An Agile Scoping Process for Software Product Lines

Marcela Balbino¹, Eduardo Santana de Almeida²,³, Silvio Meira¹,³

¹Federal University of Pernambuco (UFPE) – Recife, Pernambuco, Brazil
²Federal University of Bahia (UFBA) – Salvador, Bahia, Brazil
³Reuse in Software Engineering (RiSE) – Recife, Pernambuco, Brazil

Email: {mbsm, srlm}@cin.ufpe.br, esa@rise.com.br

Abstract – The constant changes and the search for new benefits in the software industry make possible the emergence of new research areas. In this context, a trend that has presented important benefits is the area of agile software product lines. Software Product Lines (SPL) and Agile Methods (AM) both search to satisfy the customer, increase quality and decrease time-to-market and costs. The integration between SPL and AM is a challenge, but can increase the benefits that these approaches offer. In this sense, this paper proposes an agile scoping process for SPL.

Keywords – Scoping, Software Product Lines, Software Process.

I. INTRODUCTION

The main aspect for software development processes adoption, with objects or not, is the idea of reuse. The idea is to build software across the use of existing artifacts or knowledge. The implications for decreasing development time and costs and quality increase make the reuse approach highly attractive. In this context, one of the reuse approaches with significantly and increasing success is Software Product Lines (SPL) [5].

In order to obtain success in the SPL development, the planning should be made carefully. The planning performed in the initial phase of software product lines development is called scoping. Product lines scoping is the phase by which information used in software systems development within a domain is identified, captured and organized with the purpose of making it reusable when building new products [2]. The literature has highlighted the importance and benefits of scoping for the product line success [13][14][15][21].

On the other hand, another success practice in industry is agile methods that encourage strong business involvement in development activities, focus only on the requirements at hand with incremental planning and design. Initial evidences based on the results of ongoing research suggest that agile methods are advantageous, given the right context [3][6]. In spite of the differences, when compared to SPL, AM has the same overall objective: improve software development productivity. In this sense, recently, the community started to investigate if these approaches can be combined and how the agile aspects can be integrated in product lines processes for maximizing the benefits searched by product lines and agile methods [7][10][11][18][19][20][24]. However, even with the initial efforts, specific areas have been few explored on this perspective, such as scoping. In this sense, this paper presents a scoping process for SPL based on some agile principles.

II. PROCESS OVERVIEW

For more than one decade, the SPL scoping has been investigated [5][8][13]. However, the studies do not address the issue “how to perform systematic and agile scoping” which starts a new research direction.

The importance of scoping to be systematic in SPL is based on the idea that it should manage variabilities and commonalities among several applications, factor which increases its complexity compared to traditional software development. Thus, in order to develop a SPL is needed systematic scoping to obtain positive results. On the other hand, as SPL scoping is totally defined up-front, it demands high effort and costs. In this sense, introducing agile aspects in SPL scoping enables to add agility for scoping decreasing effort and costs.

In this context, a systematic and agile scoping process with tasks, guidelines, inputs, outputs and well defined roles, incorporating agile practices in their lifecycle is important to decrease the risks related to product lines and decrease the effort and costs up-front.

Based on this scenario, this work presents RiPLE-SC, an agile scoping process for SPL. It is part of the RiPLE (The RiSE Process for Product Line Engineering), project that is being developed within Reuse in Software Engineering (RiSE) Labs¹ to develop a process covering the full SPL lifecycle.

RiPLE-SC is the first discipline of the RiPLE as can be seen in Figure 1 and has a direct relationship with the process of Requirements Engineering (RE), Risks Management (RM) and Evolution Management (EM) from RiPLE.

The RE activities are responsible for refining the scope, thus, the scope definition is a pre-requisite to start the RiPLE-RE which has the Product Map artifact (a matrix of features and products generated by the RiPLE-SC) as a mandatory input. The RM activities are related to the identification and management of the risks related to scoping as well as all the risks identified during the RiPLE execution. If some risk is identified, it is catalogued by the RM and techniques for risk management are applied to mitigate it.

The communication between SC and EM is performed by Change Requests and maintenance tasks in the artifacts created during the scoping phase. If some artifact of SC is incomplete

¹ http://labs.rise.com.br.
or inconsistent and it is discovered in some of the phases of the scoping process, the SC requests a change to EM. The EM analyzes the change and when approved, sends a task to SC.

