of a group that works on the whole to achieve a common goal. Individual members of the development organization can perform different roles and for a role to be played by several individuals [88]. Working in a collaborative way involves joining the efforts of a group of people to achieve a common goal, so it is important that the roles are well defined so that each participant knows what their roles are and how they contribute to the project. The CoMeS-SPL method tasks are collaborative performed by the stakeholders during the planning of a specific SPL. The required responsibilities and skills are represented by the roles. A role defines the behavior and responsibilities of an individual or a group of individuals working in in the execution of a task to achieve a goal. The behavior is expressed in terms of functions in which each role performs and the knowledge that is required to develop these functions [97].

5.9.1 Mandatory roles

Expert domain of application

Task 5	**Specify product map**
Input	Features List line products list
Description	The characteristics are assigned to the products. With this matrix, common and variable characteristics can be identified, and a first estimate of the variations among the products can be obtained
ThinkLet	StrawPoll
Output	Product map
Steps	1. The scoping expert locate the products in the columns and the features in the rows of product map. 2. The participants indicate that features are required for each product, In the box that intercepts the row of the feature with the product the right value must be placed: **O**: if the feature is required in an indispensable way **D**: If the feature is not indispensable but it is desirable **F**: if the feature does not correspond the product 3. The scoping expert will increase a column called feature type: if the feature has **O** for all products it is a mandatory feature If the feature has **O** for some products and **D** for other it is variable if a feature has **D** for all products it is variable if a feature has **F** for all products it means that it is outside of the scope
Rules	• If there is any discrepancy as to whether a feature is mandatory or not, the members will state their reasons, if even there is no agreement the feature will be classified as mandatory. • Priority and priority value columns are not filled during this task, but in Task 8 Quantify product map.

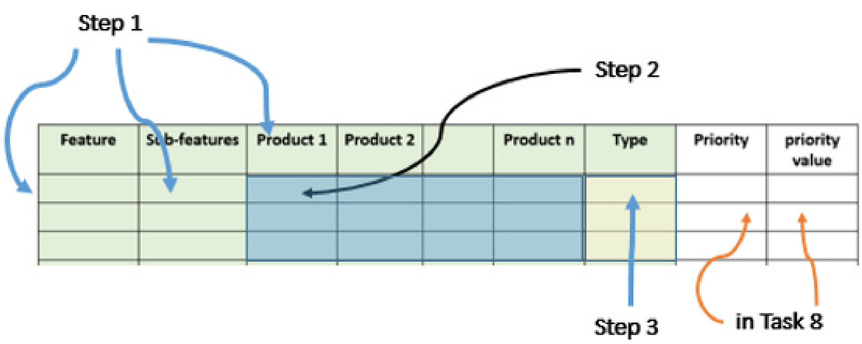

Figure 5.13: Relationship between steps of the task with the artefact template

This participant is usually an external advisor, that belongs to the companies or organizations of the target domain. This role provides knowledge about the target domain, context, customers, related products and associated regulations that belong to the companies or organizations of the target domain.

- Knowledge:

  This role knows the potential market domain, and the products related to it, also potential customers and the final users

- Responsibilities:
  Propose features from its domain knowledge Evaluate that features that belong to the target products Solve discrepancies about features and types of the features Collaborate in the evaluation of assets to be developed in a reusable way

Business administrator
This role belongs to the administrative unit of the software producing company (a manager or administrator)

- Knowledge:
  This person provides a strategic vision, an enterprise approach to the project that considers knowledge about company projection, organization, budget, time and resources.

- Responsibilities:
  Communicate the company objectives Inform the management concerns of the project Evaluate the viability of the line considering the goals of the company and the resources projected for the project of the product line.

Marketing expert
This role represents the business concerns of the company against the production of a SPL. This person belongs to the unit or unit of marketing and sales of the production company.

- Knowledge:
  This person represents the business concerns of the company and business strengths. This person also knows about the competitors and their products. This role has access to sales data, estimations of sales and customers, knows the potential market to which the product line is addressed

- Responsibilities:
  Propose features according to market target and the products offered by other software companies. Identify features that make the products differ from the products of the competition. Help in the identification of the domains and products more relevant for a determined market segment. Evaluate the features that belong to the market target and that are commercially attractive.

Software architect

A software architect is a responsible role for the high-level design and strategic planning of a software. It is usually the person with the most experience in the development team and with good communications skills.

- Knowledge:
  The architect has knowledge about the software structure and the challenges that involve the development in a reusable way, the variability required to generate different products. Also, he knows the implications and techniques required for the design and development based on the reuse of assets

- Responsibilities:
  The architects are responsible to determine which features will constitute the assets that will be reusable developed. This person evaluates the technical feasibility of the proposed features.

SPL project leader

The SPL leader is the person who manages and controls the resources assigned to the SPL project, with the purpose that the plans are correctly fulfilled in the estimated time. This person provides strategic vision, a business approach that considers aspects like cost, time and resources of the project.

- Knowledge:
  The leader must know about: Clear vision and mission of the project Objectives and organization of the company Available resources, the investment budget. Project management
- Responsibilities:
  This role is in charge of organizing meetings and workshops during the scope activity. The leader coordinates the efforts, spaces and necessary resources for this activity.

5.9.2 Optional roles

Potential Customers representative This role represents the possible clients of the products to be developed and that belongs to the SPL. The objective of the client's participation is to identify real needs.

Sales staff This role knows and collects all possible information about the sales of the company's products, competitors and aspects of the customer's purchasing processes.

Domain analyst

This role interacts with potential users and experts in domains to establish the line scope, gives an overview of the target domain and determines the common and variable characteristics of the products of the line and the restrictions. This role is a link between the scope definition activity and the following SPL development activities. The analyst must be a sociable person, who expresses ideas clearly in a common language with potential clients and experts in the domain, and helps to understand between non-technical and technical roles.

Technical expert He/she knows different tools, techniques, environments and programming languages. He/she provides technical knowledge of the products and helps the team evaluate different technical options.

SPL expert This role is necessary if the leader of SPL has no experience in the development of SPL, he provides knowledge in the planning and development of a SPL initiative.

Teamwork advisor He/she knows collaboration techniques and practices, which will help in the execution and management of the workflow, in the solution of impediments and in the interaction between the participants, he/she supports and encourages communication and collaboration among the participants.

5.10 method summary

The table 5.6 presents the summary of the CoMeS-SPL method, associating, tasks, input and output artefacts, and the mandatory roles involved in the task.

Task	Sub-task	Input artefact	Output artefacts	Mandatory roles
Initial meeting	Assemble the profile of the line	– Business objectives – Market study	– SPL Profile	– Expert Domain – Business Administrator – Software Architect – SPL Project Leader – Marketing expert
	Baptize the line	– SPL Profile	– SPL Profile	– Expert Domain – Business Administrator – Software Architect – SPL Project Leader – Marketing expert
Identify features	Explore existing products	– Similar products (own or alien) – Documentation of similar products	– Preliminary Features List	– Expert Domain – Business Administrator – Software Architect – SPL Project Leader – Marketing expert
	Propose features	– Preliminary features list – SPL Profile	– List features	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert
	Analyze features	– List features	– Revised features lists	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert
	Concert features	– Revised features lists	– Concerted features list	– Expert Domain – Business Administrator – Software Architect – SPL Project Leader – Marketing expert
Identify Products		– Concerted features list – SPL Profile	– Products list	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert

Task	Sub-task	Input artefact	Output artefacts	Mandatory roles
Identify functional domains		– Concerted features list	–Functional domain list	– Expert Domain – Software Architect – SPL Project Leader
Classify features in functional domains		–Concerted features list – Functional domain list	–List of categorized features	– Expert Domain – Software Architect – SPL Project Leader
Tabulate products and features		– Concerted features list – Products list	– Product map	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert
Validation product map		– Product map	– Validated Product map	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert
Set metrics		– SPL Profile	– Metric list	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert – Business Administrator
Quantify product map and functional domains		– Metric list – Validated Product map	– Quantified product map – Quantified functional domains list	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert – Business Administrator
Final meeting		– SPL Profile – Quantified product map	– Perspective of the line	– Expert Domain – Software Architect – SPL Project Leader – Marketing expert – Business Administrator

Tabla 5.6: Summary tasks of CoMeS-SPL

5.11 Chapter Summary

SPL Scoping is a challenging and critical activity that can mark the success or cause of an SPL failure. One of the complex aspects of SPL scoping is that it must be carried out by a group of actors with different points of view and varied concerns. The combination of method engineering and collaborative engineering for defining a method for SPL Scoping provides benefits organizations that want to plan an SPL. The collaboration engineering provides patterns that guide the interactions among the participating actors in such a way that their efforts, knowledge and expertise are combined to achieve the objectives set forth in the SPL Scoping. Additionally, the engineering method allows the definition of a systematic method to detail the tasks, roles, specification documents and techniques to be used, with the level of detail that allows to instantiate concrete steps in practice.

We consider that the differences and advantages of CoMeS-SPL is in its orientation towards a collaborative approach that defines and describes the roles, their knowledge and responsibilities in specific steps that are combined with the contributions of the other roles for the development of specified artefacts and obtain the Scope of the SPL.

The applicability of the collaboration engineering in SPL Scoping has already been validated by other researchers in previous works, however, the availability of this proposal is limited, which makes the replication of these proposals difficult, and limits the flexibility of adapting the method to the particularities of the company. CoMeS-SPL has been published on a website, its design has been oriented to companies, and in facilitating its application and adaptability.

Chapter 6

Evaluation of the CoMeS-SPL Method

"It's time to get your hands dirty.
to soil the practical issues of creating and its consequences"
Will Gompertz

6.1 Introduction

When proposing a method for SPL scoping, it is necessary to evaluate the proposal to design collaborative methods combining method engineering and collaborative engineering. The evaluation from the perspective of method engineering must consider the description of its elements, their completeness, and traceability; and from the perspective of the collaboration engineering must examine the participation of the roles. To propose the CoMeS-SPL method implied to consider different aspects, the design proposal considered iterations that would allow to increase the specification of the method, and to carry out several evaluations that would consider direct aspects and contexts. The empirical experiences allowed to contrast the theoretical elements obtained from the review of the literature and the conformation of the method base composed of method components with the practical elements obtained from the observation and the found results in the empirical studies and the case study.

