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The use of software product lines for business process management: A systematic literature review

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ABSTRACT

Context: Business Process Management (BPM) is a potential domain in which Software Product Line (PL) can be successfully applied. Including the support of Service-oriented Architecture (SOA), BPM and PL may help companies achieve strategic alignment between business and IT.
Objective: Presenting the results of a study undertaken to seek and assess PL approaches for BPM through a Systematic Literature Review (SLR). Moreover, identifying the existence of dynamic PL approaches for BPM.
Method: A SLR was conducted with four research questions formulated to evaluate PL approaches for BPM.
Results: 63 papers were selected as primary studies according to the criteria established. From these primary studies, only 15 papers address the specific dynamic aspects in the context evaluated. Moreover, it was found that PLs only partially address the BPM lifecycle since the last business process phase is not a current concern on the found approaches.
Conclusions: The found PL approaches for BPM only cover partially the BPM lifecycle, not taking into account the last phase which restarts the lifecycle. Moreover, no wide dynamic PL proposal was found for BPM, but only the treatment of specific dynamic aspects. The results indicate that PL approaches for BPM are still at an early stage and gaining maturity.

Contents

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1. Introduction

The current complexity of the corporate world has required dynamism from the Information Technology (IT) infrastructure in order to provide technical solutions to conduct business [1–3]. In this context, Business Process Management (BPM) [4,5], Service-oriented Architecture (SOA) [6,7] and Software Product Line (SPL, or simply PL) [8,9] may provide technical and systematic support to improve the competitive edge of organizations [10]. If used together, they could help companies achieve the expected strategic alignment between business and IT [11,12].

BPM support the lifecycle of business processes by involving different parties which act cooperatively and seek to achieve common business goals [4,5]. The activities include the definition, execution, monitoring, control, analysis, and improvement of business processes [4,13]. As for SOA, it addresses the integration of different applications through the provision and consumption of electronic services (e-services), providing the exchange of services considering an interorganizational scope; in SOA, software is broken down into services running distributed in a network [6,7].

BPM and SOA, when used together [14], can help in achieving the strategic alignment between business related areas and IT [15], which is important to synchronize IT resources and efforts with the key strategic business objectives of an organization [11,12]. Whereas, in BPM, the focus is on managing the business processes that align the different organization activities in cross-flows [13]; on the other hand, SOA provides a modern and flexible platform capable of providing support to those processes through a combination of structured IT resources based on the service-orientation paradigm [7].

So that BPM and SOA can fulfill their role in the organizational environment, a systematic approach is desirable to provide quality and productivity increases [14,15]. In terms of systematization, PL can be applied given that analysts and engineers have successfully used PL concepts in various application domains [8,9]. PL exploits software reuse for developing a family of products with reduced time to the market and with improved quality, including in the BPM and SOA contexts [10]. BPM is one of the potential domains in which PL concepts can be successfully applied [16].

Dynamic PLs (DPLs) are a specific type of PL [17]. A DPL produces software that can adapt to changes in order to meet user needs, taking into account resource constraints [18]. DPL have been efficiently providing a way to handle product changes at runtime within the general context of PL [19]. Although DPLs are built around the central idea of a typical PL, there are important differences between them [18]. More specific than general PLs, DPLs can be applied to the BPM domain in order to meet the dynamism requirements of IT infrastructure such as stated by Tallon [1], Overby et al. [2] and Lee et al. [3].

Aiming to contribute to this research area, an extensive Systematic Literature Review (SLR) was conducted on the existing research works presenting PL and BPM joint implementation approaches, including the SOA support for BPM. Considering the flexibility needs inherent to the BPM domain, special attention was given to the application of DPL concepts into such a domain. Therefore, the main objective of this paper is to present the results of this investigation conducted so that researchers interested in this area may have a broader picture of it and some important questions may be answered.

The remainder of this paper is structured as follows: Section 2 presents the basic concepts related to BPM and PL; Section 3 presents some works similar to the SLR presented here; Section 4 presents the methodology applied to conduct this SLR; Sections 5 and 6 present, respectively, the review results and the discussion of the results; Section 7 presents a discussion of the validity threats considered for this SLR; and, Section 8 presents the conclusion of this paper.

2. Background

In this section, the basic concepts related to BPM (Section 2.1) and to PL (Section 2.2), which are used in the rest of the paper, are presented.

2.1. Business process management

BPM (Business Process Management) has been presented as a key factor to the success of an IT infrastructure prepared for today's organizational demands [15]. Moreover, BPM is seen as a competitive edge for the organizations, as with it they can determine and exhibit their maturity level [16].

According to van der Aalst et al. [4], BPM includes methods, techniques, and tools to support the design, enactment, management, and analysis of operational business processes. BPM can therefore be considered an extension of classical Workflow Management approaches and systems [4]. Several specification and modeling languages and tools have been proposed to be used in BPM, from which the BPMN (Business Process Model and Notation) language [20] has become the 'de facto' standard language to represent business processes. Nevertheless, other languages such as UML Activity Diagrams have also been used for modeling business processes [21,22].

A business process consists of a set of tasks performed in a specific sequence to achieve a common business goal [13,23]. The BPM lifecycle includes several phases, such as [4,5]: (a) business process modeling; (b) business process model instantiation; (c) business process enactment and administration; (d) business process monitoring and auditing; and, (e) business process assessment and optimization. In the last phase, the execution history can be analyzed, looking for ways to improve the business process, which leads to business process remodeling, restarting the cycle all over again [13]. Considering the markets' current dynamics, each sequence in such lifecycle is usually completed in a very short time, due to the constant need for new versions of the business processes running in the organizations [24].

In order to make the management and integration of business processes possible, from a technical point of view, different technologies have been proposed, including, not so recently, the middleware frameworks such as CORBA, DCOM and Java-RMI [25], which were properly used in the intra-organizational context. As the need for interoperability has evolved towards interorganizational cooperation, the existing solutions failed to meet their objec-

Table 1
Comparison of related systematic literature reviews.

SLR work	Year	Context	Period	Data sources[a]	# of screened works/primary studies	Quality assessment of primary studies
Khurum and Gorschek [31]	2009	Domain analysis for PL	1998–2007	1/2/3/4	843/89	No well-defined evaluation criteria applied
Alves et al. [32]	2010	Requirements engineering for PL	1995–2009	1/2/5/6	77/49	Evaluation criteria proposed by Dybå and Dingsøyr [33,34]
Engström and Runeson [35]	2011	Testing for PL	2001–2008	4/7/specific venues	177/64	No evaluation criteria applied
Chen and Ali Babar [36]	2011	Variability management for PL	1990–2008	1/2/3/4/5/8/9	628/97	Based on evaluation criteria proposed by Dybå and Dingsøyr [33,34]
González et al. [37]	2010	Measurement in BPM	2001–2008	1/2/5/6/8/10	308/17	Based on SMO model [38], specific for "software metrics" domain
Houy et al. [39]	2010	Empirical research in BPM	1992–2008	4/11 [only journals]	1,260/355	Based on a framework defined by the authors, specific for their context
Niehaves and Plattfaut [40]	2011	Collaborative BPM	1999–2009	4/specific venues	150/39	No evaluation criteria applied
This SLR	2013	PL for BPM	2003–2012	1/2/3/4/5/9/10	3,649/63	Based on evaluation criteria proposed by Dybå and Dingsøyr [33,34]

[a] 1: IEEE Xplore; 2: ACM DL; 3: Engineering Village (Compendex); 4: ISI Web of Science; 5: ScienceDirect; 6: Wiley Inter Science Journal; 7: Google Scholar; 8: Citeseer; 9: Springerlink; 10: Scopus; 11: Business Source Premier (EBSCO).

tives [25]. Such limitation was finally resolved when SOA and their implementations emerged [26], mainly through the web services technology, offering new perspectives to this need and providing, for example, the composition of e-services through WS-BPEL (Web Services Business Process Execution Language) [27] to enable the execution of business processes.

2.2. Software product line

PL (Product Line) is a set of software-intensive systems that share a common, managed set of properties satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way [8]. Different PL approaches proposed in literature share a set of core concepts [9], although slightly different among them. The key concepts usually presented in PLs are [8,9]: Domain Engineering, Application Engineering, PL Architecture and Variability Management. Also according to presented by Clements and Northrop [8] and Pohl et al. [9], there is a vast set of other concepts used to support PLs – as a complete Software Engineering approach – which are not focused in this work.

The systematic PL Engineering has two processes – Domain Engineering and Application Engineering – with both using the PL Architecture as the base artifact [9]. The PL Architecture is one of the most important artifacts of a PL, representing its core infrastructure [8]; in essence, it represents the configurations of modules and components that satisfy a given set of selected features, and provides ideas for reuse opportunities [28]. Variabilities are tangible differences between products that can be revealed and distributed among PL artifacts [29], including the architecture, components, and interfaces between them. Variations can be revealed at any step during development, starting with the requirements analysis, and therefore need to be well managed [9]. Feature Modeling is one of the most used techniques for Variability Management in different PLs [30].