In the composition of RiPLE-SC, there are phases related to tasks, roles and work products (inputs and outputs). The roles defined in the process are: **scoping expert** - responsible to conduct the scoping process, driving the workshops performed in the process; **customer** - it has critical role in the process and their presence is essential for that the product lines products present their real needs; **domain expert** - provides their knowledge on the domains and the products related to it; **market analyst** - provides knowledge on market analysis and can help in the identification of the domains and products more relevant for a determined market segment; **developer** - important for the assets scoping phase, where they define estimative related to effort; **architect** - responsible to indicate which features will constitute the reference architecture; and **product line manager** - responsible by providing the organizational goals.

Regarding the phases, they are iterative, incremental and clearly integrated with agile aspects, such as: review meetings to obtain customers’ feedback; creation of user stories to obtain the real needs from the customers; pre-scoping meeting to gather the different visions of the stakeholders; and so on. The phases are discussed in details in the next section.

III. PHASES AND GUIDELINES

RiPLE-SC consists of four main phases that are performed in an iterative way to enable frequent feedback: (A) **Pre-Scoping**, (B) **Domain Scoping**, (C) **Product Scoping** and (D) **Assets Scoping**. Besides, we believe that during the achievement of these phases it is very important the use of reflection meetings, meetings that should be performed at regular intervals in order to discuss, what is good, what should be improved and what should be performed to improve, adjusting the behavior of the team adequately.

A. Pre-Scoping

This phase is composed of two tasks: **pre-scoping meeting** and **analyze market**. In it, relevant characteristics that will influence the next stages of the scoping process such as project vision, operational and organizational context, stakeholders and roles, business goal and market potential are identified.

1) Pre-Scoping Meeting

This task has as objective to identify general information related to: customer, team and organization. Moreover, this task aims to provide an initial contact between the customer and the project team and exposes the agenda that will drive the application of the process.

The identification of the information necessary from the customer, project team and organization can be obtained with the use of questionnaires and semi-structured interview that drive the **pre-scoping meeting**. The meeting is conducted by the scoping expert through informal conversation with the stakeholders, factor that encourages the customer collaboration in the project and the collaboration inside the team. The active involvement of the customer and the cooperation among all the stakeholders is essential for the success of agile projects [9]. Besides, the communication face-to-face is considered by the Agile Manifesto as the most efficient and effective method of conveying information in a project team.

Four steps should be performed in the **pre-scoping meeting**: identify organizational context, identify operational context, analyze stakeholders and identify business goals. For performing these steps, the pre-scoping meeting receives as inputs the stakeholders’ information, which are related to information such as “what” are the expectations of the stakeholders for the SPL, “what is the profile of the project team” and in “which” operational and organizational context the project will be inserted; and a **domains list**, an artifact in which are defined the domains that will be analyzed in the product line. As output is produced, the **SPL vision**, where relevant information for the project, identified in the pre-scoping meeting, are documented.

a) Identify Organizational Context

It must capture context aspects of the organization for identifying how the activities performed during the identification of the scope will be influenced. Thus, the following aspects should be considered: **1. structure**, it is an aspect that can influence the planning of meetings and workshops. In the context of small organizations, the execution of an agile approach, i.e., focused on workshops integrated by all the projects stakeholders, makes possible the face-to-face communication, the collaboration among the stakeholders and consequently the decrease of documentation. On the other hand, in complex organizations, dates are harder to find and important experts might miss due to other obligations and sometimes it is not possible that all people meet at the same location [13], thus for mitigating these problems, we recommended the use of different ways such as workshops and individual interviews for communication and coordination; and **2. maturity**, it directly influences the problem understanding and consequently the agility in which the scoping process is performed. The knowledge of both, process and domain is fundamental for the best scoping result. Therefore, the maturity will determine the need for trainings on the process and the investigation of documentation about the domains before performing the scoping process.

b) Identify Operational Context

The operational context has impact on the scoping planning, influencing the overall scoping process [13]. They drive decisions that affect all further scoping tasks. These decisions are exposed in the following aspects: **1. business constraint**, (e.g. time-to-market and resources) can affect the process lifecycle and the detail level of some assets. Furthermore, it influences on the choice of stakeholders, tools...
and in the scope size. In projects where the time and the resources are limited, the team should commit oneself with a smaller scope; and 2, process, the identification of the process used by the organization determines if there is a relationship between it and reuse practices. In cases where the organization presents reuse practices inserted in the current process, the adoption of SPL practices is easier, as well as the understanding of why specifics scoping tasks are performed.

c) Analyze Stakeholders

A stakeholder is someone who has a defined interest in the outcome of the project. In the RiPLE-SC, the choice of the stakeholders and their respective roles is performed according to the profile analysis of each stakeholder in the initial context of the product line.