Figure 6.1 summarizes the main elements of the four empirical experiences that were carried out during the development of this re-

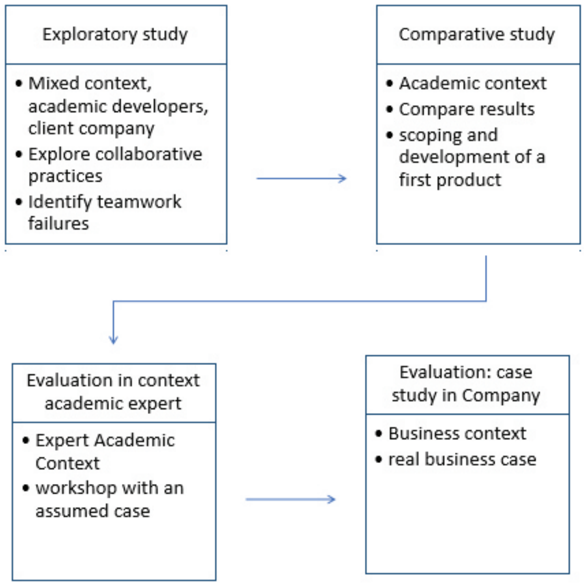

Figure 6.1: Empirical Experiences

search project, which will be explained in the sections of this chapter.

6.2 Exploratory study: A line of training micro-games

This section reports an exploratory study aiming to identify which SPL scoping tasks require collaborative practices for improving communication and interaction among participants. Also, in this section is described the effects identified by including collaborative patterns and thinkLets in some of the scoping tasks.

This study was conducted in a mixed context, where a group of students developed a line of training micro-games for a company. The scope of the line was determined in a group of meetings and workshops in which students and employees of the company participated.

6.2.1 Exploratory study design

Research question

RQ1: What problems related to the interaction and collaboration of the stakeholders can be observed when groups of developers define a scope for a Software Product Line?

RQ2: What are the tasks of the scope in which the participation and interaction of the participants have greater incidence?

RQ3: How can a process, such as the Small-SPL, be improved by using the identified thinkLets?

Objective
The study aims to give us empirical and exploratory knowledge about scoping task, regarding contributions, communication, and interactions of the participants in this task. We were interested in exploring the problems related to the diversity of roles required in this activity and the effects of including collaborative patterns and thinkLets may have in favor of improving the participation and the result obtained in the scoping

Case Selection Strategy: Availability
Type of Case according to its objective: Exploratory
Type Analysis according to the Analysis Units: Holistic
Unit of Analysis: Project of Development of a line of micro-games

6.2.2 Exploratory study context

The study was done in a mixed environment. The development group belonging to an university environment and customers corresponding to a business environment. The development group was made up of 25 students of an elective course of the third year of the Informatics Engineering at Institución Universitaria Colegio Mayor del Cauca

(Popayán - Colombia). On the other hand, the stakeholders or product customers belong to four organization units of METREX S.A. company [1]. METREX is a Colombian company leader in the manufacture and marketing of high precision equipment for the measurement of flows and fluids for public services such as water, energy and gas. METREX is located in the industrial park in the city of Popayán.

6.2.3 Small-SPL process

The process that was followed for the development of the micro-games line was a Small-SPL. Small-SPL is a process for SPL engineering for small development companies based on the SEI's framework [98]. The life cycle of Small SPL includes three subprocesses: Domain Engineering and Product Engineering, geared by a third subprocess called Asset Management based on Requirements. The domain engineering responsible for the production of the assets, the domain engineering of the construction of products, and the Asset Management based on requirements allows to communicate the two fundamental processes in the construction of a line of processes, facilitating the identification, development, documentation, storage, search and use of the assets that will be used in the development of the products of the SPL. See Figure 6.2 [98]. It starts with *Line Scoping*, an activity that defines the products that comprise a software product line, specify the features and requirements for each product and sketch the reusable assets that must be developed.

Figure 6.3 describes the scoping tasks. It starts studying the domain of applications for the product line and identifying the needs of the stakeholders. Then, the process continues exploring existing solutions in the same domain, listing possible products for the product line and identifying the features for each product. Once, the involved stakeholders have achieved agreements regarding products and features, the process continues establishing common and variable features and

[1] https://www.metrex.com.co

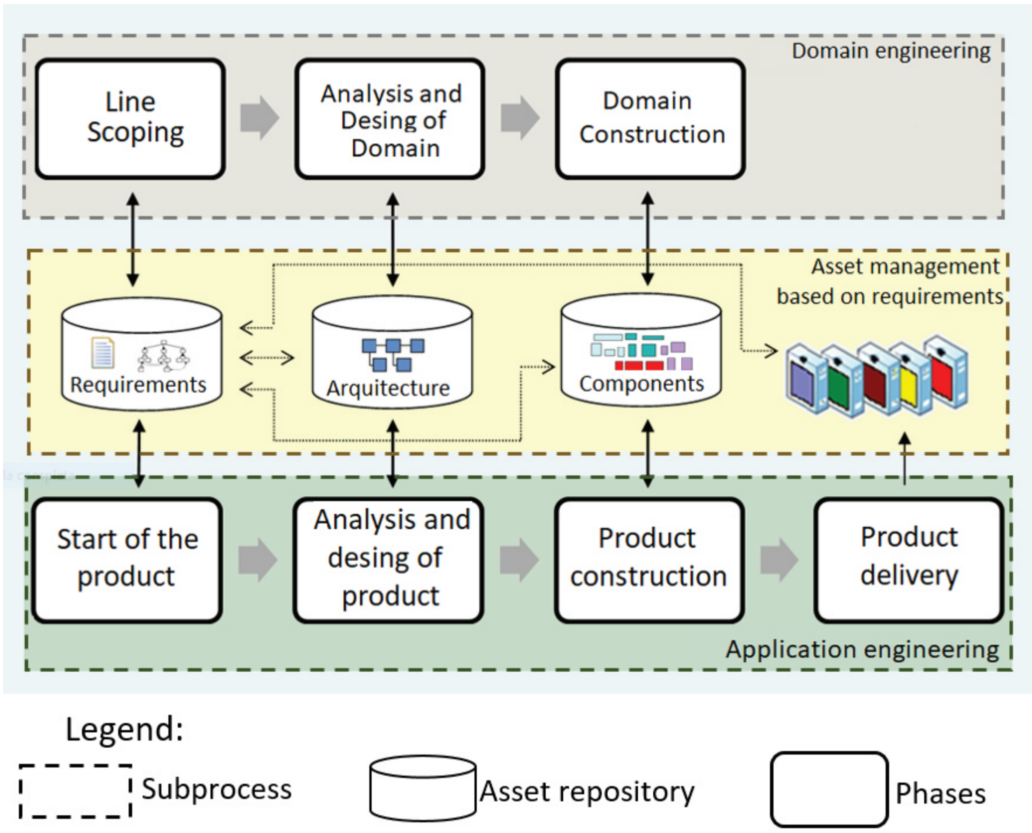

Figure 6.2: Small SPL process

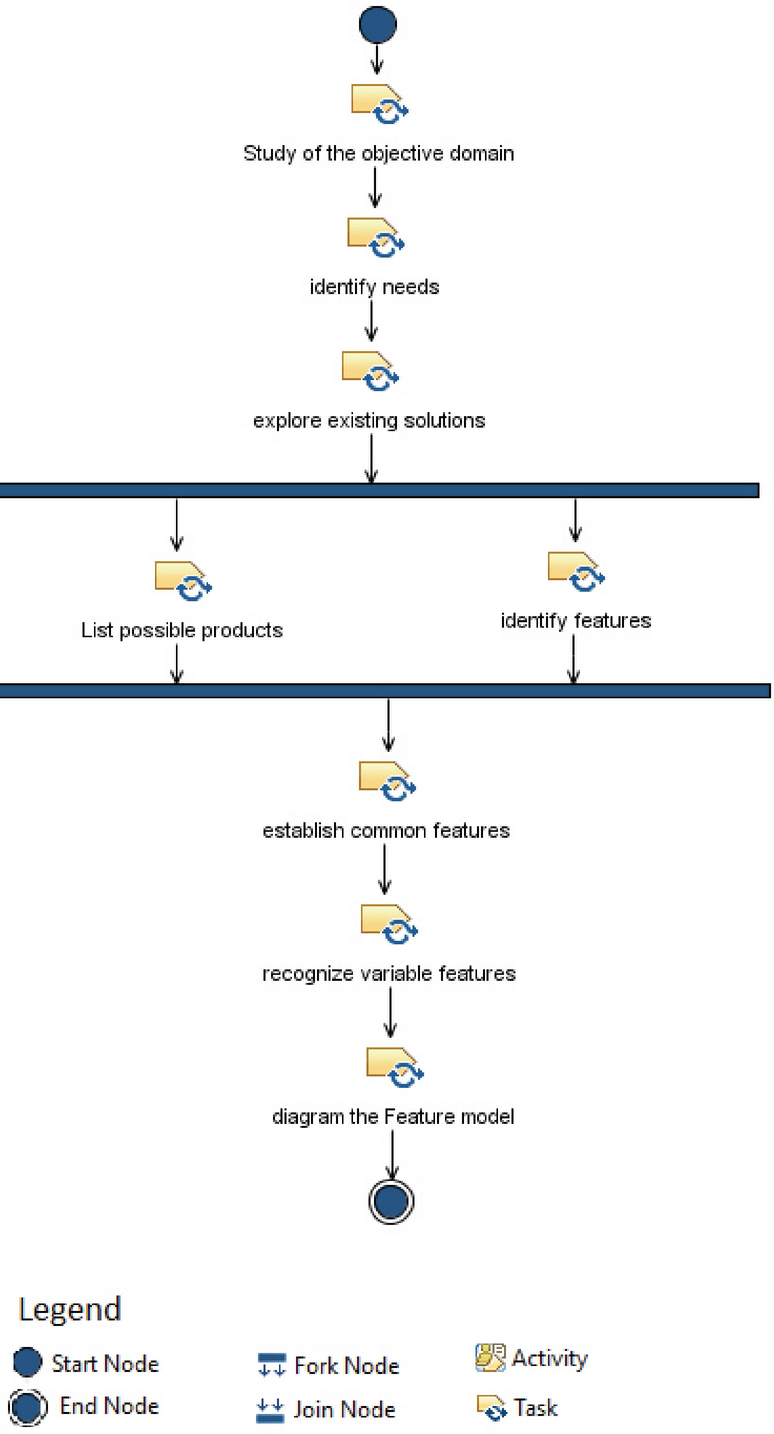

Figure 6.3: the task Scoping in the process Small SPL

Indicators	Metrics	Methods for data collection	Instruments
Effectiveness (Quantitative)	Products that belong to line scope but that were considered out of it (False Positives)	indirect	Project Repository
	Products outside the scope that were considered within it (False Positives)	indirect	Project Repository
	misclassified features	indirect	Project Repository
Problematics (Qualitative)	Problems identified in the execution of scoping	direct	survey
		direct	Observation protocol
Opportunities (Qualitative)	Opportunities identified in the scoping due to the limitations of the applied techniques	direct	Observation protocol

diagramming a feature model for the software product line.