Specific types of PL, the DPLs (Dynamic PLs) produce software that can adapt to changes to meet user needs, considering resource constraints [17,18]. DPL has been identified as a promising strategy to address the design and implementation of changes that need to be carried out at run-time in new areas of application [19]. Although DPLs are built based on the central idea of a typical PL, there are differences between them, since DPLs have many of the following properties [18]: (a) dynamic variability – configuration and binding at runtime; (b) changes that bind several times during its lifetime; (c) variation points change during runtime; (d) deals with unexpected changes, in a limited manner; (e) deals with changes by users, such as functional or quality requirements; (f) context awareness and situation awareness; (g) autonomic or self-adaptive properties; (h) automatic decision making; and, (i) individual environment/context situation instead of a "market".

3. Related work

Despite the existence of joint works in the areas of PL and BPM, no previous systematic investigation of the works jointly covering these two areas has been identified. On the other hand, in terms of the overall scope of PL or BPM, there are some studies that have to some degree analyzed different specific aspects of both research areas – individually. Table 1 presents a comparative summary of seven relevant SLRs conducted in the PL area or the BPM area,[1] including this one presented in this paper.

According to information in column "Context" of Table 1, the first four SLRs presented are related exclusively to some aspect of PL [31,32,35,36] whereas the subsequent three other ones are exclusively related to some aspect of BPM [37,39,40]. In the last line of Table 1, information regarding the SLR covered in this paper is also presented, whose context, unlike all the other seven presented in this table, is exploring PL and BPM in conjunction.

All the seven related SLRs, presented in Table 1, were published between the years 2009 and 2011. With respect to the period in which those SLRs have found and reported the primary studies, they range from eight to 19 years, with an average of 13 years; whereas this SLR found and is reporting primary studies for a 10-year period. Most of the related SLRs presented, as well as this SLR, have not forced a cut in any specific year to establish the initial year of these periods, but left the cut came up naturally in function of the returns of the searches performed.

In terms of data sources used in searching works candidate for primary studies, the seven related SLRs diverged considerably in both: the number of data sources used and the choices of which data source to use. As presented in column "Data sources", they

[1] The following criteria was used to chose such relevant SLRs for comparison: papers undoubtedly related to BPM or PL, referring to a SLR, mandatorily published in journals (i.e. disregarding papers published in conference proceedings, for not being considered extensive enough SLRs), related to the Computing or Business areas, and cited at least five times in the last 3 years according to Scopus. The string used for this search through Scopus website was: (TITLE ("business process*" OR "product line*") AND TITLE-ABS-KEY ("systematic review" OR "systematic literature review")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (SUBJAREA, "COMP") OR LIMIT-TO (SUBJAREA, "BUSI"))

ranged from one to seven different data sources, with an average of four. Each SLR explain theis own choices as part of their methodological procedures. Specifically for this SLR, a set of seven data sources was chosen in order to maximize the chances of identifying relevant candidate works to be selected as primary studies.

Another difference among those related SLRs is on the number of candidate papers that they identified from the data sources and the final number of primary studies considered after screening the candidate papers. Both numbers are presented for each related SLR in column "# of screened works/primary studies". These variations may be related to, for example: contextual differences in each specific investigation area; differences in the data sources used; and differences in usage of keywords (which are not explored in this comparison, since they are too specific for each related SLR). Specifically for this SLR, the high number of screened works is a result of the large number of data sources used in combination with generic keywords, whereas the final number of primary studies is similar to the other related SLRs; details of this search strategy are presented in the Methodology section.

Considering the quality assessment, although this is an important part of SLRs according to the experts [41,42], not all related SLRs showed clearly how this evaluation was conducted. For two of them (SLRs conducted by Engström and Runeson [35] and Niehaves and Plattfaut [40]), no mention was made regarding to possible criteria used to assess quality of the primary studies; whereas for another one (SLR conducted by Khurum and Gorschek [31]), only some general considerations were done regarding quality assessment. For the SLRs conducted by González et al. [37] and Houy et al. [39], their authors used classification models specific for their contexts in order to ensure that only quality primary studies were selected, although no specific criteria for assessing quality were applied. Only the SLRs conducted by Alves et al. [32] and Chen and Ali Babar [36] used specific criteria for quality evaluation of the selected primary studies; both of them based on the evaluation criteria proposed by Dybå and Dingsøyr [33,34], the same used by this SLR.

As a summary of the purpose of those seven related SLRs, we highlight:

- Khurum and Gorschek [31]: the goal of this review was to analyze the proposed solutions of domain analysis for PL, considering their level of industrial application and/or empirical validation with the purpose of mapping maturity in terms of industrial application, as well as to what extent proposed solutions might have been evaluated in terms of usability and usefulness.
- Alves et al. [32]: the goal of this review was to analyze the requirements engineering within PL, focusing on the assessment of research quality, the synthesis of evidences to suggest important implications for practice, and the identification of research trends, open problems, and areas for improvement.
- Engström and Runeson [35]: the goal of this review was to survey existing research on PL testing in order to identify useful approaches – in terms of focus, research type and contribution type – and needs for future research.
- Chen and Ali Babar [36]: the goal of this review was to analyze the status of evaluation of reported variability management approaches in PLs and to synthesize the available evidence about the effects of the reported approaches.
- González et al. [37]: the goal of this review was to analyze the current state of the art and trends with regard to proposed approaches for measurements or metrics in the BPM area, through a classification of the approaches found in the selected primary studies.
- Houy et al. [39]: the goal of this review was to provide a survey of the development of empirical research in BPM, through a study of trends in empirical BPM research and an application of methodologies by means of a developed framework in order to identify the status quo and to assess the probable future development of this research field.
- Niehaves and Plattfaut [40]: the goal of this review was to analyze the status quo with regards to BPM and collaboration and to show potential fields of future research in the area of collaborative BPM.

All the seven works presented in this section are examples of SLRs related exclusively either to the PL area or to the BPM area, but none for both together. Therefore, aiming at covering what could be considered a gap, this paper presents the results of a SLR directly related to the application of PL in the BPM domain.

4. Methodology

A SLR (Systematic Literature Review) is a means of identifying, evaluating, and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest [42]. Individual studies contributing to a SLR are called primary studies; a SLR is a form of secondary study. A SLR differs from traditional reviews (such as simple literature reviews) and surveys with comments made by domain experts because a replicable, scientific, and transparent approach is used to avoid bias [41].

To conduct this SLR, the guidelines proposed by Kitchenham [42] were used. According to these guidelines, a SLR includes several steps, which can be grouped into three main phases: (i) planning the SLR; (ii) conducting the SLR; and, (iii) reporting the SLR. Details of the review planning and review conduction are described in Sections 4.1 and 4.2, respectively, as follows. The review results are presented in Section 5.

4.1. Systematic literature review planning

The following steps are included in planning the SLR [42]: (i) identification of the need for a SLR; (ii) commissioning a SLR; (iii) specifying the research questions; (iv) developing a SLR protocol; and, (v) evaluating the SLR protocol. In the following steps (i), (iii) and (iv) are detailed, since they are considered the main and mandatory steps of the SLR planning.

4.1.1. Need for a systematic literature review

The authors of this study are one of the several research groups developing works in the PL for BPM area; hence they were interested in evaluating the primary studies published in this area. Considering that no SLR had thus far been published for this purpose, these authors deemed important and useful undertaking such a SLR and consequently share it with other potentially interested researchers. Thus, other research groups can start their work from this review, saving research time and resources to focus on proposals and evaluations of new approaches, using the existing works as a basis. The SLR was chosen for this research due to its methodological benefits, as it maximizes the possibility of recovering complete data sets, minimizing bias possibility.

4.1.2. Research questions

Assuming the need for a SLR, a set of research questions was specifically defined for this work. They are mostly related to discovering how PL and BPM are interrelated in general existing approaches, called here "PL approaches for BPM", aiming at a comprehensive understanding of this joint research area. The main interest of this study is to identify and assess those works proposing some type of PL approach, which can include methods, tools and techniques, specifically applied to the BPM domain.

Q1. Which phases of the BPM lifecycle are addressed when PL is applied to such a domain?

The purpose of this question is to identify which phases of the BPM lifecycle have actually been addressed in the BPM domain, especially when reuse systematization and improvement based on PL concepts are sought. For this question, the following phases of the BPM lifecycle were considered: Design & Analysis; Configuration; Enactment; and, Evaluation – according to the taxonomy proposed by Weske [13]. The Weske's model for BPM lifecycle was used as a reference here due to its completeness; although there are others as complete as this one, only one was chosen for sake of simplicity of the process. Through a preliminary analysis, the following hypothesis was formulated:

Hypothesis 1. "Only the first two phases, 'Design & Analysis' and 'Configuration', are considered in the works singled out"; taking into account that the BPM lifecycle is too wide-ranging to have been completely covered by the PL approaches for BPM proposed in this emerging area.

Q2. Which PL concepts are applied to the BPM domain?

Inversely to question Q1, the purpose of this question is to identify which key PL concepts have been actually applied to BPM when reuse systematization and improvement are sought in the BPM domain. For this question, the following concepts related to PL were considered: Domain Engineering, Application Engineering, PL Architecture, Variability Management and Feature Modeling [8,9]. These six concepts were used in this work since they can be considered the most representative in PL, i.e., they usually appear in most works involving PL, as presented, for example, by Clements and Northrop [8], Pohl et al. [9]. Although there are other concepts related to PL, they are not so representative to be used in this research question because they explore items more specific in PLs. Through a preliminary analysis, no previous hypothesis was formulated for this specific question.