A product line can start from the scratch, i.e. it can be introduced while some products are already under development, or its core assets can be reengineered from legacy systems. Thus, the initial context influences on the identification of the stakeholders and consequently in the scope definition, because it can present different information sources. In this choice is also considered the maturity of the stakeholders on the domains that will be analyzed in the SPL.

d) Identify Business Goals

In this step, stakeholders’ goals are identified. RiPLE-SC considers that scoping is not only an economical activity, but also a social activity and, therefore, should be defined with the participation of each relevant stakeholder group for the SPL, making possible the identification of different views and business goals. In this sense, there are an arbitrary number of business goals for the product line development. However, according to the study on software reuse measurement based on experts performed by the RiSE Labs, the business goals most considered in organization that adopts practices of product line development. However, according to the study on software reuse measurement based on experts performed by the RiSE Labs, the business goals most considered in organization that adopts practices of product lines are, respectively: reduce costs, improve the productivity, improve the time-to-market, improve the quality, increase the company portfolio and gain new markets.

2) Analyze Market

The systematic research and the analysis of external factors such as market segments and potential determine the success of a domain in the market. It involves the gathering of business intelligence, competitive studies and assessments, market segmentation, customer plans, and the integration of this information into a cohesive business strategy and plan [5]. Thus, the task analyze market aims to obtain information of the market segments in which the domains are inserted for identifying issues that can determine their success in the marketplace.

This task uses as input the domains list that will be analyzed in the product line and the SPL vision, producing as output the business plan. The business plan is a strategic plan that has information about the domains potential in the market, the market segments related, their sales channel and the factors that determine the success of these domains in the marketplace. The market expert performs this task.

B. Domain Scoping

A key question in developing a domain scoping process is: which set of factors can determine the domains and sub-domains of more potential? The answer for this question is to consider dimensions such as: maturity, volatility, market potential, reuse potential, risks, experience, coupling and existing code potential. These dimensions directly impact on the potential of a domain or sub-domain, for example, mature domains make possible easy access to documentation and the existence of reusable code is more probable. In this sense, the domain scoping phase of the RiPLE-SC combines the fundamental aspects for a success domain analysis.

The domain scoping of RiPLE-SC aims to analyze and discuss the domains and sub-domains among the projects members, considering points which aid in the definition of the most relevant ones. Moreover, this phase proposes the knowledge dissemination of the domain and sub-domain among the team, decreasing the need for documentation.

This phase is composed by the task analyze domains, which has as inputs: an already prepared list of domains, the SPL vision, the stakeholders' knowledge, relevant information of each stakeholder about the dimensions discussed, and the business plan. It produces as output: the domains and sub-domains list, which is composed by the domains and sub-domains of more potential for the SPL.

1) Analyze Domains

In the RiPLE-SC, the task analyze domains as well as the other tasks of the process is iterative and incremental. Therefore, in each iteration, new information can be searched and thus evidenced the need of inclusion or exclusion of some domain. For example, it is common that in the definition of the products, new domains are identified and thus an analysis of these domains should be performed. It is possible also that with the prioritization of the features, a domain is considered dispensable and excluded.

The domain analysis of the RiPLE-SC uses the workshops culture in its execution, i.e., all steps of the task analyze domains are performed in the workshops format, mediated by the scoping expert. The workshops are a fundamental resource from agile methodologies for maintaining the integration in a team. Moreover, it allows that the stakeholders of the project discuss several aspects expressing their viewpoints.