Note that, the scoping in Small-SPL does not define their tasks collaboratively, it's not used collaborative patterns, either thinkLet. The goal of Small-SPL is to be an SPL development process focused on small software producing entities

6.2.4 Execution of exploratory Study

The students were distributed among the organization units as follows indicate in the table

The Meetings between the students (development groups by unit) with the heads of the organizational units were initially scheduled every 3 weeks at the company's facilities. The participants of the company in this exploratory study were the head of each unit and some employees from each unit. The participation of other employees was a decision

Organization units of METREX S.A	Students number	Products number
Production unit	9	4
Laboratory	6	3
Warehouse	6	2
Human talent unit	4	2
Total	*25*	*11*

Tabla 6.1: Distribution of students and products by organizational unit

of each unit head. The students knew the processes and procedures of each unit during the first meeting, in which they also toured the facilities. The unit heads determined the operators who participated in this training; for example in the production unit, some of the operators explained their functions when the students went through their job positions.

Line of training micro-games
Students developed a product line of micro-games for training employees of the company. The products line were questions and answer games related to the topics of four organization unit of the company. These organization units were production unit, laboratory, warehouse, and human talent unit. The SPL of training games shared the design basis on questions of the unit's procedures and the possible answers, but also each unit had its own requests, this made the games different. The production unit emphasized in their process for which the boss requested to include videos or animations previous to the game as a training. While the warehouse objective was the recognition of the pieces of the meters, whereby the games of this unit required the use of the images or photos of these pieces. The total project was divided into: 64 hours of work in classes and 80 hours of autonomous work, for a total of 144 hours.

For scoping the exercise, it was divided as follows:
Training of development groups:

6 hours in product lines
5 hours in serious games (theory)
3 hours on the company and the corresponding dependence.

Realization of scoping

Training in scoping practices (4 hours)
3-hour joint working session of the development groups
2-hour session each sub-group
Meeting with the client 3 hours
3 hour scoping refinement section

Training

The students from development groups did not have previous experience in the development of serious games nor in SPL development, therefore training in SPL, serious games and the unity platform were carried out. A training on the video game engine Unity and on video game development was oriented by two experts in game development. This training on game development was carried out gradually and in parallel to the progress of the project with a duration of 32 hours.

Scoping

After the initial training, the development group started to define the scope following the scoping activity of the Small-SPL process. For this task, developers meet with staff members of the company for two hours each 15 days. As mentioned before, four organization units participated in these meetings. The first meeting was held among the group of students and flow meter company people. In this meeting, the staff manager was in charge of communicating general aspects of the company, its organizational structure and some remarks about its operation. She explained the objective of the project from the company viewpoint, described the participating departments and the products per department and presented the heads of each department who would be the ones who would interact with the development groups. A second meeting was held between department heads and development teams, where the particularities of the operative processes of each department and the training needs of its operators were explained. This meeting lasted two hours.

The students held a workshop with the objective to propose possible products and their features, as well as the groups identified the common features and the variability between the products; The proposals were presented and validated in a fourth section with the representatives of the departments. Although, we initially had planned only four meetings, other two scoping meetings were necessary because (1) there were differences between the product proposed by the developers and the expected by the company and (1) changes on the staff members that participated in the meetings.

Finally, a scope refining session was carried out in which the students participated cooperatively to be able to agree on the characteristics and the type of products that make up the line.

6.2.5 Data collection in the study

During the four months the project lasted, a constant follow-up process was done inside the development group, the professor accompanied them in all the meetings with the boss of the units, and meetings were held every two weeks with the whole group and with each subgroup. The recollection of information was made during all the meetings by means of interviews and recordings, also through the artefacts produced such as models and prototypes. The professor was also in constant contact with the staff manager of the company to monitor the vision of the project and company interest.

Scoping was performed in four steps. First, there was a general meeting in which the boss of the units participated, in which the staff manager explained what the objective of the project was, the process of training the employees and that it was intended to include serious games as well as to verify if they were looking forward to applying it, then the group was divided according to the needs of each unit, and these subgroups met with each boss to understand the processes and specific procedures, such as the expectations of each unit boss. Second, the developers proposed the training products and features for each organization unit. They presented and discussed these proposals at a meeting with the coordinator of the corresponding office. Third, a task for refining the scope was carried out with the cooperatively participation of all the students. Finally, product proposals were presented to the heads of department and a vote was taken on the features of the products.

One of the problems that was presented in the scoping was the head of the unit appointed one or two employees to replace him in some of the meetings when he could not attend because of other more priority work commitments.

6.2.6 Results and Discussion

The products of the SPL of serious games for training were identified in the scoping activity, in two types of workshops, some were carried out with the participation of the entire development group and unit heads, others only with the development group and the specification of features was initially performed in the subgroups with and without the participation of the head of the unit, finally, refinement meetings were held. The results are presented in the table 6.2.

Products determined by scoping			
Products omitted	2		
Products belonging to line	10		
False products (out of line)	2		
Characteristics of the line			
Mandatory	7	should be	12
Optional	10	should be	6
Xor (only selects 1)	3	of	3
Or (one or several)	4	of	6

Tabla 6.2: Results of scoping exploratory study

Some observations form this study were:

- The lack of experience in the development of serious games was notorious in the exercise of establishing the products of the SPL and its features. In addition, the difference in perspective of the products of the different organizational units was notorious, some of which were expected for training video games and other employee evaluation information systems. The groups that made the practice of reviewing existing products, searched online for available training games. This made it easier for these groups to identify features of the products to be developed.

- One of the departments of the company made very specific requests that became limiting of the possible products to be proposed in the SPL, it facilitated to delimit which features belonged to the line.

- The development of assets to reuse was difficult, the times of production of the groups did not match, because of that, some groups developed their own assets.

- Two of the products differed between their initial approach and the final product, the features of these products did not really belong to the SPL, these games went from the question-answer scheme, to using puzzles of photographs but failing in the strategies and techniques of serious games for training. Therefore, these games did not meet the training objectives set by the head of unit.

- The model of characteristics and matrix attributes/products were made in a collaborative way, with the participation of the entire development group, this achievement unified the terminology used, and prioritized on the characteristics of the products

- Together with the product line practices, serious game design tasks were carried out, this made that the development groups not forget about features that the products had to include because they were serious products, one of the added artefacts was a format for the design of the learning objectives that each game would have. This format managed an unified language and ideas between the developers and the heads of unit, while helping to delimit the possible products.

- The development group considered technical aspects of the project that limited the scope of the SPL as a platform and language of development, computer equipment of the client, and access to information.

- The lack of experience of the development groups influenced the estimation of development effort, some groups projected very ambitious products while others limited them a lot, and it did not have foundations that allowed them to establish the needed time for its production.

6.2.7 Conclusions of the experimental study

- In order to propose the scoping activity in a collaborative way, first, we should identify the tasks that need to be collaboratively performed, the tasks where the interaction of the knowledge related to the context, the objective market, and technical aspects that are decisive for the decision making. These are tasks where achieving the collaboration of the different roles is vital.

- This experience evidenced problems of communication between the same clients and lack of availability, which became more critical when having to communicate with the development group, and the absence of experts and advisor was also noticeable.

Note: In the appendix C, you find details, photos and the material used and resultant by of the study.

6.3 A comparative study

This section describes an exploratory study with the aim of comparing the defined scope following two scoping methods: one including collaborative aspects whereas the other does not.

6.3.1 Study Design

Research question

What are the effects that the addition of collaborative practices has on an approach that guides the SPL scoping activity?

Objective

The goal of this study was to obtain empirical and exploratory knowledge about the scope definition activity, regarding the team members, their participation, and interaction. This study seeks to compare the results obtained by two scoping methods, in one case following the selected method and in the other by introducing collaborative patterns and thinkLets in the selected method. The scope obtained was compared with respect to the correctness and usefulness of the obtained artefacts.

Study context

This case was planned and performed in the context of “Summer of Scientific Research from the Mexican Academy of Sciences” 2017. The experience was carried out with 12 students of computing engineering from sixth to eighth semester, belonging to different Mexican universities. The students worked for 7 weeks, 25 hours a week. During that time, the students designed several serious video games for children with dyslexia as an SPL and developed the first product of the SPL.

6.3.2 Study measurements

The **Effectiveness Measurement** indicates the degree to which an SPL meets its overall goals. One of the measures proposed for measuring this effectiveness is the **Market Feature Coverage (MFC)**. This measure captures the degree to which the features of the line cover to the features those related with the target market [99]. A key toward assessing the Market feature coverage is the identification of features that are relevant to the market. For this study, the evaluation of the features that belong to the target market was made by a professional in the treatment of dyslexia.

The adaptation of this measure for this study is:

Market feature coverage of the scoping: this measure captures the extent to which the features identified in the scope (product catalog) cover the features related to the target market.

Market feature coverage of the first product of line: this measure captures the extent to which the features currently available in the first product of the line belong to features related to the target market.

6.3.3 Scoping approach for this study

There are different approaches to scoping that were addressed in the section 3.1 of this document, for this study, the practical guide to PuLSE-Eco proposed by John et At [27] was followed. This approach has been the basis for more recent studies. For this comparative study, an adaptation of the practical guide was made in which collaborative patterns and thinkelts were incorporated according to the table 6.3.

6.3.4 Study execution

Initially, the students received training on SPL and serious video games by 8 hours, each group was trained in the method specific to follow in the project. For the development of products lines, students used the Small-SPL process [98], an adaptation of the SPL framework of the SEI [5] for small entities. During this experience, the group was divided into two teams of 6 members each. Specifically for the scoping activity, The first group, called NCTeam (Non-collaborative Team) followed the practical guide to PuLSE-Eco proposed by John et At [27] without considering any collaborative practices. The second team called CTeam (Collaborative Team) followed the same guide combining some collaboration patterns [57] [4]. In both cases, some design aspects of serious educational video games were included [100]. The scoping in this study was focused on the product catalog and the domain delimitation.

The roles were assigned taking into account the abilities and knowledge of the students, each member played a role: a domain expert (dyslexia assessor), a marketing person, a user representation, a developer, a technical expert and a project leader. Previously, participants were informed about their responsibilities according to the role played. Each student had time (initially ten hours) to prepare their role before each work section.

Both groups had the same conditions, each team had the participa-

Task	Collaborative Pattern	Thinklet	Purpose
Identify features	Diverge	OnePage	The participants exchange possible features of products
Identify domains	Organize	ThemeSeeker	The participants select the target subdomains
Identify products line goals	Converge	FastFocus	The participants agree on the objectives of the line
Select characteristics	Converge	Broomwagon	The participants select the features of the subdomain
Identify products	Organize	ThemeSeeker	The participants exchange ideas on possible products
Specify product feature Matrix	Organize	PopcornSort	To classify the features of each product
Assess features	Evaluate	Bucketwall	To approve the features of the products.
Identify assets	Diverge	Leafttopper	To propose the components that will be developed.
Relate components	Evaluate	Bucketwall	To link the components with the features of the products

Tabla 6.3: Scoping Task with Collaborative Patterns

tion of two students with some experience in video game development (acquired in previous academic projects) that was selected by the technical experts and the developers. For the other roles, the students did not have any experience.