Q2.1. Are there DPL concepts being applied to the BPM domain?

Complementing question Q2, the purpose of this question is to identify whether there are, among the existing PL approaches for BPM, DPL concepts being applied to the BPM domain considering the dynamic properties for PLs presented by Hallsteinsen et al. [18]: (a) dynamic variability – configuration and binding at runtime; (b) changes that bind several times during its lifetime; (c) variation points change during runtime; (d) deals with unexpected changes, in a limited manner; (e) deals with changes by users, such as functional or quality requirements; (f) context awareness and situation awareness; (g) autonomic or self-adaptive properties; (h) automatic decision making; and, (i) individual environment/context situation instead of a "market". The investigation of this question is important for this context, taking into account that organizational environments currently using BPM require flexible and dynamic solutions [1–3], which could be provided by applying DPL in such a domain. Based on the results of a preliminary mapping work to characterize DPLs conducted by Burégio et al. [19], whose results reported that no DPL approach for BPM had been identified so far and, considering the rather short time that has elapsed since that work was conducted, the following hypothesis was formulated for this research question:

Hypothesis 2. "Concepts specifically related to DPL are not yet being applied to the PL approaches for BPM or they are being applied in a very limited degree"; since BPM is a very specific PL domain and the properties proposed by Hallsteinsen et al. [18] to define DPL, although important in the PL context for BPM, can be still considered advanced taking into account the current state of this area.

Q3. Are the existing PL approaches for BPM all SOA-based approaches, with regards to the technology for application integration and process enactment?

A complementary research question is assessing to what degree BPM and SOA [6,7] are used in conjunction when PL is applied to the BPM domain. Currently, SOA and web services have been presented as the most effective solutions to enable process enactment by integrating applications in an interorganizational context [25]. On the other hand, several SOA-based PL (SOAPL) approaches have also been presented to address the specific issues related to software development [43]. Based on such so intrinsic BPM-SOA relationship, the following hypothesis was formulated for this research question:

Hypothesis 3. "The vast majority of PL approaches for BPM, if not all, are SOA-based"; since SOA has become the main type of paradigm used for this purpose, and web services the main type of technology [7].

Q4. Which are the limitations of PL approaches for BPM?

In addition to conceptually assessing the existing PL approaches for BPM, expected in all the previous research questions, a quality evaluation of these works is also important [42]. For this purpose, the evaluation criteria proposed by Dybå and Dingsøyr [33,34] were used in this SLR. These criteria are formed by 11 attributes grouped in four issues: "Reporting", "Rigor", "Credibility" and "Relevance". There are alternative evaluation models with similar purpose to these criteria, such as those proposed by Ivarsson and Gorschek [44]; nonetheless, the Dybå and Dingsøyr's criteria were chosen because they were considered, at same time, reasonably simple to ensure an agile quality assessment and complete enough to cover a basic set of attributes needed for the assessment. In addition, these criteria have been rather used as the basis of quality assessments of other SLRs, including two of the related works [32,36] presented in Section 3. Through a preliminary analysis, the following hypothesis was formulated for this question:

Hypothesis 4. "Considering this as an area still emerging, only a small number of PL approaches for BPM should be well assessed according to the criteria proposed by Dybå and Dingsøyr [33,34] in terms of reporting, rigor, credibility and relevance issues".

4.1.3. Systematic literature review protocol

According to Kitchenham [42], a SLR protocol specifies the methods that will be used to undertake a specific review. Moreover, a pre-defined protocol is essential to reduce the possibility of research bias; it describes how to search and select relevant primary studies and analyze the data extracted to answer the predefined research questions. The main components of a SLR protocol include the definition of: (i) data sources; (ii) search strategy; (iii) primary study selection strategy; (iv) extraction method; and, (v) data summary.

A software tool was used to support the SLR of the protocol definition. The tool, called StArt (State of the Art through Systematic Reviews) [45], is used to provide support to researchers conducting SLRs. StArt has been used by graduate students who have reported positive support and some benefits over other tools.

A. Data sources and search strategy

The following data sources were chosen to be used here in this SLR: Scopus,[2] ISI Web of Science (WoS),[3] IEEE Xplore,[4] ACM Digital

[2] http://www.scopus.com.
[3] http://apps.webofknowledge.com.
[4] http://ieeexplore.ieee.org.

Table 2
Search string.

((“product*[a] line*” **OR** “product* famil*”[b] **OR** PL **OR** SPL **OR** SPLE[c] **OR** SPF[d]) **AND** (BPM* **OR** (process* **AND** software*) **OR** (process* **AND** business*) **OR** workflow*))[e] **OR** (“process line*”[f]) **OR** (“process famil*”)

[a] Minor variations such as singular and plural forms should be considered. The same applies to the other “*” signals in this search string.
[b] Product Family: a commonly used synonym for Product Line [8,9].
[c] SPLE: initialism for Software Product Line Engineering.
[d] SPF: initialism for Software Product Family.
[e] The complete forms “business process management” and “business process” were not used since they would be more restrictive than the word “process” already used together with “business”.
[f] After some initial exploratory searches, it was noted that for some PL approaches for BPM the expression “process line“ was being used, which was then included in this string search. The same applies to the expression “process family”.

Library (ACM DL),[5] SpringerLink,[6], ScienceDirect[7] and Engineering Village.[8] Seven different data sources were used in order to maximize the number of candidate works to be located: the greater the number of different data sources used, the greater the chance of obtaining all existing related works, since there is no unique data source that indexes all existing papers at once [46]. Comparing to the data sources used by those related SLRs presented in Section 3, the data sources used here can be considered appropriate. Whereas those SLRs used an average of four data sources each one, this SLR used seven. In addition, from the 11 different data sources used by them, the five most used were also used here.

For the search strategy, the search string shown in Table 2 was built using keywords derived from the aforementioned research questions, connected through the logical connectives AND and OR. Complementing the large numbers of data sources chosen, this search string was elaborated also seeking to maximize the number of candidate works to be located for this SLR. Thus, we attempted to use a broad range of options (among words, expressions and initialisms) to widely represent both the PL side and the BPM side, besides also covering the direct union between PL and BPM (with, for example, “process line”).

Since it is not possible to use a single string for all the seven data sources, the base search string shown in Table 2 had to be adjusted in order to be directly applied to the search engines of each one of the used data sources. Table 3 present the search strings modified to fit the characteristics of each one of these engines. These adjusted search strings have already embedded some additional restrictions, as part of this SLR protocol (as explained as follows in the Inclusion and Exclusion criteria), whenever the specific search engines for each data source allowed to do it, in order to perform a prefilter to discard applicable records for this SLR.

The search was applied by the first time at the end of 2011 and reapplied in early 2013; a very few specific recent works published in 2013 were not considered since only works regarding to complete years were considered in this study scope, i.e., until 2012.

B. Primary study selection strategy

A set of inclusion and exclusion criteria was specified based on the analysis scope and the quality of found papers to guarantee that only works really related to the context of PL approaches for BPM should be selected as the primary studies of this SLR. A study, identified after applying the search string, is selected as primary study if it meets all the predefined inclusion criteria; but it is eliminated if it meets any of the predefined exclusion criteria. Considering the objectives of this SLR, as well as its respective identified research questions, the following criteria were defined:

(B.1) *Inclusion criteria:*

IC-1 The paper actually addresses PL, i.e., PL is directly related to the main scope of the work rather than PL terms merely mentioned in a generalized manner in the paper.
IC-2 The paper actually addresses BPM (including workflow), i.e., BPM and/or workflow are directly related to the main scope of the work rather than BPM/workflow terms merely mentioned in a generalized manner in the paper.
IC-3 Both PL and BPM are treated together in the paper to present a PL approach for BPM rather than each one of them being treated independently in the paper.

(B.2) *Exclusion criteria:*

EC-1 The paper is not electronically available on web.
EC-2 The paper is not presented entirely in the English language.
EC-3 The paper is not related primarily to the Software Engineering or Information Systems fields (for example, the paper is related to Artificial Intelligence field of Computer Science, or even other areas such as Medicine or Industrial Engineering and Manufacturing).
EC-4 The data register identified after applying the search string does not actually refer to a scientific paper, but to some non-peer reviewed publication, such as: technical reports; books and book chapters; proceedings’ prefaces; and journal’s editorials.
EC-5 The paper addresses workflows, but the focus is on scientific workflow and not on business workflow.
EC-6 The paper addresses processes, but the focus is on software processes, or software development processes, and not on business processes.
EC-7 The paper addresses exclusively PL for SOA (SOAPL) without focusing on BPM aspects.
EC-8 The paper presents some type of review, such as a survey or some SLR (i.e., a secondary study), and not the outcomes of some specific research work (i.e., a primary study).

4.2. Systematic literature review conduction

This section presents the main steps to conduct the SLR. They are grouped into two principal steps: (i) identification and selection of primary studies as well as the quality assessment of the primary studies; and, (ii) data extraction and synthesis of the primary studies.

4.2.1. Identification, selection, and quality assessment of primary studies

Identification and selection of primary studies were based on the strategy proposed by Chen and Ali Babar [36], which consists of three steps as shown in Fig. 1 and described as follows.