The domain analysis workshops proposed in the RiPLE-SC makes possible the communication face-to-face and the collaborative work between business and technical people. It has as goal to identify the domains and sub-domains more relevant for the product line. In addition, this analysis requires a clear understanding of the stakeholders that integrate the workshops of the domains, because the agility can be negatively influenced when the stakeholders do not have experience with them. Thus, before the beginning of the domain analysis, the participants should explore information on the domains that will be analyzed. This information can be obtained from: project plans, user manuals, modeling, data dictionary, existing applications and knowledge from domain experts.

Four steps should be performed in the task analyze domains: review domains, identify sub-domains, analyze sub-domains and prioritize domains and sub-domains. These steps are discussed in the next sections.

a) Review Domains

In this step, the objective is to discuss general characteristics of the domains, making possible to align the knowledge of the stakeholders regarding them. The review of
each domain is performed in pre-determined timeboxes. The timeboxes are time interval which cannot be exceeded. With them is possible to limit the time of the analysis and maintain the focus on the workshop. In the review, the stakeholders should express their understanding on the domains, enabling them to identify new domains, exclude existent ones or maintain the initial set of domains.

b) Identify Sub-Domains

A domain can be composed by a big number of systems. Furthermore, the identification of “what” is in and out in a given domain depends on the vision of specialists and stakeholders in general, because each one has their particular interests. Thus, the division of the domains in technical sub-areas (sub-domains) makes possible a deepened analysis of each individual area of the domain, facilitating the choice of the areas where the reuse is adequate and where the economical potential is most suitable.

The sub-domains definition is performed in brainstorming sessions. These brainstorming sessions provide an opportunity for the stakeholders, together, gather information about their needs and expectations regarding to key sub-domains that are of particular concern to them. In this step, it is important also that the team is aligned with the customer’ needs and the product line as whole. Thus, the knowledge of domain experts and market experts is determinant to drive the team in the choice of which sub-domains are more relevant for SPL and their customers.

c) Analyze Sub-Domains

In this step, each sub-domain is individually discussed by the stakeholders concerning the relevant dimensions previously defined for the analysis. Thus, considering the different visions of the stakeholders, a conclusion about each dimension evaluated in each sub-domain is performed. The following dimensions are considered in the analysis: 1. experience, it indicates the level of knowledge that the participants of the workshop have on the sub-domain; 2. risks, they are identified and analyzed to determine the negative impact on the sub-domain. In the analysis, the risks are prioritized according to the perceptions of the team about their severity; 3. volatility, it determines if the sub-domain changes with the time; 4. maturity, it determines if the sub-domain is stable; 5. code potential, the code existence facilitates the understanding of the sub-domain and aids in the development; 6. market potential, it identifies which sub-domains can obtain greater economical return in the market segments; 7. reuse potential, it determines the possibility of the sub-domains to compose a generic reuse infrastructure; and 8. coupling, it identifies if the sub-domains can be dealt in an independent way. The dimensions considered in the evaluation of the sub-domains were defined with base on relevant aspects identified in [21].

d) Prioritize Sub-Domains

The prioritization is performed based on the results obtained in the sub-domains analysis, the business goals and considerations made by the customers in the task of pre-scoping meeting.

This step is performed by different stakeholders and is possible that the different viewpoints result in conflicts. Thus, it is recommendable an initial search for common interests and the negotiation of the divergent ones. In this case, discussion sessions moderated by the scoping expert can be made, enabling the alignment of the interests for all the team. With these sessions is constructed the final list of domains and sub-domains more relevant for the product line.

C. Product Scoping

In today’s competitive business environment, it is extremely important to offer for customers exactly the products that they want. SPL has the potential to enable companies to offer a large variety of products while still being able to manage the complexity caused by this increased number of products. In this sense, the product scoping phase aims to define the product portfolio that optimally satisfies customer demands, characteristic of highest priority in agile process, where the customers’ role is critical [22] and at the same time restricts the number of products offered.

In this phase, the products and features associated with them are identified and evaluated with respect to their potential for introduction in the product line. In this identification and evaluation, the market analysis as well as the real needs of the customers are considered.

In order to define the product scoping, five tasks should be performed: construct user stories, identify features, features review meeting, identify products, construct product map and validate product map.