During the preparation, the marketing person and user representative examined some video games for dyslexic children available on the web or in mobile app stores. The objective was to obtain some initial ideas about games by identifying deficits addressed and the associated exercises on each deficit. The domain expert (dyslexia assessor) prepared them by carrying out the first interview with a professional expert in language problems, and reading about the subject and then exposing it to their peer group. In a first session, the purpose was: to exchange information and achieve a common starting point for the stakeholders. In this case dyslexia and the explored video games.

The goal of the scoping was to establish the video games of the line and its characteristics, for which the ages and the objective deficits were determined. Both teams identified four games as part of the line, identifying the common and variable characteristics of the proposed games, thus, defining a catalog of products.

After the training and preparation sessions, the teams performed the scoping activity, the NCTeam initially defined only one product and its features, using this product as a base, the group defined second and third products that were visualized in a feature model. On the other hand, CTeam initially brainstormed ideas about the possible features by using the generation collaborative pattern. Then, those features defined the products that would make part of the SPL by using reduction collaboration pattern throughout the evaluation of products and their features using a voting strategy according to their roles. Finally, the products and features were defined by using a feature model.

6.3.5 Results and Analysis

The evaluation of the effectiveness of the line of games to support the treatment of children with dyslexia was done with the support of a speech therapist expert in dyslexia treatment. This evaluation was made in two moments: it was evaluated during domain engineering and after they evaluated the first prototype of the video game corresponding to the first product of the line, at product engineering moment. The evaluation of the SPL was as follows: each group presented the speech therapist their portfolio of products, age range, objective, difficulties, and the storyboard related to the first product. The evaluation objective was to validate products and characteristics with regard to its relevance to support the treatments according to the difficulties and ages considered (market).

The results obtained can be seen in the table 6.4. These results allow to deduce that CTeam identified a greater number of characteristics belonging to the domain (market) than the NCTeam.

MFC	NCTeam	CTeam
MFC scoping	75%	87,5%
MFC first product	76,92%	95,2%

Tabla 6.4: MFC of games line to support treatment of children with dyslexia

The difference in the coverage of market features is greater in the first product proposed by the CTeam. It can be deduced that the interaction of the participants achieved with the inclusion of the collaborative patterns and the thinkLets helped achieve more accurate results in the identification of the features of the products of the scoping objectives. Each one of the teams conducted two evaluations with an external professional in language problems, an expert in dyslexia treatment. The first evaluation was carried out during the scope activity, at that moment, the proposal of each team was evaluated, the proposed video games and its features were evaluated using the product catalog, the product map, and a storyboard, the expert took into account the characterization of the target market, the age of the children and the deficits to be addressed.The second evaluation was made to the first developed product. The obtained results were:

- The NCTeam required less time that CTeam to clearly describe the first product and list its features. However, CTeam was much faster in describing a set of products and identifying common features and variabilities.
- The NCTeam required less time that the CTeam to clearly describe the first product and list its features. However, CTeam was faster in describing a set of products and identifying common features and variabilities.
- The defined products by CTeam corresponded more to a set of products than to modifications of a product, whereas the approach of NCTeam corresponded to a product and two products that made modifications of form but not functional of the first product (such as the characters, the scenario of the game, or the representation of the lives and the score).
- The role interaction in NCTeam was harder since the roles were not well defined in the original approach.
- The first proposal in both teams was very ambitious and dealt with an extended range of ages, also considered each possible deficiencies that children with dyslexia suffer. The CTeam limited the target domain in the evaluation exercise of products. In this task, the products, and their features were categorized and evaluated according to the vision of each one participating roles; However, for the NCTeam, the lack of dominion delimitation was only obvious with the observations made by the expert in dyslexia.
- The students seriously played the roles, this contributed to the definition of the scope, each participant gave from their role the required knowledge. This situation was more visible in the CTeam

because the responsibilities and contributions of roles were clearer in the modified and defined approach rather than in the original approach.

- The modified approach that followed the CTeam had more details about the steps to follow and the artefacts to build. This facilitated the accomplishment of the tasks and artefacts.
- During the socialization process of the projects in the section which each group presented the idea of the product that it was going to develop, the CTeam observed that its selected product was very similar to the one exposed by the NCTeam, so when presenting its catalog of products, this team changed the first product that would be developed by another product of its SPL. This change was not problematic in the exposure of product ideas, neither was it in the development of the mentioned product.

6.3.6 Conclusions of the study

This study allowed us to demonstrate in a practical way the differences between applying a certain scope task collaboratively or performing it in a traditional way.

One of the observations obtained is about the participating roles, although the two groups were made up of students, which did not make it possible to have roles with different knowledge and interests as would happen in a company; however, it was evident that in the collaborative group the roles had clearer responsibilities and where they should participate, while in the non-collaborative group there was evidence of insecurity by the participants and fewer number of participation compared to the collaborative team.

The collaborative construction of the artefacts facilitated that the participants made contributions, essays, proposals, while the individual construction of the artefacts required more time and it was evident that they did not know how to translate the information in them, this may also have happened due to the granularity with which the steps of each task were described in each of the methods applied.

The thinklets related to brainstorming to propose features, those for classifying features in domains and evaluating the proposed features were the tasks with a greater number of participation and in which communication was observed between roles, exposition of ideas and even discussions prior to reaching agreements.

Under the conditions of the study, scoping artefacts defined in a collaborative way, presented a clearer scope definition, resulting in a greater utility for the development of the first product. Although it is an exploratory study, it shows in a concrete way the benefits that the collaborative work has on the scoping activity. According to this study, SPL scoping requires the participation of different interdisciplinary roles that contribute from different areas of knowledge and expertise. However, to ensure that this participation is effective, a systematic and collaborative way is required that guides the scoping team to make the artefacts correct and useful in the development of the line.

The main drawbacks were evidenced in both groups in the tasks belonging to the asset scoping, one of the possible causes we believe is the moment in which they are carried out, since the participants had already taken a long time in performing the scoping, and also because of the lack of experience related to development for reuse. The results had to be reviewed later and adjusted.

Note: In the appendix D, photos of the study can be found, and used material and the obtained results.

6.4 Evaluation of the CoMeS-SPL method: a study with SPL experts in a research context

6.4.1 introduction

This section presents the application of the CoMeS-SPL method in the development of an SPL Scoping in the context of a local research workshop. The objective of the application of the CoMeS-SPL method is to evaluate the usefulness of the method to define the scope of an SPL, from the point of view of the practitioners, as well as the level of collaboration reached by the work team. This evaluation was planned, designed, executed and reported as an empirical study, following the guidelines presented in by Wohlin and others [35]. The stages of the empirical study were: design, preparation, data collection and data analysis. In order to define the objectives of the empirical study, the GQM (Goal-Question-Metric) approach proposed by Basili and others [101] was applied.

6.4.2 Experiment measurement design

The objective of the empirical study was to examine whether the CoMeS-SPL collaborative method proposed generated a collaborative dynamic among the participating actors and if this collaborative dynamic facilitates the definition of the SPL scope, also it was assessed whether the proposed method was perceived as useful and easy to use.

Through GQM, the following measurement questions are posed:

1. What is the level of collaboration achieved by the team through CoMeS-SPL?
2. What is the perception of the members regarding the utility and ease of use?

To answer the first question, the quantitative indicators of collaboration proposed by Avouris and others [102] were used and adapted. To answer the second question, the variables of perception formulated by Davis were used and adapted [103]. Quantitative indicators of collaboration to measure the level of collaboration were four established:

1. Contribution of an actor to an artefact,
2. Factor history of the artefact
3. Factor collaboration of an artefact
4. Factor collaboration of an activity.

The following describes each of these indicators proposed by Avouris and others [102].

Contribution of an actor to an artefact (AC_{ar})

This factor indicates the weight of the contributions made by an actor in the construction of an artefact. The contributions are the actions (T) made for the diagramming in models or the joint elaboration of documents or other artefacts, for example, insert, modify, eliminate, move or classify information (each type of action is assigned a weight W(T) In calculating the contribution of an actor to an artefact (AC_{ar}),

W(A) is the weight of an actor in the construction of the artefact, considering its expertise and knowledge, W(A) is a multiplicative factor between 0-1 [102]. The weights of the type of action and the actor are assigned by the moderator of the activity [102]. The following formula expresses how to calculate the (AC_{ar}).

$$AC_{ar} = W(A) \sum_{i=0}^{N} W(T_i)$$

Factor Artefact History (HF_{ar})

This factor indicates the balance in the amount of contributions to an artefact made by the participating actors. It is calculated with the standard deviation and the average value of the actor's contribution to an artefact. This value is in the range [0, 1]: values close to 0 indicate that the contributions were made only by some of the actors, while close to 1 express a higher degree of balance in the contributions of the participants [102]. The following formula is the one that must be used to calculate the (HF_{ar})
.

$$HF_{ar} = 1 - \frac{stdev(AC_{ar})}{med(AC_{ar})}$$

Factor of Collaboration of an artefact (CF_{ar})

This factor describes the level of relative participation of the actors involved in the development of an artefact, it is based on the type and size of contributions or events made to the artefacts that constitute in this case the scope of an SPL(46). The Collaboration Factor (CF_{ar}) is directly proportional to the artefact's history factor (HF_{ar}), the relative weight of the artefact in the solution (War), the value between 0 and 1 that is assigned by the moderator, and the number of participation to the specific artefact (CP_{ar}); and it is inversely proportional to the length of participation in the collaborative activity (l), as it can be seen in following formula.

$$CF_{ar} = HF_{ar} * W_{ar} * \frac{CP_{ar}}{l}$$

The value of the collaboration factor (CF_{ar}) ranges from [0, 1], where values close to 0 indicate unbalance in the contributions of the participants, little weight of the artefact in the complete solution, or few contributions in an artefact compared with the contributions totals in the different artefacts of the solution. Values close to 1 indicate a higher degree of collaboration in the artefact, where a great level of balance is distinguished in the participation of the actors for an artefact of great importance in the activity and where the number of contributions is similar to the average contribution of the different artefacts. In order for the analysis to be carried, the weight or importance of the artefacts is considered the equal for all, which allows to observe the participation behavior of the actors.