- *Step 1. Identifying relevant primary studies on search databases*: to identify candidate primary studies, the specific search strings for each one of the seven defined data sources (Table 3) were applied to the respective search engines. The searches returned 3649 registers, considering the sum of the seven data sources and eliminating duplicate results. This can be considered a large number, resulting from the strategy to maximize chances of finding candidate works as explained in the SLR planning.
- *Step 2. Applying the inclusion and exclusion criteria*: in this step, each data register returned and identified as a candidate to be a primary study was analyzed for inclusion or exclusion based on the predefined criteria (as defined in Section 4.1.3). The

[5] http://dl.acm.org/.
[6] http://link.springer.com/.
[7] http://www.sciencedirect.com/.
[8] http://www.engineeringvillage.com/.

Table 3
Search strings specific for each data source.

Data source	Specific search string
Scopus	TITLE-ABS-KEY (((“product* line*” OR “product* famil*” OR pl OR spl OR sple OR spf) AND (bpm* OR (process* AND software*) OR (process* AND business*) OR workflow*)) OR (“process famil*”) OR (“process line*”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (SRCTYPE, “j”) OR LIMIT-TO (SRCTYPE, “p”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “cp”) OR LIMIT-TO (DOCTYPE, “ip”)) AND (LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “COMP”) OR LIMIT-TO (SUBJAREA, “BUSI”)) AND (EXCLUDE (PUBYEAR, 2013))
ISI Web of Science	((TS = ((“product* line*” OR “product* famil*” OR PL OR SPL OR SPLE OR SPF) AND (BPM* OR (process* AND software*) OR (process* AND business*) OR workflow*) OR (“process famil*”) OR (“process line*”)))) AND Language = (English) AND Document Types = (Article OR Proceedings Paper); Refined by: Research Areas = (COMPUTER SCIENCE OR ENGINEERING OR BUSINESS ECONOMICS); Timespan = 1900-01-01–2012-12–31. Databases = SCI-EXPANDED, CPCI-S.
IEEE Xplore	(((“product line” OR “product lines” OR “product family” OR “product families” OR “production line” OR “production lines” OR “production family” OR “production families” OR PL OR SPL OR SPLE OR SPF) AND (BPM* OR (process* AND software*) OR (process* AND business) OR workflow*)) OR (“process family”) OR (“process families”) OR (“process line”) OR (“process lines”)); Content Type: Conference Publications, Journals & Magazines, Early Access Articles; Publication Year: 1955–2012
ACM Digital Library	((Abstract:“product* line*” OR Abstract:“product* famil*” OR Abstract:PL OR Abstract:SPL OR Abstract:SPLE OR Abstract:SPF) AND (Abstract:BPM* OR (Abstract:process* AND Abstract:software*) OR (Abstract:process* AND Abstract:business*) OR Abstract:workflow*)) OR (Abstract:“process famil*”) OR (Abstract:“process line*”)
SpringerLink	‘((“product* line*” OR “product* famil*” OR PL OR SPL OR SPLE OR SPF) AND (BPM* OR (process* AND software*) OR (process* AND business*) OR workflow*)) OR (“process famil*”) OR (“process line*”)’; within English, 1996–2012
ScienceDirect	pub-date >1822 and pub-date <2013 and TITLE-ABS-KEY ((((“product* line*” OR “product* famil*” OR PL OR SPL OR SPLE OR SPF) AND (BPM* OR (process* AND software*) OR (process* AND business*) OR workflow*)) OR (“process famil*”) OR (“process line*”)) [All Sources (Business, Management and Accounting,Computer Science,Engineering)]
Engineering Village	Compendex, GEOBASE & Referex for 1969–2012: ((((“product line” OR “product family” OR “product lines” OR “product families” OR “production line” OR “production family” OR “production lines” OR “production families” OR PL OR SPL OR SPLE OR SPF) AND ((process* AND software*) OR (process* AND business*) OR BPM* OR workflow*)) OR (“process family”) OR (“process line”) OR (“process families”) OR (“process lines”)) WN KY)

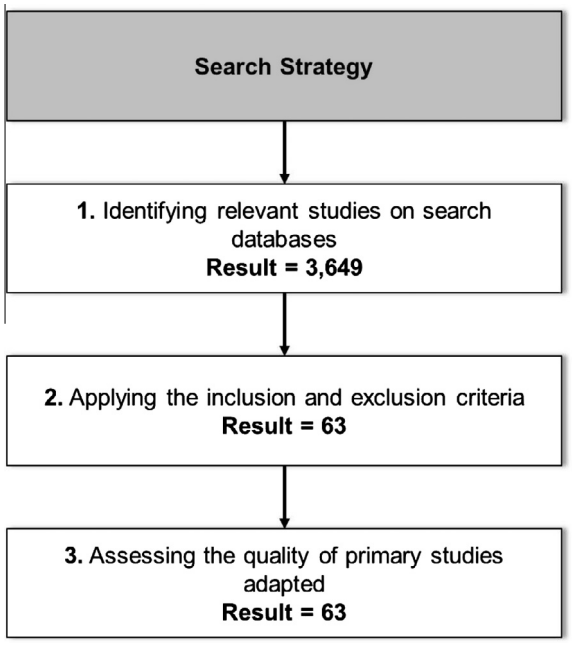

Fig. 1. Primary studies selection process [36].

inclusion and exclusion criteria were applied based on a thorough reading and analysis of at least the title, abstract and keywords of the respective paper. To provide more reliability to the result, when it was not completely clear if the paper should be included or excluded only with this first reading, the introduction and conclusion sections were also considered in the reading and analysis. The reading and analysis work were done mainly by the first author of this paper, aided by the second author in the first trial tasks. The second author, considered the most experienced of the group, addressed issues about the inclusion or exclusion of certain registers when necessary. As a result of applying the inclusion and exclusion criteria, out of the 3649 initial candidate registers, only 63 primary studies were selected, considered the primary studies for this SLR.

- *Step 3. Assessing the quality of primary studies*: this step is considered critical and mandatory to assess the quality of primary studies for [42]: (i) providing more detailed inclusion/exclusion criteria; (ii) investigating whether quality differences provide an explanation for the differences found in the study results; (iii) as a means of weighting the importance of individual studies when the results are synthesized; (iv) guiding the interpretation of findings and determine the strength of inferences; (v) guiding recommendations for further research. Specifically for this systematical review, the primary studies were only classified so that the quality level could be known as intended by the Research Question number 4 (stated in Section 4.1.2); however, no further exclusion was done, as proposed by the Chen and Ali Babar [36]. The procedure to this classification is better described in next section (Section 4.2.2).

Table 4 show a summary of the 63 primary studies, resulting from the Step 2 described above. The data show that 52 primary studies were published in events – 11 in workshops and 41 in conferences (including symposiums), whereas 11 of them were published in journals.

Considering that, from the 63 primary studies, some of them have similar groups of authors, an additional analysis was performed to identify groups of papers that are related to a same work. As a result, of the 63 primary studies originally identified, 33 independent works were recognized, after a more in-depth analysis of papers with common authors, as shown in Table 5. These data are presented here only to help understand the works

Table 4
Final list of primary studies.

Year	Workshop (ID/Ref.)		Conference (ID/Ref.)		Journal (ID/Ref.)	
2012	W01	Barat and Kulkarni [47]	C01	Boffoli et al. [49]	J01	Barat and Kulkarni [53]
	W02	Boffoli et al. [48]	C02	Khoshnevis [50]	J02	Gröner et al. [54]
			C03	Ognjanovic et al. [51]		
			C04	Zhang et al. [52]		
2011	W03	Kulkarni [55]	C05	Abu-Matar and Gomaa [59]	J03	Boskovic et al. [68]
	W04	Kulkarni and Barat [56]	C06	Abu-Matar and Gomaa [60]	J04	Kulkarni and Barat [69]
	W05	Machado et al. [57]	C07	Alférez and Pelechano [61]	J05	Gonçalves et al. [70]
	W06	Siy et al. [58]	C08	Alférez and Pelechano [62]	J06	Park et al. [71]
			C09	Boskovic et al. [63]		
			C10	Mohabbati et al. [64]		
			C11	Nguyen et al. [65]		
			C12	Park and Yeom [66]		
			C13	Gröner et al.[67]		
2010	W07	Leitner and Kreiner [72]	C14	Barat and Kulkarni [74]	J07	Marchione et al. [81]
	W08	Kulkarni [73]	C15	Donko and Sabeta [75]	J08	Sun et al. [82]
			C16	Nguyen and Colman [76]		
			C17	Rolland and Nurcan [77]		
			C18	Medeiros et al. [78]		
			C19	Park et al. [79]		
			C20	Reuter [80]		
2009	W09	Asadi et al. [83]	C21	Xu et al. [84]		
			C22	Marchione et al. [85]		
			C23	Park et al. [86]		
2008			C24	Gimenes et al. [87]	J09	Zaupa et al. [94]
			C25	Adam and Doerr [88]	J10	Fantinato et al. [95]
			C26	Moon et al. [89]	J11	Karam et al. [96]
			C27	Montero et al. [90]		
			C28	Montero et al. [91]		
			C29	Razavian and Khosravi [92]		
			C30	Kim and Doh [93]		
2007			C31	Bae and Kang [97]		
			C32	Ye et al. [98]		
			C33	Fantinato et al. [99]		
			C34	Schnieders and Weske [100]		
			C35	Chang and Kim [101]		
2006	W10	Altintas and Cetin [102]	C36	Fantinato et al. [104]		
	W11	Schulz-Hofen and Golega [103]	C37	Fantinato et al. [105]		
			C38	Bayer et al. [106]		
			C39	Kulkarni and Reddy [107]		
2005			C40	Keuler et al. [108]		
2004						
2003			C41	Gimenes et al. [109]		

Table 5
Paper groups singled out.