1) Construct User Stories

In a product line started from scratch or in its evolution, the utilization of user stories as basis for identification of customers’ needs and consequently features of product is very important. It is well known the fact that customers have difficulties of expressing their expectations before using the final product [23]. Thus, user stories should be used in these cases, because in our vision this is the most natural way for customers express their needs. However, in cases where is necessary to construct a product line of pre-existents products, i.e. in cases of reengineering, the construction of user stories is unusual, and the features are identified from the analysis of documents associated to products or through the code.

RiPLE-SC defines user stories as brief descriptions on how customers will use the system [9]. The stories present short names, business value and are written in a short way or graphical description.

Each story can be written in index cards because they are relatively small, easy to move and order [9]. If there is the need to report the progress to others parts of the organization in a traditional format, electronic media can be used.

2) Identify Features

The goal of this task is to determine the features which will be present in the further products of the SPL. It is performed across a workshop whose collaborative participation of the team is essential. This workshop should be moderated by the scoping expert, and all participants are expected to be fully engaged. During the workshop is possible to identify and discuss several issues with base on different perspectives. In this sense, different views of the stakeholders will be confronted and analyzed enabling a better scoping result.

For identifying the features, RiPLE-SC uses as base: 1. user stories, in this case an evaluation of the user stories by representative stakeholders is essential to determine if the stories are feasible and complete, and thus to identify potential
features for the product line and create competitive products; and/or 2. the abstraction of the previous knowledge obtained from e.g. books, user manuals, design documents and code.

In the RiPLE-SC process, functional and non-functional features are considered. The functional features are related to aspects as “what” the system has to do. The non-functional features are associated with quality attributes, which the products should address. These attributes will serve as architectural drivers for the product line and present impact on the product line architecture. Therefore, the identification of non-functional features is of extreme relevance for the architecture of the product line.

3) Feature Review Meeting
The feature review meeting is related to feature evaluation and negotiation between the organization (domain expert and marketer) and customers. Domain experts and market experts are indicated for this task because they have high knowledge of the domains, and also know potential market segments and their needs. In this context, it is possible to obtain the customer’s feedback enabling them to evaluate the work performed and define if the releases are aligned to their real needs. With the review meeting, new features can be included, excluded or reprioritized in the list.

4) Identify Products
The task identify products has as objective to find appropriated products for the product line. This task receives as inputs the market experts’ knowledge, the SPL vision, the features list and the business plan. The output of this task is a list that presents the products of more potential for the SPL.

The choice of products for a product line is critical for the organizations, because the market is competitive and requires products diversity, factor that can have negative consequences, such as; increase of costs, complexity and time-to-market, causing decrease of benefits for the product line [12]. Thus, in this choice it is highly important to consider a set of products aligned with the goals of the organization and needs of a specific group of customers or market segment.

5) Construct Product Map
After the identification of the products and their features, these are organized in a product map. In this map, columns and rows are used to represent products and features, respectively. Moreover, in this map, each column is composed of two other columns; the first indicates if the feature is a possible further feature of the product; the second indicates if the feature is required in the product. Thus, it is possible to determine which features will integrate or not each product. In addition, in the product map, each feature is related to a scope as follows: mandatory, features that are required by all members of the product line; optional, features that are part of some products, i.e., can or cannot be selected by the SPL products; or out of scoping, features that are part of only one product.

6) Validate Product Map
The product map validation is performed in meetings with the participation of customers, domain experts and market experts. These meetings have as objectives: 1. identify if any feature was forgotten or allocated improperly in some product; and 2. verify the scope defined for the features.

With this task, the product map is consolidated enabling the choice of the assets that will integrate the reuse infrastructure for the SPL.

D. Assets Scoping
The goal of the assets scoping is to determine the appropriate features that should be built for reuse. Thus, the assets scoping establishes the reusability of features relevant for the development of the reference architecture. This phase is based on a quantitative analysis of the benefits of making the feature reusable. In this sense, our process determines the definition of metrics for measuring the benefits that specific feature has for the product line. It aims to optimize the product line according to specific benefits.

It is well known that projects have different visions from different stakeholders and that benefits can differ according to the business goals of them. In this context, we consider Goal Question Metric (GQM) [4] as a way for deriving metrics based on different business goals expected by the stakeholders. The choice of performing assets scoping focused on GQM was influenced by the study performed in [1], where ten experts were surveyed regard some factors related to software reuse measurement and was identified that GQM is the most utilized method for reuse measurement.

This phase is composed by the tasks: create metrics, apply metrics and prioritize product map, as next described.