Factor of Collaboration of an activity(CF_a) :
This factor describes the level of relative participation of the actors in a collaborative activity constituted by artefacts. It is based on the type and size of the contributions made to the artefacts that constitute in this case the scope of the SPL Scoping (46). The factor of collaboration of the activity (CF_a) is calculated as the average value of the factors of collaboration of the artefacts.

$$CF_a = \frac{sum_{i=1}^{n} CF_{ar_i}}{n}$$

This indicator can take values among [0, 1], where values close to 0 can indicate low balance in the contributions of the participants in the activity, or show noticeable differences between the number of contributions made to each of the artefacts. Values close to 1 indicate a higher degree of collaboration in the activity and where the contributions of the actors made to the different artefacts are numerically similar.

Perception variables:

- **Perceived ease of use (PEU):** the degree to which participants think that using CoMeS-SPL is easy and does not imply an overexertion to the activity. This variable represents a perceptive judgment of the effort required to learn and use the CoMeS-SPL method [103].

- **Perceived utility (PU):** this is the degree to which the participants in the SPL Scoping consider that both the defined scope and how to define them through the CoMeS-SPL method are useful [103].

- **Intention of use (ITU):** is the measure of the intent to use the CoMeS-SPL method in future development projects of SPL by the study participants. This variable represents a perceptual judgment to know the level of acceptance of the CoMeS-SPL method [104].

- **Perceived Collaboration (CP):** this is the degree to which participants in SPL Scoping activity believe that using CoMeS-SPL encourages collaboration and effective communication in defining the scope of an SPL.

To measure the variables perceived ease of use (PEOU), perceived utility (PU), intention to use (ITU) and Perceived Collaboration (CP), a proposed measurement instrument was adapted and evaluated for the evaluation of the requirements modeling methods. In perceptions [104] and the Technology Acceptance Model (TAM) [103], concepts that were adapted to the object of the study and were applied after the CoMes-SPL method workshop. A set of items was defined to measure each of the perception variables. The evaluation of these elements used a Likert scale of 5 points (the lowest value or disagreement 1, and the highest value or agreement 5). The items were randomly organized in the questionnaire to prevent the participants from giving systematic answers. Four open questions were included in the instrument to obtain suggestions and observations regarding the proposed method. The design, instruments and documents of the experiment are available and the full description of each task can be seen in the appendix C.

6.4.3 Study context

The study object is the CoMeS-SPL collaborative method, and it is carried out on a team of participating actors in the definition of scope for a practical case following the method, moderated by the principal investigator of this study. The research subjects of this empirical study is a group of professionals, experts in the development of software product lines that currently carry out related doctoral studies at the Federal University of Bahia, Brazil. The practical case consisted of defining the scope of a software product line of mobile applications to manage and visualize agendas of events, starting from three products considered successful that were developed for three academic congresses, two of an international character and the other of a national one.

6.4.4 Conducting the study and gathering information

The empirical study was conducted at the Federal University of Bahia, city of Salvador de Bahía, Brazil. A group of 10 professionals, doctorate students and a master's degree in computer science was summoned for the same. In the workshop finally 3 professionals, doctoral students and 2 professionals, masters students, participated. The selection of the collaborators was made by convenience (knowledge in aspects of the SPL development) and disposition. Four of the participants have worked on research projects related to SPL, two of them have applied the SPL approach in development projects (3 during a range of 5 to 10 years and one in a range of 1 to 5 years), one of the participants has knowledge of SPL, but he has not participated in development or research projects. Regarding knowledge in the SPL Scoping activity, the categorization of the participants is as follows: two of the members have participated in this activity in SPL development projects, two other participants have worked on topics related to the SPL Scoping activity in research projects, and only one has heard or read about SPL Scoping. The roles defined by the CoMeS-SPL method were distributed and assigned by the participants in the workshop considering their knowledge and affinity. Due to the number of participants the roles were combined: the domain expert with the potential client, the marketing expert with the sales staff, the software architect with the technical expert, and the line manager with the company manager.

The workshop was held in a single day and was divided into three sessions, in the first one a training was carried out in the CoMeS-SPL method and in SPL Scoping during 90 minutes. Then, the workshop for applying the method to determine the scope of an SPL of Events Agenda was developed, lasting 220 minutes and finally for 30 minutes the participants completed the survey. The study subjects had two recess spaces (80 minutes total). The participants had access to the applications, and artefacts such as list of characteristics, the models of characteristics that allowed to visualize the common and variable among the three products. It was proposed as a business objective to increase the number of products and address them to other possible types of events, seeking to expand the target market and reduce the delivery time of the product to the customer.

The workshop was held in one of the meeting rooms of the Federal University of Bahia, making use of the walls of the room, the giant size templates were organized to build the artefacts, which allowed to have a common work space for all the equipment and the constant display of information. Each member had the CoMeS-SPL method guide [105] available, the business objectives of the organization, and the artefacts of the three base products. For reasons of time, the analysis was limited to four new possible products that were selected by the participants.

6.4.5 Results and Analysis of Results

Quantitative indicators of collaboration

The data collection of the participation made in each one of the tasks proposed by the CoMeS-SPL method was carried out considering all the tasks and 8 artefacts of the 9 that the method guide proposes, because the quantified product map and the quantified characteristics classification matrix are generated in the same task, only the first of these two artefacts is considered. For this measurement, it was considered that the weight of all the actors, as well as that of the different types of contributions, was the same (W = 1) seeking to observe the contributions in a neutral manner in the different artefacts that were taken into account.

For this case, the number of participation in the specific artefact (CPar) coincides with the duration of the participation in the collaborative task (I), It is also taken into account that the artefacts have the same weight for the scope, so HF_{ar} = CF_{ar}

Figure 7 and Table 6.5 present the values obtained for the quantitative indicators of collaboration corresponding to the artefacts generated in the CoMeS-SPL method workshop. It allows to observe that the tasks where a thinkLet was applied have a greater balance of contributions and a greater factor of collaboration. The tasks with associated thinkLet present a balance of contributions higher than 0.5, which allows to deduce that the actors participated in this task in a very homogeneous way by entering, modifying and classifying characteristics, domains or products.

This workshop allowed the participants to show the importance of the collaboration for the performance of the artefacts, this was valuable, because it became a tangible need, so that in the survey the observations to the tasks matched the historical values of the artefact and the collaboration factor of the artefact, which allowed to identify aspects to be improved in tasks of CoMeS-SPL, such as the writing of the steps and the examples of the artefact in the established metrics task.

Task	ThinkLets	Artefact	CF_{ar}
Initial meeting	Does not apply	Vision of the product line (VPL)	0,37
Identify products	Popcorn-Sort	List of products (LP)	0,78
Identify characteristics	One Page	Feature list (FL)	0,63
Identify functional domains	One Page	Domain description (DD)	0,65
Classify features in functional domains	Dealers-Choice	Feature classification matrix (FCM)	0,81
Specify product map	StrawPoll Concentration	Product map (PM)	0,91
Set metrics	DimSum	List of metrics (LM)	0,67
Quantify product map	CheckMark	Quantified product map (QPM	1
Collaboration factor of SPL activity Scoping (CFar) = 0.63			

Tabla 6.5: Quantitative indicators of collaboration obtained

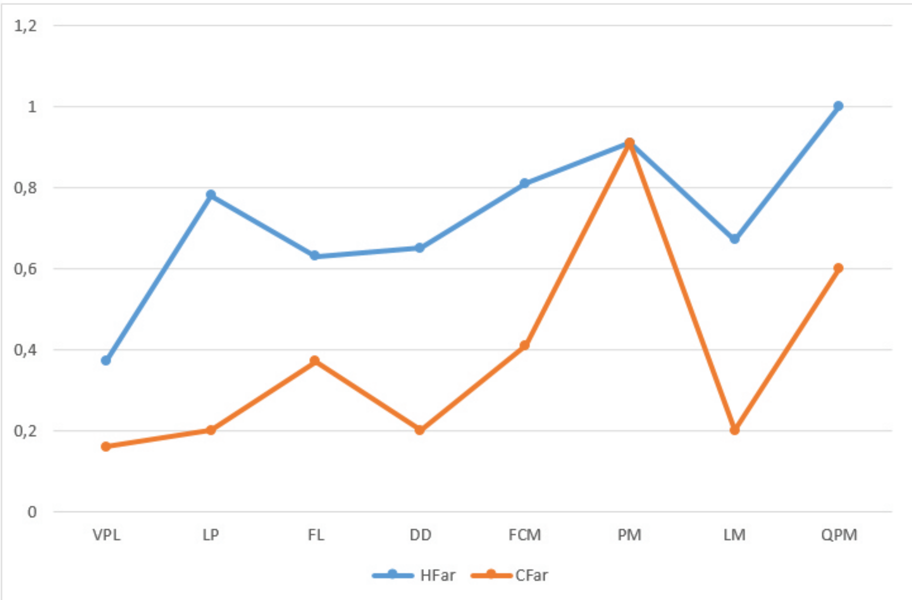

Figure 6.4: Quantitative indicators of obtained collaboration

Acronym	Variable	Median	Standard deviation
PEU	Perceived ease of use	4.72	0.573
PU	Perceived utility	4.1	0,906
ITU	Intention of use	4.54	0,542
CP	Perceived Collaboration	4.95	0,223

Tabla 6.6: Perception variables obtained

Perception variables:

Table 6.6 presents the values obtained for the perception variables obtained, with a range of 1 to 5, where 5 is the highest value that participants could give in their assessment.

Table 6.6 presents the results of the survey applied to the participants at the workshop end, according to the median of the qualifications obtained, it can be stated that CoMeS-SPL is perceived as a collaborative method that encourages participation and cooperation between required roles. It is also perceived as an easy way to use a useful method, and the participants have a high level of intention to use it in the future. When corresponding to indicators of perception, it corresponds to the opinions of the participants in the workshop, and there were no points of comparison to generalize or establish whether the method is useful or easy to use.

Among the suggestions of the participants, one is to use a software tool for the completion of artefacts in a collaborative manner, which reduces the time required to manage the information obtained in the SPL Scoping and facilitates the completion of tasks, automatically transferring the information of an artefact entry to another exit artefact. This empirical study showed that it is necessary to improve the description of some of the tasks of the method, such as the "quantify product map" that belong to the CoMeS-SPL method. The empirical study carried out has some threats to its validity, related to the selection of the participants that was carried out for availability and knowledge in SPL, but not with expertise in other areas of knowledge needed in the SPL Scoping such as marketing, sales, and domain objective. Although the time of the workshop was limited, the authors consider that communication and collaboration practices could be observed during the study.

6.4.6 Conclusions of the evaluation of the CoMeS SPL method by experts in a research context

This empirical study was conducted in an academic environment but unlike the two previous studies, the participants of this study were experts in product lines, most of them knew that it was SPL scoping and had participated in other studies or projects where the scoping of a product line was carried out; This makes this visions and contributions as interesting.