Group ID	Paper ID(s)	Group ID	Paper ID(s)
G01	W01, W03, W04, W08, C14, C39, J01, J04	G17	C15
G02	C22, C24, C33, C36, C37, J05, J07, J10	G18	C17
G03	C12, C19, C23, C26, C32, J06	G19	C18
G04.A	W09, C03, C09, C10, J03	G20	C20
G04.B	C13, J02	G21	C21
G05	C05, C06	G22	C25
G06	C07, C08	G23	C29
G07	W02, C01	G24	C30
G08	C27, C28	G25	C31
G09	C11, C16	G26	C34
G10	W05	G27	C35
G11	W06	G28	C38
G12	W07	G29	C40
G13	W10	G30	C41
G14	W11	G31	J08
G15	C02	G32	J09
G16	C04	G33	J11

singled out and to facilitate further analysis of the area, while other data are presented and evaluated based on the previously 63 identified primary studies.

4.2.2. Data extraction and synthesis

During this stage, all primary studies underwent more in-depth readings, going beyond their introduction and conclusion sections, mainly seeking to answer the research questions specified (as presented in Section 4.1.2). Moreover, during such a detailed reading and analysis, the application of exclusion criteria could be refined in some cases. Specifically for data extraction, a form was used to capture relevant information from the primary studies, in order to answer the research questions. A set of common attributes was used, in such a form, to extract data from each primary study; these attributes were: publishing vehicle (workshop, conference, or journal); title; and, author (s). Besides theses common attributes, a series of other specific attributes was also used during the paper analysis and form filling in; these specific attributes were used to extract data taking into account each one of the different research questions, for which specific extraction strategies were also established as described in the following.

Q1. Which phases of the BPM lifecycle are addressed when PL is applied to such a domain?

In order to evaluate question Q1, four attributes for data extraction were determined based on the BPM lifecycle as defined by Weske [13]. Table 6 presents such attributes including brief

Table 6
Attributes for data extraction related to research question Q1.

ID	Attribute	Description
Q1.1	Design & Analysis	Are the activities related to Business Process Design (Process Identification and Modeling) or Business Process Analysis (Process Validation, Simulation and Verification) explicitly addressed in the approach covered by the primary study?
Q1.2	Configuration	Are the activities related to Business Process Configuration (System Selection, Process Implementation, Process Testing, and Process Deployment) – whose goal is the inclusion of technical information to allow the execution of processes – explicitly addressed in the approach covered by the primary study?
Q1.3	Enactment	Are the activities related to Business Process Enactment (including Operation, Monitoring, and Maintenance) – whose main objective is the creation of process instances for execution and the administration support – explicitly addressed in the approach covered by the primary study?
Q1.4	Evaluation	Are the activities related to Business Process Evaluation (including Process Mining and Business Activity Monitoring) – whose main objective is searching for process optimization culminating in the process remodeling – explicitly addressed in the approach covered by the primary study?

descriptions. Each primary study could be classified from one to four according to these attributes.

Q2. Which PL concepts are applied to BPM?

Q2.1. Are there DPL approaches applied to BPM?

In order to evaluate question Q2, and its sub-question Q2.1, six attributes for data extraction were determined based on the core PL concepts [8,9] and the DPL defintion [18]. Table 7 presents such attributes, also including brief descriptions. Similar to the previous category, each primary study could be classified from one to six according to these attributes.

Q3. Are the existing PL approaches for BPM all SOA-based approaches, with regards to the technology for application integration and process enactment?

In order to evaluate question Q3, four simple attributes for data extraction were defined to categorize the primary studies in terms of the type of technology used to support application integration and process enactment, which can be SOA-based or not. Table 8 presents such attributes, also including brief descriptions. Unlike the two previous categories, each primary study should be classified into only one of these four attributes.

Table 7
Attributes for data extraction related to research question Q2.

ID	Attribute	Description
Q2.1	Domain Engineering	Are the Domain Engineering concepts explicitly applied to the approach addressed in the primary study?
Q2.2	Application Engineering	Are the Application Engineering concepts explicitly applied to the approach addressed in the primary study?
Q2.3	PL Architecture	Are the PL Architecture concepts explicitly applied to the approach addressed in the primary study?
Q2.4	Variability Management	Are the Variability Management concepts explicitly applied to the approach addressed in the primary study?
Q2.5	Feature Modeling	Are the Feature Modeling concepts, used as a specific type of variability management, explicitly applied to the approach addressed in the primary study?
Q2.6	DPL	Are the DPL concepts, according to the dynamic properties for PLs presented by [18], explicitly applied to the approach addressed in the primary study?

Table 8
Attributes for data extraction related to research question Q3.

ID	Attribute	Description
Q3.1	SOA (Generic)	The SOA paradigm, in a generic manner, is seen as a support for the PL approach for BPM, which is presented in the primary study
Q3.2	SOA (Web Service)	The SOA paradigm, specifically in terms of web services technology, is seen as a support for the PL approach for BPM, which is presented in the primary study
Q3.3	Other	Any other approach than the SOA paradigm is seen as a support for the PL approach for BPM, which is presented in the primary study
Q3.4	Not informed	No mention in done regarding the type of support for the PL approach for BPM, which is presented in the primary study, in terms of technology for application integration and process enactment

Q4. Which are the limitations of PL approaches for BPM?

In order to evaluate question Q4, 11 attributes for data extraction were used to categorize the primary studies in terms of their quality, as proposed by Dybå and Dingsøyr [33,34]. Table 9 presents the attributes, which are grouped into four issues types – "Reporting", "Rigor", "Credibility" and "Relevance" – to systematize the analysis of such attributes as described as follows [34]:

- *Reporting* issue: attributes related to the "Reporting" issue (attributes Q4.1, Q4.2 and Q4.3) are concerned with the quality of the information being reported in terms of a study's rationale, aims, and context;
- *Rigor* issue: attributes related to the "Rigor" issue (attributes Q4.4, Q4.5, Q4.6, Q4.7 and Q4.8) are concerned with the accuracy of the research methods employed to establish the validity of data collection tools and the analysis methods, and hence the trustworthiness of the findings;
- *Credibility* issue: attributes related to the "Credibility" issue (attributes Q4.9 and Q4.10) are concerned with the trustworthiness of the study methods used for ensuring that the findings were valid and meaningful;
- *Relevance* issue: the attribute related to the "Relevance" issue (attribute Q4.11) is concerned with the assessment of the importance of the study for the software industry at large and the research community.

Table 9
Attributes for data extraction related to research question Q4 (proposed by Dybå and Dingsøyr [33,34]).

ID	Question	Issue
Q4.1	Is the primary study based on research (or merely a "lessons learned" report based on expert opinion)?	Reporting
Q4.2	Is there a clear statement of the research goals?	Reporting
Q4.3	Is there an adequate description of the context in which the research was carried out?	Reporting
Q4.4	Was the research design appropriate to address the research goals?	Rigor
Q4.5	Was the recruitment strategy appropriate for the research goals?	Rigor
Q4.6	Was there a control group to compare the treatments?	Rigor
Q4.7	Was the data collected in such a way that it addressed the research issue?	Rigor
Q4.8	Was the data analysis sufficiently rigorous?	Rigor
Q4.9	Was the relationship between researcher and participants adequately considered?	Credibility
Q4.10	Is there a clear statement of the findings?	Credibility
Q4.11	Is the study of value for research or practice?	Relevance

Using a spreadsheet, the data extraction form was built considering all the attributes presented in the previous four classifications. For the data synthesis, meta-analysis is a reasonably common technique for SLRs [42]. However, synthesizing the data from qualitative research can be rather challenging [36]. As a result, to summarize the data of this SLR, descriptive statistic techniques were chosen, such as, for example, the use of graphics, tabular description, and parametric description (average). The data extraction and synthesis processes were documented using the spreadsheet and the results are presented in the next section (Section 5).

5. Results

This section presents the results produced by conducting this SLR according to the protocol presented in the Section 4. Table 10 shows the temporal distribution of the primary studies (from 2003 to 2012), separated by publication type – workshop, conference and journal. It is noteworthy that only 17% were published in journals; and, of the total, 57% were published in the last 3 years, in a period of 10 years. Fig. 2 presents a visual summary of these results, considering the total of publications by year, regardless the publication type.