1) Create Metrics
The metrics creation involves two well-defined steps: refine and operationalize business goals, develop benefit and characterization metrics.

a) Refine and Operationalize Business Goals
This task initiates with the step refine and operationalize business goals. Initially, the goals, prior produced in the pre-scoping phase, are analyzed and refined. The refinement is made because in the phase of pre-scoping, the goals are identified generically. Thus, the goals are refined according to their relevance for the customers, organization and domains.

After the refinement, it is performed the operationalization of the goals according to four distinct levels: goal, question, characterization metrics and benefits metrics. The operationalization flow starts with the goal level, where the optimized description of the goal is performed following the schema that has the form of <Purpose><Issue><Object><Context>, such as Minimize the effort needed for the development of new applications from the viewpoint of software engineers in the company.

In the question level, additional aspects are elicited and the goal is defined more precisely. After the aspects have been elicited, the goal is expressed in characterization metrics that will be used in the benefits metrics. The characterization and benefit metrics are next detailed.

b) Develop Benefit and Characterization Metrics
The characterization metrics are used for identifying the need of a specific feature to integrate a product in the product line. The benefit metrics describe the potential of introducing a specific feature into reuse infrastructure considering a defined business goal.

2) Apply Metrics
In this task, the benefit and characterization metrics are applied for the product map in two steps: apply characterization metrics and apply benefit metrics.
a) Apply Characterization Metrics

In general, this task is performed by the stakeholders who provided the different goals, e.g., the developer can be useful to estimate effort, while the architect can help in the definition of which are the impacts of some features in the reuse infrastructure.

b) Apply Benefit Metrics

After the application of the characterization metrics, the benefits of the assets for the product line are evaluated. In this step, the metrics are applied based on the goals previously considered.

3) Prioritize Product Map

After assigning the values for the benefit metrics, the task prioritize product map is performed. In this task, the features with more potential for the product line are selected.

The product map prioritization is performed in a meeting which involves the customer, manager, marketer and domain expert, where considerations and negotiations are performed.

As RIPLE-SC is intended to satisfy the customer’s real needs, their feedback is indispensable for definition of the SPL scope. Thus, the base to perform the prioritization of the product map is the customers’ need.

IV. RELATED WORK

In [21], we performed a systematic review on scoping approaches for SPL, where relevant approaches were analyzed and clustered. Therefore, in this section, we will make a brief discussion about the main related work.

Helferich et al. [8] focus on Product Portfolio Planning (PPP) based on Quality Function Deployment. Their work demonstrates how QFD-PPP can be used to identify different customer groups and their needs, derive systematically product portfolio (i.e. members of a product line) and derive common and variable product functions.

The scoping customization is inserted in [13]. This work highlights that scoping should be customized for concrete situation and activities, because representative stakeholders, artifacts and execution time for the tasks can change according to several factors, such as: resources, organizations factors, etc.

In the context of agile product lines, one approach proposes agile scoping [24], where the goal is to define a product map, i.e. a matrix that relates products and features using active participation and collaboration among the project stakeholders. During the approach, tasks of Collaboration Engineering and practices of AM are used in parallel.

In our work, we defined a systematic agile scoping process for SPL making possible the incremental scope definition and agility, favoring the up-front costs and effort decrease.

V. CONCLUSIONS

During the last decade, several efforts were conducted to achieve effective ways of dealing with the software industry competitive needs. In this context, Agile Product Line Engineering (APLE) is a new research area that aims to join the benefits of product lines and agile methods and which was motivated by the need to rapidly deliver high quality software that meets the changing needs of stakeholders.

In this paper, we explored this combination in the scoping phase. Scoping is the first activity to start a software product line and is considered key for its success. It aims to decide which features are in and out in the product line. We believe that our work can be used as important base to develop the next generation of scoping approaches covering agile issues. As future work, we intend to evaluate our process in an industrial case study in the medical domain.

ACKNOWLEDGEMENT

This work was partially supported by the National Institute of Science and Technology for Software Engineering (INES), funded by CNPq and FACEPE, grants 573964/2008-4 and APQ-1037-1.03/08. CNPq grants 305968/2010-6, 559997/2010-8, 474766/2010-1 and FAPESB grant 783/2010.

REFERENCES