When facing the shortcomings of the method, they made several comments, the first one being printed became a tiring material to consult and manage, making it difficult to see the parallel specification of the steps in the table and the location of the spaces in the artefact template and review the artefact example.

The initial meeting was a challenge for the participants' knowledge because they did not count on experts in other disciplines that would offer different visions as competitors, clients and objective domain. Although the roles were distributed among the participants, there was no time to allow them to prepare the knowledge they required. But this allowed to demonstrate the participating team the importance of the diversity of knowledge that is required to delimit the scope of a line.

Among the artefacts such the list of features, the features/domain matrix and the product map, were inconvenient, since the feature cards had to pass from one artefact to another, which lost the stored information in the prior artefact; Although the team recognized the importance of working face-face on a board as an artefact, they suggested the use of software tools that would facilitate the exchange of data, maintaining the information of the input artefacts and that simplifies the systematization and storage of the artefacts that make up the scope .

The exercise showed some problems with the thinklets selected for some tasks, such as the Identify features and OnePage thinklets task, although the exercise was carried out the number of contributions exceeded the recommended number to handle these thinklets, in addition to using Long time by the team to propose the features. For other thinklets such as those of arranging and voting, it was observed how the group actively participated as expected due to their characteristics.

Another observation was the closure of the scoping activity, which was not clear to some of the participants, so a closing task was improvised, which was added in the next version of the method.

The notation used to specify the version of the CoMeS-SPL method used in this study was a model for the flow of tasks using SPEM, and a textual description of each task (table) however flaws were detected in the description and representation of the collaborative elements that sought to be transmitted.

Also, the study allowed the identification of shortcomings in the description of some elements of the method component, the level of effort required in its execution and some problems in the artefacts obtained when performing them manually using cards.

The differences identified in the number and types of participation required by the artefacts, allows us to conclude the importance of specifying the required roles in each one of the tasks, as well as the importance of indicating in a timely manner the contributions that each participant must give from expertise and role.

Note: In the appendix E, photos of the study are found and used material

6.5 Evaluation of the CoMeS-SPL method: a case study in a software small company

The case study is an empirical method that we use to investigate the Collaborative Method for Scoping Software Product Lines (CoMeS-SPL) in the industrial settings. For the design and implementation of this validation, the case study method proposed by Runeson and Höst was followed [34]. Case studies are by definition conducted in real-world seeking to analyze a phenomenon in a real context, but this is achieved at expense of the level of control. The definition of case study focuses on "studying phenomena in their real context, so the boundary between the phenomenon and its context is unclear" [34]. This study case combined qualitative and quantitative data to achieve a better understanding of the studied phenomenon.

6.5.1 A case study design

Research question

The design of this case study was based on several related research questions. First, the basic research question raised in the project: can a collaborative method achieve the effective participation of stakeholders in determining a range of useful and well-defined scope product lines? Then the case study question is: Can CoMeS achieve an effective participation of stakeholders in the scoping activity building together a useful product line scope in the Sunset company?

Objective
The purpose of this study was to verify the effectiveness of the CoMeS-SPL method in scoping the first software product line of a small software company, as well as to evaluate the utility of the obtained scope.

Indicators and metrics To evaluate the CoMeS-SPL method through the application of a case study, indicators, metrics and instruments that help understand and analyze the proposed method that were considered and designed.

- **Perception of the effectiveness**

  Effectiveness of a scoping method refers to the usefulness of the method outputs in relation to the expectations and needs of the company, and therefore method effectiveness implies that the tasks being performed in the method are adequate to produce the desired results [106]. In order to measure the effectiveness of CoMeS-SPL, three qualitative metrics were considered: perceived ease of use, perceived usefulness and intention to use. To measure these variables after applying the CoMeS approach, it was adapted and used an existing measurement instrument proposed for the evaluation of requirements modeling methods based on perceptions [104] and the Technology Acceptance Model (TAM) [103].

  – **Perceived Ease of Use (PEOU):** The degree to which a person believes that using CoMeS-SPL will be effort-free. This variable represents a perceptual judgment of the effort required to learn and use the CoMeS-SPL (Davis, 1989).

  – **Perceived Usefulness of method (PUM):** The degree to which a person believes that the method CoMeS-SPL was clear, their level of detail and its description facilitated its follow-up, the accomplishment of tasks and acquisition of the required artefacts. The perceived usefulness is a subjective dependent variable, to measure it, instrument supported in the proposals was used: the Evaluation of requirements modeling methods based on user perceptions (Abrahão, et al., 2011), the Technology Acceptance Model (TAM) (Davis, 1989) and The Method Evaluation Model (Moody, 2003) that was done after applying the method.

  – **Intention to Use (ITU):** The extent to which a person intends to use a CoMeS-SPL. This variable represents a perceptual judgment of the method's efficacy that is, whether it is cost-effective, if the participant considers that the method was effective it will have the intention of using it in the next occasion that requires scoping for a product line. This variable is used to predict the likelihood of acceptance of a CoMeS-SPL in practice (Abrahão, et al., 2011).

- **Participation Effectiveness**

The term effective interaction or effective participation is used in the collaboration processes or collaboration methods for naming the collaborative interactions that are made during their execution, instead of supposed comparisons or measuring the effectiveness of the equipment, but it implies some relevant characteristics such as a good social atmosphere, group involvement, and consideration of the other members and of the collaborative process ecology. [107].

The level of the Effectiveness of Participation in a collaborative method can be measured according to the participation degree and the cohesion degree [107]

- **Participation degree (PD):** the intensity with which the individual members participate in the group's activities and their proactive commitment [107].
- **Equal participation degree (EPD):** In an 'effective' collaborative group all members should participate in a similar degree without monopolizing behavior [107].
- **Collaboration Factor (CF):**Describes the level of relative participation of the members of a collaborative activity [102]. It is based on the type and size of contributions or events made to the artefacts that constitute the scope. The contributions are the actions carried out for the diagramming of schemes or joint elaboration of documents, for example insert, modify,

delete, move, classify, etc. The result allows to infer elements of cooperation, such as the evolution of group performance in the time, as well as the effectiveness of the collaboration. Both measures are calculated with respect to the amount of contributions in each task according to the spent time [102].

- **Range of correctness of scope**
  We evaluated the scoping process in terms of the correctness and usefulness of the obtained artefacts.
  - **Perceived Usefulness of Scope Obtained (PUSO):** The degree to which a person believes that Scope defined will be useful in the following activities of the product line development. The perceived usefulness is a subjective dependent variable and to make decisions about the production or not of the product line. To measure this variable after applying the Scoping approaches, it will be used a measurement instrument supported in the proposals: the Evaluation of requirements modelling methods based on user's perceptions (Abrahão, et al., 2011), the Technology Acceptance Model (TAM) (Davis, 1989) and The Method Evaluation Model (Moody, 2003)
  - **Scope Usefulness (SU)** The degree to which the scope is used for making decisions such us SPL adoption or cost estimation.
  - **Range well-defined scope (RWS):** The resultant artefacts of the execution of the method CoMeS-SPL were assessed in terms of the completeness, correspondence with the requested and value of the artefacts for decision making regarding the production of the product line and the next stages of development.

The table 6.7 summarizes the design of the case study proposed to evaluate the proposed method. The instruments used in the case study are found in Annex B.

Selection of the Case Study

To carry out the case study, it was necessary to look for a company with some characteristics, the first being a software production company with a number of employees greater than 10, with specific roles as a marketing and / or sales person, developers, a software architect and with availability for this study.

The basic conditions to address our problem, goal, and research questions are that the company has or looks for a product portfolio for a specific domain and the included products sharing some commonalities. The type of case study according to the research perspective is positivist because it searches to test the hypotheses with respect to the CoMeS SPL. This study is also holistic because the case is studied as a whole. The case study has a unit of analysis that corresponds to the definition scope definition of the first SPL of the company.

6.5.2 Case context: The Sunset company

The case study was conducted within a Colombian company. Sunset Software House S.A.S is a technological solution company, with seven years of experience in the market, dedicated especially to outsourcing services in human talent for software development. It is a small Colombian company with 20 employees located in the city of Popayán. It has a total of 53 projects developed so far. The company is dedicated to:

- Outsourcing in operative capacity in the different phases of the development cycle
- Custom development of web and mobile applications
- Implementation of e-commerce stores and software for project management for MIPyMES

Objective	Indicators	Metrics	Methods for data collection	Instruments
This case study seeks to evaluate how applicable and effective the CoMeS-SPL method is in a real scenario of a software production company, verifying the effective participation of the stakeholders involved and the utility of the scope defined by the company.	Perception of the effectiveness	Perceived Ease of Use (PEOU)	direct	survey
		Perceived Usefulness of method (PUM)	direct	survey
		Intention to Use (ITU)	direct	survey
	Participation Effectiveness	Participation degree (PD)	indirect	Scope artefacts produced
		Equal participation degree (EPD	indirect	Scope artefacts produced
		Collaboration Factor (CF)	independent	Scope artefacts produced
	Range of correctness of scope	Perceived usefulness of scope Obtained (PUSO)	direct	Scope artefacts produced
		Range well-defined scope (RWS)	independent	survey

Tabla 6.7: Parameters of the evaluation case study of the CoMeS-SPL method

Session	Task	Duration
1	Training in Software Product Lines (SPL)	3 hours
2	Training in the CoMeS-SPL Method	3 hours
3	Initial meeting	3 hours
4	Specify Product Portfolio	10 hours
5	Identify Functional domains	2 hours
6	Definition of the assets scoping	
7	Final meeting of the scoping	
Total time		21 hours

Tabla 6.8: Schedule of the case study

6.5.3 Execution of the case study

The company developed a product for the management of employees and projects, and from this product, it developed two more, and the company wanted to organize the development of these products from a common and reusable base, in this context the company considered to define the scope of its potential SPL. In this activity 6 members of the company participated: Manager and Legal Representative, Project manager, Director of innovation, Director of Marketing and Sales, Technology Director, and Analyst and developer. The table presents the times used in scoping tasks 6.8

Lie data collection procedures, this study adopted three data collection methods, namely documentation analysis, observation, and survey. The documents related to the artefacts produced in the scoping were analyzed.

6.5.4 Results of the case study

In this section, the findings of the case study are presented describing the scoping activity performed within the company. The product scoping was performed to identify and review features, identify products, and construct and validate the product map.

The perception metrics defined in the table 6.7 for this study were

Perception of the effectiveness			
Acronym	**Metrics**	**Median**	**Standard deviation**
PEOU	Perceived Ease of Use	5,6	0,48
PUM	Perceived Usefulness of method	5,4	0,5
ITU	Intention to Use	5,7	0,4

Range of correctness of scope			
Acronym	**Metrics**	**Median**	**Standard deviation**
PUSO	Perceived Usefulness of Scope Obtained	5,4	0,64

Participation Effectiveness			
Acronym	**Metrics**	**Median**	**Standard deviation**
CP	collaboration perception	4,2	0,55

Tabla 6.9: Perception Metrics obtained in the survey

evaluated by means of a survey, using a Likert scale of 1 to 6, where 6 indicates the highest value that the participants could assign in their assessment.