An additional analysis was performed for the specific event or journal in which each primary study was published, looking for the existence of vehicles that, due to their nature, could be publishing a greater number of works related to the PL for BPM area. However, according to the data presented in Fig. 3, there is no important standard identified for workshops, conferences or journals. In fact, primary studies are for the most part published and distributed in different events and journals – 40 primary studies (which represent 63% of them) are published in 40 different vehicles. Even for the other 23 primary studies, there is no important standard to be highlighted: they are distributed by other nine vehicles, with two or three papers per vehicle. The unique exception is the SPLC conference, considered the most representative conference for the PL area, for which four papers published were identified. On the other hand, for the BPM conference, considered the most representative conference for the BPM area, only one paper was identified. The definitions of the initialisms and acronyms shown in Fig. 3 are shown in Table A.16 (Appendix).

An analysis of the primary studies produced the classifications shown in Tables 11–13, Tables 14. Each one presents the primary studies classified in terms of one of the four classification schemes established, considering the attributes defined in Section 4.2.2 for the research questions Q1, Q2, Q3 and Q4 (Tables 6–9).

The following sections show the structured results specifically related to the responses of the research questions.

Table 10
Summary of primary studies by publication type and by publication year.

Venue	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Workshop	–	–	–	2	–	–	1	2	4	2
Conference	1	–	1	4	5	7	3	7	9	4
Journal	–	–	–	–	–	3	–	2	4	2
Total	1	0	1	6	5	10	4	11	17	8

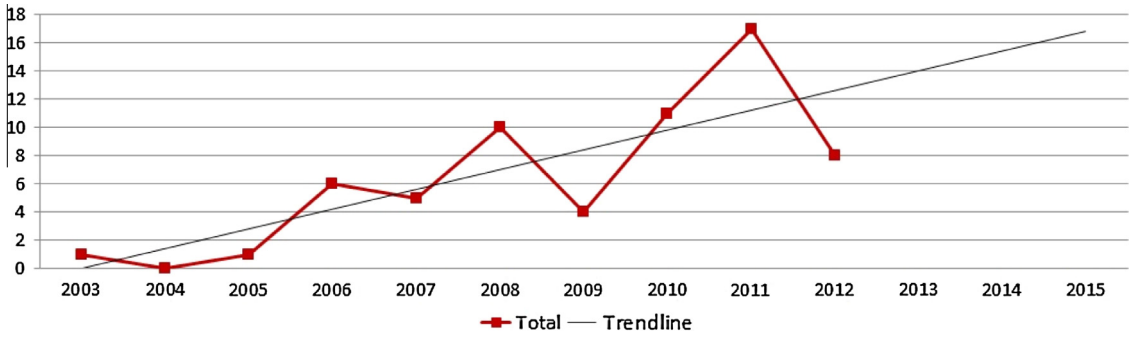

Fig. 2. Distribution of primary studies by publication year.

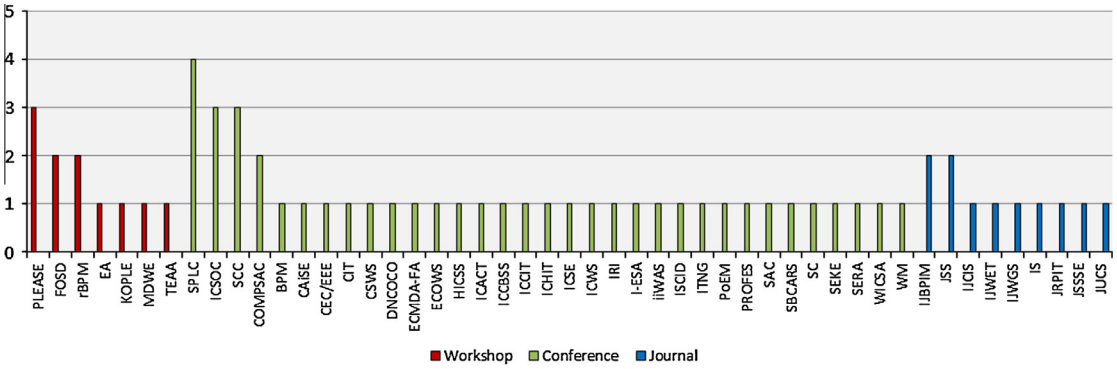

Fig. 3. Distribution of primary studies by specific event or journal.

Table 11
Classification of research question Q1.

Att.	Primary studies
Q1.1	• W01, W02, W03, W04, W05, W06, W07, W08, W09, W10, W11 • C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41 • J01, J02, J03, J04, J05, J06, J07, J08, J09, J10, J11
Q1.2	• W01, W03, W04, W06, W07, W08, W09, W11 • C04, C07, C08, C09, C10, C11, C12, C13, C14, C16, C18, C19, C20, C21, C22, C23, C24, C25, C27, C30, C31, C32, C33, C36, C37, C38, C39, C40, C41 • J01, J03, J04, J05, J07, J09, J10
Q1.3	• W06, W07, W11 • C11, C21, C22, C24, C27, C31, C32, C33, C36, C37, C38, C39, C40, C41 • J05, J07, J09, J10
Q1.4	None

Table 12
Classification of research question Q2.

Att.	Primary studies
Q2.1	• W06, W07, W09, W11 • C02, C07, C08, C09, C10, C12, C15, C16, C18, C19, C22, C23, C24, C25, C26, C31, C32, C33, C34, C36, C37, C38, C39, C41 • J03, J05, J06, J07, J09, J10, J11
Q2.2	• W06, W07, W09, W11 • C02, C07, C08, C09, C10, C12, C16, C18, C19, C22, C23, C24, C25, C26, C31, C32, C33, C34, C36, C37, C38, C39, C41 • J03, J05, J06, J07, J09, J10, J11
Q2.3	• W01, W06, W07, W09, W10, W11 • C03, C05, C06, C07, C08, C09, C10, C12, C16, C18, C20, C21, C22, C24, C25, C27, C30, C31, C32, C33, C34, C36, C37, C39, C41 • J01, J03, J05, J06, J07, J08, J09, J10, J11
Q2.4	• W01, W02, W03, W04, W05, W06, W07, W08, W09, W11 • C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C16, C17, C18, C19, C20, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41 • J01, J02, J03, J04, J05, J06, J07, J08, J09, J10, J11
Q2.5	• W01, W02, W03, W04, W05, W06, W07, W08, W09, W11 • C01, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C14, C16, C18, C19, C20, C22, C24, C27, C28, C31, C33, C36, C37, C38 • J01, J02, J03, J04, J05, J07, J09, J10
Q2.6	• W01, W10, W11 • C02, C04, C08, C11, C16, C17, C20, C27, C28, C38 • J01, J08, J11

Table 13
Classification of research question Q3.

Att.	Primary studies
Q3.1	• W01 • C02, C03, C04, C05, C06, C17, C18, C20, C35, C38, C39 • J01
Q3.2	• W02, W09, W10, W11 • C01, C07, C08, C09, C10, C11, C16, C19, C21, C22, C23, C24, C30, C33, C36, C37, C40 • J03, J05, J07, J08, J09, J10, J11
Q3.3	None
Q3.4	• W03, W04, W05, W06, W07, W08 • C12, C13, C14, C15, C25, C26, C27, C28, C29, C31, C32, C34, C41 • J02, J04, J06

Table 14
Classification of research question Q4.

Paper	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11
[W01]	X	X	X					X		X	X
[W02]	X	X	X	X				X		X	X
[W03]	X	X	X							X	X
[W04]	X	X	X	X						X	X
[W05]	X	X									X
[W06]	X	X	X	X			X	X	X	X	X
[W07]	X	X	X	X			X	X		X	X
[W08]	X	X	X							X	X
[W09]	X	X	X								X
[W10]		X	X	X						X	X
[W11]	X	X	X	X	X			X		X	X
[C01]	X	X	X	X						X	X
[C02]	X	X	X	X							X
[C03]	X	X	X	X	X		X	X		X	X
[C04]	X	X	X								X
[C05]	X	X	X	X						X	X
[C06]	X	X	X	X						X	X
[C07]	X	X	X	X			X	X		X	X
[C08]	X	X	X	X						X	X
[C09]	X	X	X							X	X
[C10]	X	X	X	X				X		X	X
[C11]	X	X	X	X						X	X
[C12]	X	X									X
[C13]	X	X	X	X	X	X	X	X		X	X
[C14]	X	X	X								X
[C15]	X	X	X								X
[C16]	X	X	X							X	X
[C17]	X	X	X	X						X	X
[C18]	X	X	X	X			X	X		X	X
[C19]	X	X	X	X						X	X
[C20]	X	X	X	X						X	X
[C21]	X	X	X	X							X
[C22]	X	X	X	X						X	X
[C23]	X	X	X	X						X	X
[C24]	X	X	X	X			X	X		X	X
[C25]	X	X	X							X	X
[C26]	X	X	X	X						X	X
[C27]	X	X	X							X	X
[C28]	X	X	X	X						X	X
[C29]	X	X	X	X						X	X
[C30]	X	X	X	X						X	X
[C31]	X	X	X	X						X	X
[C32]	X	X	X	X						X	X
[C33]	X	X	X	X						X	X
[C34]	X	X	X	X						X	X
[C35]	X	X	X	X						X	X
[C36]	X	X	X	X						X	X
[C37]	X	X	X	X						X	X
[C38]	X	X	X	X	X	X	X	X	X	X	X
[C39]	X	X	X	X						X	X
[C40]	X	X	X	X						X	X
[C41]	X	X	X	X			X	X		X	X
[J01]	X	X	X					X		X	X
[J02]	X	X	X	X			X	X		X	X
[J03]	X	X	X	X			X	X		X	X
[J04]	X	X	X	X						X	X
[J05]	X	X	X	X	X	X	X	X	X	X	X
[J06]	X	X	X	X	X	X		X		X	X
[J07]	X	X	X	X						X	X
[J08]	X	X	X	X						X	X
[J09]	X	X	X	X						X	X
[J10]	X	X	X	X			X	X		X	X
[J11]	X	X	X	X	X	X	X	X	X	X	X

5.1. BPM lifecycle phases addressed in the primary studies

According to the data presented in Fig. 4, data extraction and synthesis found evidence covering only three of the BPM lifecycle phases in the primary studies selected for this SLR. The "Evaluation" phase showed to be completely outside the application scope of PL concepts to the BPM domain for the current PL approaches for BPM. For the other BPM lifecycle phases, "Design & Analysis" is

present in 100% of the primary studies, "Configuration" in 71% and "Enactment" in 33%.