The table 6.9 presents the results of the survey applied to the participants according to the average of the grades obtained, allowing us to state that the method CoMeS-SPL was perceived as an easy use, a useful method and that the participants intend to use again in future projects.

The results obtained when applying the method are perceived as useful and the participants considered that they managed to contribute and collaborate in the construction of the line's scope using the CoMeS-SPL method.

The table allows us to observe the results obtained regarding the participation reached in the tasks of the scoping activity, the collaboration factor of each of the tasks are located in the third quartile of the possible values, indicating that a level has been achieved almost homogeneous participation of the participating roles, the variable, and there were no phenomena of hoarding or marginalization of the shares, although there were differences indicating variables called Equal Par-

Task	Artefact	Participation degree (PD)	Equal participation degree (EPD)	Collaboration Factor (CF)
Initial meeting	SPL Profile	75	10,79	0,69
Identify features	List features	1520	66,10	0,73
Identify functional domains	Functional domain list	15	0,76	0,69
Classify features in functional domains	List of categorized features	211	11,29	0,69
all the activity		**1818**	**17,4**	**0,70**

Tabla 6.10: Participation Effectiveness Metrics obtained

ticipation Degree (EPD), you can see the difference of shares, with values manageable and according to the total number of participation, and what is expected in view of the importance of the roles in relation to the performed task.

The survey also included some open questions, and interviews were conducted with the participants during the scoping. Regarding the method and the tasks, they consider that the method facilitates the exchange of ideas, contributions and knowledge, evidencing the importance of the different roles. So much so, that the company considers that the representative of potential clients must be a mandatory role and that it was necessary to improve the results obtained in scoping. The software tool [2] that was used to facilitate the exchange of contributions, the team considered that it helped increase the number of proposals, it facilitated that everyone read the proposals of others and questions and contributions were made. Among the deficiencies, the team considers that it is necessary to first agree on the wording and granularity of the features; the lack of agreements in front of the

[2]Preliminary software tool, an online spreadsheet was used to design a tool that supports the execution of subtasks complying with the specifications of the applied thinklets and obtaining the target artefacts, and exchanging output data as input data between Different artefacts

features increased the time and the effort that required the tasks after the brainstorming of features.

Note: In the appendix F ,photos of the study are found, and used material.

6.5.5 Conclusions and analysis of results of the evaluation of the CoMeS SPL method in a case study

The application of the CoMeS-SPL method in a real case, we faced variables that we could not handle such as the availability of the work team, although the scoping belongs to a project of the company, corresponds to the planning of a project and not to a project in execution. This makes other urgent tasks run the dates of meetings or that some of the participants could not attend; This makes it possible to lose the common thread between one meeting to another, and the group does not remember what step it is in, what activity was being carried out. Although a possible cause is that it is the first time that the company performs the activity of the scoping, also supposes that there must be an element that facilitates the location in the flow of the method, the use of an online tool facilitated if a participant was missing from a meeting, he would then make his contributions and read those from others, however the evidence shows the importance of interacting in a space that fosters osmotic communication and collaboration as well as achieving shared awareness.

This experience was able to demonstrate the importance of the exchange of knowledge between the participating roles, thanks to the fact that in a company different knowledge and roles are really identified, so much so that the same team members stated that the optional roles proposed by the method as the potential customers representative are very important and the lack of the contributions that they had to make was noticeable, so much so that the group considered that it is not an optional role.

The use of a preliminary software tool facilitated the systematization of the obtained information, and production peaks were detected in some of the subtasks as proposing features. However, it is necessary to previously make an agreement on how the features and the degree of granularity will be described to be applied, since in the exercise there were many discrepancies that were reflected in the Analyze features and Concert features sub-tasks, they required more time than estimated. Although the discussions made in these subtasks, reflect a high interaction of the roles, an achievement for a method that seeks collaboration among the participants.

Regarding the types of scope, we consider that the CoMeS method has successfully covered the Product Portfolio Scoping and Domain Scoping, but it is still necessary to improve some aspects of the Asset Scoping related to the estimates of possible efforts, costs and ROI assets, features and products.

6.6 Chapter Summary

The empirical experiences exposed in this chapter were carried out at different stages of the formulation of the CoMeS-SPL method, each experience contributed practical knowledge in its moment and allowed to compare the results and approaches of related works. Empirical experiences were valuable and allow us to experience the maturation that the method was gaining in the different phases of the project.

The studies were carried out by different types of participants, students, experts in lines, and a software production company, giving different visions and points to consider.

SPL scoping is a crucial activity that represents a challenge for companies that have no experience in the development of SPL, and that require guidelines that can be made in concrete steps and in specific and useful artefacts.

The formulation of the CoMeS-SPL method was carried out following the Proposal for the construction of collaborative methods that defined an iterative and incremental cycle, each of the empirical studies carried out corresponds to an evaluation of a version of the method, the findings constituted the starting points for the new versions, indicating the shortcomings to be improved, for which it was necessary to resume the construction cycle of the method. The figure indicates the evolution of the proposed method and the main items considered in each version.

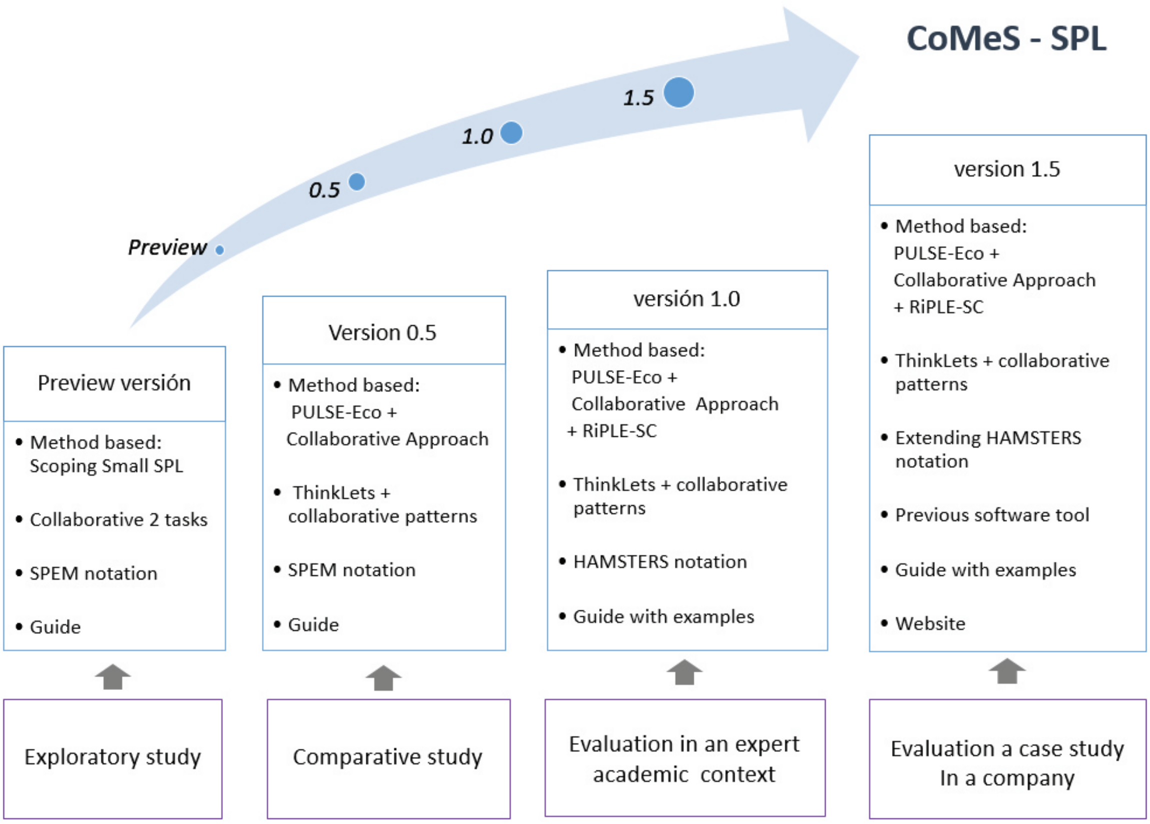

Figure 6.5: Evolution of the CoMeS-SPL method

Chapter 7

Conclusions

"Do not be afraid of perfection. You will never reach it"
Salvador Dali

There are a numerously number of research works for SPL scoping activity, which show the importance of these activities. The focus of these works has been diverse, some aimed at defining the activity itself, the scope types and the process to be followed. Recently, some approaches have aimed in the optimization of the scope of the SPL or in providing tools in order to systematize this activity in organizations or some as it is the case of this work in human, communicative and collaborative factors. It is because the scoping activity is an intensive-human activity, which requires the combination of different knowledge and visions to be able to propose a technically feasible SPL, financially profitable, relevant to the target market and framed within the objectives of the company. Therefore the diversity of participants and strategies that help manage this diversity is necessary and mandatory. This was the challenge that we accept in this research, to consider scoping at the method level, with concreted and followed guidelines that indicated the contribution and participation of each role in the construction of the artefacts that conform the scope of a software product line.

7.1 A Collaborative Method for Scoping SPL - CoMes

The collaborative method for the SPL scoping presented in this research has been designed through the combination of scoping practices using method engineering and collaborative engineering approaches. First, different approaches for scoping previously proposed were studied, considering aspects such as the types of considered scope, the production scenarios and the orientation of each approach. The method engineering allowed us to select the base approaches for formulating a novel method and the identification of the method components. The components of the method were analyzed considering the incidence of the participating roles and the purpose of each component, to select collaborative components (collaboration pattern and thinkLets).

Most of the studied SPL scoping approaches have focused on technical aspects, however they have not clearly and specifically defined roles and responsibilities for the different roles involved in scoping. Although, there is some documentation (guides or guidelines) on how to execute the scoping considering the necessary collaboration among the participants, the availability of this documentation is limited, either because the access to it is not public or because the proposal is focused only on an aspect of the scope. The guidelines of most of the approaches are general, and do not specify how they participate, or how they contribute in each role, or how they are built, or how their level prevent the deduction of concrete steps and actions, this level of description limits the collaboration of the participants and therefore, the usefulness and correctness of the obtained scope may decrease.