5.2. PL concepts applied in the primary studies

According to the data presented in Fig. 5, data extraction and synthesis found application evidence in the primary studies selected for the six PL concepts focused on this SLR.

"Variability Management" was the most common item found, found in 95% of the primary studies; and "Feature Modeling" the second one, found in 68% – equivalent to 72% of all studies applying variability management.

"Domain Engineering" and "Application Engineering" showed almost the same application rate – 56% and 54%, respectively. All primary studies that showed the latter also showed the former; and only one study showed "Domain" with no "Application" engineering, as detailed in Table 12.

"PL Architecture" was found in 63% of the primary studies. In fact, the primary studies in which "PL Architecture" was found are very similar to those ones in which "Domain Engineering" and "Application Engineering" were also found. As detailed in Table 12, 73% of the studies in which "PL Architecture" was found showed also the presence of "Domain Engineering" and "Application Engineering".

And only 24% of the primary studies of this SLR indicated some DPL concept in the PL approach for BPM addressed in the respective study, which represents only 15 primary studies. Specifically for these studies, Table 15 presents some details of how these 15 studies were classified in terms of the nine dynamic properties expected for DPLs as proposed by Hallsteinsen et al. [18] as presented

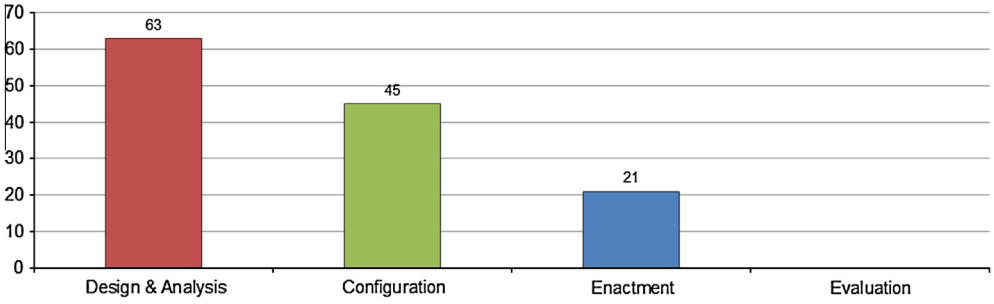

Fig. 4. Phases of the BPM lifecycle addressed when applying PL concepts to such a domain in the primary studies.

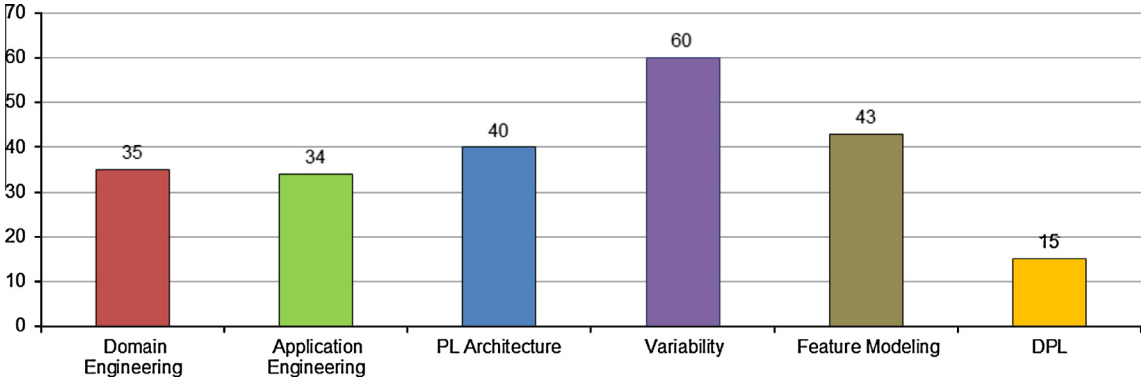

Fig. 5. PL concepts applied to the BPM domain in the primary studies.

Table 15
Classification of research question Q2.1.

Paper	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	% of properties covered
[W01]	X									11
[W10]				X	X		X	X	X	56
[W11]	X									11
[C02]	X	X	X	X						44
[C04]	X									11
[C08]				X			X	X		33
[C11]	X		X							22
[C16]	X		X							22
[C17]	X		X							22
[C27]	X		X							22
[C28]	X		X							22
[C38]	X									11
[J01]	X									11
[J08]	X		X							22
[J11]				X				X		22
% over the 15 DPL papers	80	7	47	27	7	0	13	20	7	23

in the definition of research question 2.1. On average, these 15 studies covered together only 23% of the nine dynamic properties (which represents three of the nine properties per paper on average). And only one property – (a) dynamic variability (configuration and binding at runtime) – is present in more than 50% of these 15 papers.

5.3. Comparative results between PL and BPM

Fig. 6 shows the cross-distribution of the primary studies taking into account the "BPM Lifecycle Phases Addressed in the Primary Studies" (at the horizontal axis) and the "PL Concepts Applied in the Primary Studies" (at the vertical axis). The numbers within each circle at the intersections represent the number of primary studies that fall into each bi-dimensional classification, and the size of the respective circle represents proportionally the number of primary studies at the intersections.

Except for the "Evaluation" phase of the BPM lifecycle, for which no coverage was found in the selected primary studies within the scope of this SLR (at the horizontal axis), and for the "DPL" concepts, for which only a very small number of occurrences was identified (at the horizontal axis), other attributes showed a relatively homogeneous intersection rate, ranging from 16 to 60 studies per intersection. On average, there are 31 primary studies that cover at the same time each pair of attributes defined in each one of the possible intersections (except for those that include "Evaluation" and "DPL"). Of these primary studies, 60 that represent 95% of the primary studies address the "Design & Analysis BPM lifecycle" using "Variability Management" concepts as the most important intersection identified. As the following main occurrences, 44 of the primary studies (70%) address the "Configuration BPM lifecycle" also using "Variability Management" concepts, and 43 of the primary studies (68%) adress the "Design & Analysis BPM lifecycle" using "Feature Modeling" as the specific technique for "Variability Management". In Fig. 6, it is possible observe the other also important intersections between BPM lifecycles and PL concepts.

5.4. Technology for the application integration and process enactment

According to the data presented in Fig. 7, data extraction and synthesis showed that most of the primary studies (65%) use the SOA paradigm for application integration and process enactment in the respective PL approach for BPM, from which 44% (28 primary studies) are explicitly related to web services and 21% (13 primary studies) are related to SOA in a generalized manner, with no reference to a specific implementation technology such as web service. The other 22 primary studies, which represent 35%, do not explicitly exhibit the type of paradigm or technology being used for application integration and process enactment in the respective PL approach for BPM.

5.5. Limitations of the PL approaches for BPM

According to the data presented in Fig. 8, data extraction and synthesis showed that, in general, primary studies are best assessed in terms of the "Reporting" (Attributes 4.1–4.3) and "Rele-

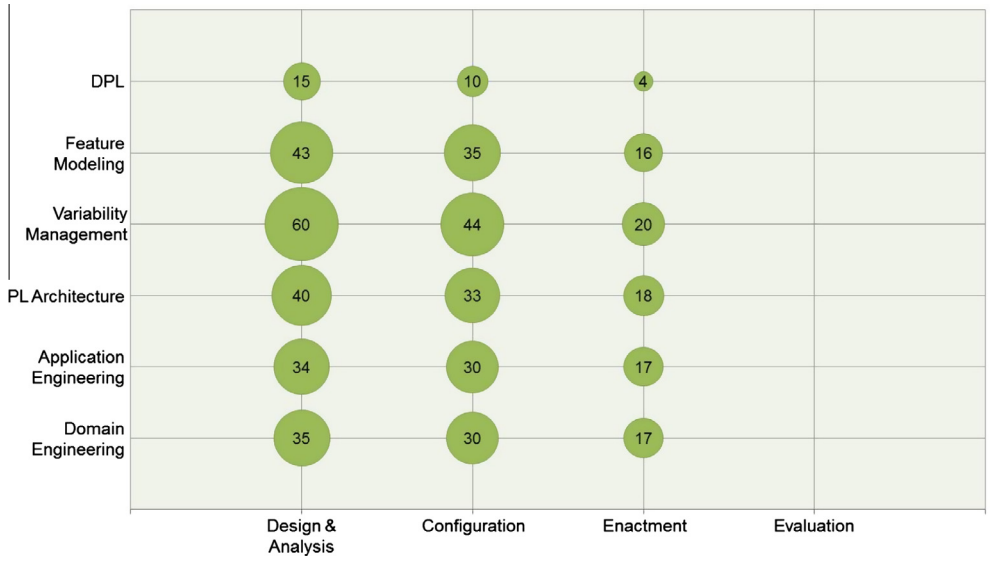

Fig. 6. Cross-distribution among BPM lifecycle phases and PL concepts in the primary studies.