In this research, we specify a collaborative scoping method providing a sequence of well-defined collaborative tasks and clear specification of work products, including the description of the different participants and the communication process among them. This work identified the different method components proposed by other researches, complemented the lack of information, and established a concrete set of traceable and structured steps applying some collaborative patterns and thinkLets, in order to encourage diverse and constructive participation. The scoping is present at different stages of the product line engineering process, however at SPL inception the knowledge is scattered in the organization (and external stakeholders), so that the knowledge exchange depends on a reliable communication among the participants. It implies being able to provide information and references, classify it and evaluate it, clear definitions regarding features, domains and products, therefore, a collaborative method tries to provide appropriate guidelines that encourage the knowledge flow.

7.2 Empirical Studies for building CoMeS

In this research a set of empirical experiences was made at different research stages and different contexts, after the execution of each one of the empirical studies, the analysis of the obtained results was made using a set of metrics previously defined (at study design). The metrics were defined in order to evaluate the scope obtained were market feature coverage or its perceived utility. The participation of the roles in the method was evaluated by the collaboration factor reached by the scoping team applying the method. Quantitative and qualitative information allowed the detection of problems and shortcomings to be improved parallel to the conceptual base collected through the study of scoping approaches available in the literature. The heterogeneity of the contexts where the method was applied was one of the advantages in carrying out the analysis, although not all possible contexts were covered, they allowed to consider different aspects and enrich the formulation of the method. It is important to emphasize that there is no "best method that fits all contexts", they all have strengths and weaknesses and are focused on specific aspects of scoping, for this reason, the company must compare and select the most appropriate aspects to its specific context and project.

7.3 Building CoMeS using Collaboration Engineering

Collaborative Engineering is focused on the design of collaborative work practices for relevant recurring tasks, collaborative work practices are applicable in different disciplines including software development, which is more complex when it is based on a planned reuse strategy. The specification of a SPL scoping method designed collaboratively increases the possibility of obtaining more complete and useful results, with respect to an approach that does not integrate aspects of collaborative work. The process to define the combinations of thinkLets (associated with the collaboration patterns) and the components of the scoping method was not easy.

First, the goal of each task was identified and, and eventually divided, in order to associate thinkLets to the respective method component, and recognize other aspects such as the number of participants, inputs and outputs. As empirical studies were made, adjustments on the method were also made considering its results such as time, the artefacts size and the number of interactions. For instance, thinkLets initially selected to be applied in one of the sub-tasks of the method were discarded after some of the empirical experiences to detect that they were not the most appropriate, such the as case of the thinkLet "onepage" applied a sub-task "proposed features", were discarded due to the number of contributions or comments obtained. In this way, the empirical cases allowed to adjust the specification of the CoMeS-SPL as a collaborative method, by observing the dynamics of the groups, as well as the contributions of the thinkLets to more organized communication processes and with a greater number of contributions and doubts. These generation of doubts, far from being considered disadvantageous, was really an advantage because doubts generate spaces for discussion and analysis prior to the scope determination.

Executing the scoping of an SPL following the collaborative method in comparison with other approaches implies additional costs and efforts since they involve more resources in the accomplishment of the tasks. However, the literature has highlighted the benefits that collaborative work has presented in software engineering, and work in scoping approaches in which collaborative elements and the same empirical experiences of this project have been reported have showed beneficial results with respect to the usefulness and correctness of the scope artefacts constructed. So, we consider as a great strategy to follow a collaborative method for SPL scoping, although, it requires more investment because it is necessary the participation of more people and the necessary time to consider their controlled contributions and discussions.

Taking into account all the previous conclusions, it is possible to confirm the defined hypothesis at the beginning of this investigation:

Thesis: The application of a collaborative method for the scoping of SPL encourages the participation of stakeholders through guidelines that provide the required steps, the interaction of the necessary roles in each task, the description and templates of the results, the collaborative method CoMeS has allowed to obtain a useful and well-defined scope regarding the information it should include. Although, executing CoMeS require more resources than previous approaches, it is not significant to consider the benefits at defining adequately the SPL Scope.

7.4 Contributions

The main contributions of this research project are: 1. An umbrella literature review about scoping approaches for software product lines; 2. The specification of a collaborative method for software product lines scoping; 3. The establishment of an approach to design a collaborative method based on method components; and 4. The execution of empirical experiences in both scholar context and industrial settings.

The review on scoping approaches for Software Product Lines. Through this review, thirty-three approaches were identified and analyzed according to the aspects related to our research questions. The analyzed results were used to guide the definition of the SPL scoping method. The results obtained from the review can be used by future researches.

CoMeS-SPL was defined after the review and study of scoping approaches and following guidelines of the engineering method and the engineering of the collaboration. It is defined in a systematic manner, with tasks, inputs, outputs, roles, and guidelines for each component method and combines collaborative patterns and thinkLets, with goals to encourage the effective participation of the roles involved and to improve the definition of the scope of an SPL.

There are guidelines for the definition of methods from method engineering [48], and Kolfschoten's proposal [4] for the design of collaborative processes; in our research, we combine these proposals to define a collaborative method from method components in which collaborative patterns and thinkLets are included.

The empirical experiences carried out in the project provide practical knowledge of the application of the scope in different contexts, it allowed us to examine and contrast the found approaches in the theoretical studies with the obtained results in practice. The made observations and the obtained results not only provided findings that allowed the proposed method to be improved, but also a set of information useful to be considered by future works.

The empirical method here proposed concretely shows how software engineering research as collaborative work could improve the performance of their activities. There are so many activities to be developed collaboratively in software engineering such as requirement engineering, software architecture, software design, testing, integration, among others. All these cases could be addressed by new researches using the approach applied in this research, where method engineering and collaboration engineering has been used in a complementary way.

7.5 Further work

A doctorate thesis is a broad work and does not cover all the possible aspects that it triggers, for which there are items that allow us to continue with the research carried out. In the specific case of this research project, future activities are related to the refinement of the proposed method.

The use of combinations of scoping method components with collaborative patterns and thinkLets was performed assuming general situations and others observed in the empirical experiences. However, it is likely that these situations are not generic, therefore it is necessary to consider elements that allow the company to analyze its own aspects such as the size of the team, the experience, the size of the expected contributions. The most convenient thinkLets combinations could vary according to these factors. As future work, we want to propose additional combinations considering other factors/characteristics, and give place to variability points in order to achieve adaptability to the proposed method.

The proposed method was evaluated in some contexts, however other contexts can be considered as a company with experience in product line development or a long case study including to evaluate the utility of the artefacts obtained across the different stages of the SPLE. Additionally, it would be interesting to have one or more metrics associated with the impact of the collaboration.

One of the observations during the empirical experiences was the need for support tools to help the information management and assist the method execution. During the first experiences, the execution was manually performed by using cards, but it was remarkable that the amount of information managed increased in the exercises while more real elements were heavier, so much that the manual handling reported inconveniences, so much so that an online tool was adapted that facilitated the handling of information and supported some collaborative elements. However, it had many shortcomings and did not provide the necessary support to the collaborative patterns and employed thinkLets.

The last two empirical experiences were related to asset scoping, in the evaluation carried out with experts in SPL, the observations were aimed at improving the description of the task so that its execution was facilitated, then with the company the observations were made with the expectations of the company and the needs to support the definition and planning of a product line with an estimate of efforts and costs, which requires the study of scoping proposals directed towards this direction.

7.6 Publications

As a result of the research work, some publications were made. However, it is still pending to publish the results achieved by the last project stage. The performed papers in this research, including its publication stage, are as follows:

International conferences

- An Exploratory Case Study for Scoping Software Product Lines in a Collaborative Way, Camacho M, Hurtado J, and Álvarez F. Paper presented in 11th International Workshop on Cooperative and Human Aspects of Software Engineering CHASE 18 in the frame of the 40th Conference on Software Engineering ICSE 2018 carried out from May 27 to June 3, 2018 in Gothenburg, Sweden (https://dl.acm.org/citation.cfm?id=3195852)
- Identifying Collaborative Aspects During Software Product Lines Scoping, Camacho M, Hurtado J, and Álvarez F, Paper submitted and accepted in Workshop: Experiences and Empirical Studies on Software Reuse (WEESR 2019), that took place in the 23rd International Systems and Software Product Line Conference (SPLC 2019) held from September 9th to 13th, in the city of Paris, France.

- Dislexpace: Videojuego serio para niños con dislexia (Dislexpace: Serious video game for children with dyslexia) Camacho M, Hurtado J, and Álvarez F, Paper presented in the 1st National Encounter of Technological Innovation for Disability ENITED, held from December 6 to 8, 2017 in Morelia, Michoacán, México; published in the memoirs of event, also selected and published in the book Health, education, culture and innovation technology for disability with ISBN: 978-607-542-048-6.

- Un método colaborativo para determinar el alcance de líneas de productos software (A collaborative method to determine the scope of software product lines), Camacho M, Hurtado J, and Álvarez F, Paper presented at the Doctoral Symposium of the Ibero-American Engineering Conference of Sofware Conference CIbSE 2018 held from April 23 to 27, 2018, in Bogotá.

National conferences

- Toward A domain analysis method for serious video games product lines, Camacho M, and Hurtado J, Paper presented at the doctoral symposium of the 11th Colombian Computer Congress, held from September 20 to 30, 2016 in the city of Popayán.

- Diseñando videojuegos serios para niños con dislexia (Designing serious video games for children with dyslexia), Camacho M, Hurtado J, and Álvarez F, Paper presented in the IV journeys of Computer Human Iteration (HCI), April 23 to 25, 2018 in the city of Popayán.

- A Collaborative Method for a Tangible Software Product Line Scoping, Camacho M, Hurtado J, and Álvarez F, Paper presented at the Workshop on Empirical Experiences and Software Reuse within the framework of the Second International Conference on Applied Informatics ICAI 2018, November 1 to 3 in Bogotá

Website

- https://comesspl.com

  The main objective is to provide the CoMeS-SPL method guide in an easy way to access by interested companies, development groups or researchers, so it has been structured following the flow of the method, and using different forms of specification such as tables and models. In addition, each of the tasks presents the templates of the output work products.

  Additionally, the page seeks to be a means of exchanging opinions and information, facilitating a forum and providing the contact of CoMeS-SPL developers.

  The description of the website is in the appendix B.

Journals
Published:

- An Incremental Method for Visual Analysis of Software Process Models, Camacho M, Hurtado J, and Ruiz P. Paper published in the Revista Gerencia Tecnológica Informática" ISSN 1657-8236, in volume 15 number 43, third edition of 2016.

In evaluation:

- Teamwork Importance in Software Product Lines Scoping, Camacho M, Hurtado J, Álvarez F, and Ruiz P. Paper presented and under evaluation to be published in the Revista IEEE América Latina, ISSN 1548-0992.

- A Collaborative Method for Scoping Software Product Lines, Camacho M, Hurtado J, and Álvarez F. paper presented and under evaluation to be published in the Ingeniare, Revista chilena de ingeniería. ISSN 0718-3291 Print Version and ISSN 0718-3305 Online version

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