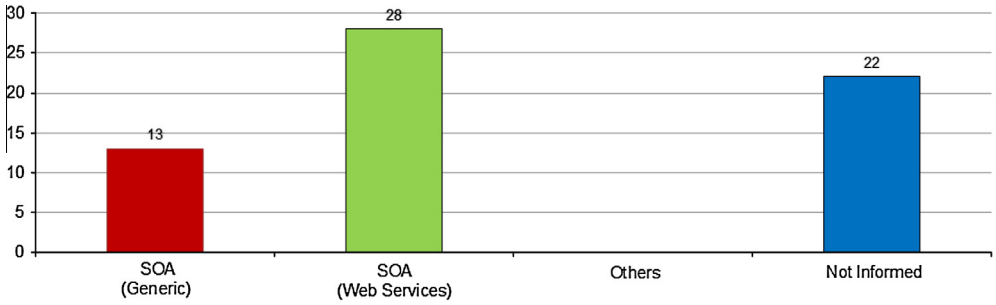

Fig. 7. Technology for application integration and process enactment in the primary studies.

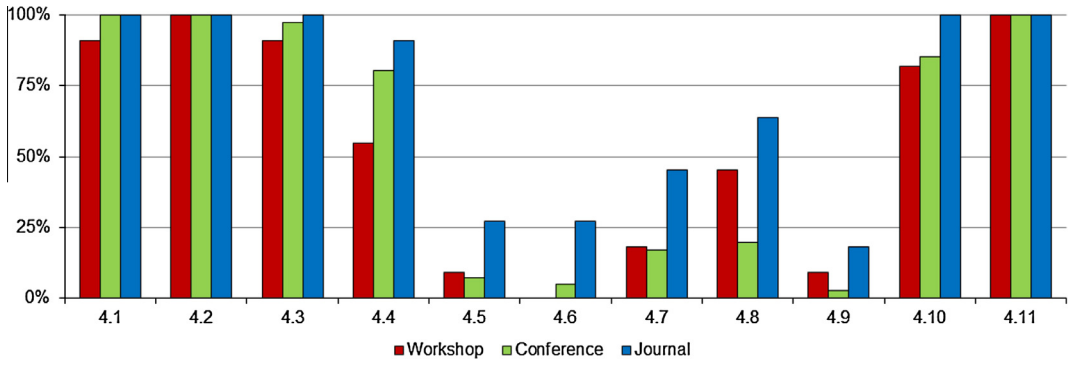

Fig. 8. Percentages of primary studies, by publication type, that satisfy the quality attributes (as proposed by Dybå and Dingsøyr [33,34]).

vance" (Attribute 4.11) attribute, and worst assessed in terms of the "Rigor" (Attributes 4.4–4.8) and "Credibility" (Attributes 4.9 and 4.10) attributes – taking into account the attributes defined in Table 9. Despite the specific types of attributes, the primary studies published in journals presented higher percentages of satisfaction – 70% on average – when compared to those published in conferences and workshops – 56% on average.

6. Discussion of results

The data presented in Section 5 enables answering, at least partially, the four research questions that guide this SLR, presented in Section 4.1.2.

Firstly, before specifically answering the research questions, the temporal distribution and the distribution by publication type of the primary studies are addressed in this section.

As shown in Table 10, according to the data obtained by this SLR, the first paper related to a PL approach for BPM was published in 2003, i.e., exactly 10 years ago. Thereafter, only a few works were published in this joint area by 2007, although both areas were already considered well established in an independent way. The vast majority of works related to PL approaches for BPM were published in the last 5 years (from 2008 until 2012), representing 79% of the total, with 57% only in the last 3 years (2010–2012). Specifically for the year 2012, it is possible that some papers published only in the last months of the year had still not been registered in the data sources used when this search was conducted (i.e. in January 2013); therefore, the final number of primary studies in 2012 could be slightly greater than eight, which is the number shown in Fig. 2. These are indications that the PL for BPM area is still at an early stage of research and development and under a maturity search process. Considering the importance of this area, it could be said that a larger number of publications was expected in the last 10-year period. Nevertheless, the positive side of the data presented is that this indicates an increase in the number of works published in this area in the coming years, as shown by the trend line in Fig. 2.

Regarding the distribution by publication type, there is also an indication of the lack of scientific maturity, since only a very small part of the primary studies was published in journals (only 17%), according to the data shown in Table 10 and Fig. 3. Additionally, these journal publications related to the PL for BPM area appear only in the last 5-year period. Taking into account only the publications in conferences – the main publication type for the primary studies, no standard was identified as a target for the authors of such primary studies. Considering the nature of each involved area in an independent way, i.e. PL and BPM, only four papers were published in the SPLC (International Software Product Line Conference) and only one paper was published in the BPM (International Conference on Business Process Management), which represent 10% and only 2%, respectively, of the total of 41 papers published in conferences (disregarding the papers published in workshops). Since they are the premier conferences for both PL and BPM areas, it would be expected to find a larger number of publications there.

Specific analyses of the research questions, which are the targets of this SLR, are presented as follows.

Q1. Which phases of the BPM lifecycle are addressed when PL is applied to such a domain?

In summary, the results shown in Table 11 and Fig. 4 indicate that the first three BPM lifecycle phases ("Design & Analysis", "Configuration" and "Enactment") are considered in the primary studies. Moreover, the last phase ("Evaluation") is not considered at all in these primary studies.

These results are partially consistent with the initially defined hypothesis stating that "only the first two phases would be covered in the primary studies". In fact, the results found are better than initially expected, since the "Enactment" phase was also identified in some primary studies, though at a smaller proportion when compared to the first two phases. Furthermore, all the primary studies in which the "Enactment" phase was identified, the "Design & Analysis" and "Configuration" phases were also identified; the same occurs between the "Configuration" and the "Design & Analysis" phases (observed in Table 11), which emphasize the lifecycle idea. With this last point, it can be concluded that only 33% of the primary studies, i.e., 21 primary studies, show a partial BPM lifecycle being addressed when PL concepts are applied to this domain; partially considering the three phases being covered. Only one or two phases should not really be considered BPM lifecycle coverage, not even partially.

The lack of coverage of the "Evaluation" phase may be justified considering that product evolution in traditional PL is essentially an extremely complicated activity, since changing a single asset can affect multiple other assets and products [110]. Taking into account the BPM case, the business processes should undergo the "Evaluation" phase – which includes monitoring, mining and optimization – and should culminate in a remodeling of the business process, hence restarting the lifecycle all over again, much more frequently than conventional software products. This higher update rate makes the "Evaluation" phase of a PL approach for BPM even more complex than in a conventional PL, which could also explain the still absence of this phase occurring in the primary studies of this SLR.

Q2. Which PL concepts are applied to the BPM domain?

In summary, the results shown in Table 12 and Fig. 5 show that all the five general PL concepts are applied to the BPM domain, considering the 63 primary studies selected in this SLR. No hypothesis had been initially raised for this question.

The results show that the vast majority of works found are applying concepts related to "Variability Management", many of

them specially related to "Feature Modeling", which could in fact be applied outside the scope of PL. In fact, 22% of the papers presenting "Variability Management", including or not "Feature Modeling", do not present any other of the PL concepts investigated in this SLR, such as "Domain Engineering" or "Application Engineering". However, since the keywords used in the search string created for this SLR use only words or expressions explicitly related to PL, it could be concluded that even in these cases the "Variability Management" applied in these primary studies are indeed within the PL context, but maybe related to other PL concepts not considered "core" concepts as the ones considered here.

Considering other concepts specifically related to conventional PL, the three ("Domain Engineering", "Application Engineering" and "PL Architecture") were found in slightly more than half of the primary studies – 56%, 54% and 63%, respectively. As already stated, the primary studies that presented "Application Engineering" also presented "Domain Engineering"; and only one primary study presented only "Domain Engineering" without "Application Engineering" as detailed in Table 12. Moreover, 73% of the primary studies identified with "PL Architecture" coverage also presented "Domain Engineering" and "Application Engineering" coverages, according to the data shown in Table 12, which drives to the conclusion that these three PL concepts are commonly applied together in PL approaches for BPM.

Comparative evaluation of research questions Q1 and Q2

Although not an initial specific goal of this SLR, a cross evaluation was performed considering the data extracted to answer Q1 and Q2 separately, which can be observed in Fig. 6. Assessing these data, and also mainly the data from Tables 11 and 12, it can be concluded that the most significant primary studies selected in this SLR are those partially addressing the BPM lifecycle (i.e., all the first three phases) while having applied at least the first four PL concepts (i.e., Domain Engineering, Application Engineering, PL Architecture, and Variability Management) into this domain. Feature Modeling was not considered since it is a specialization type of Variability Management, and DPL was not considered as it is an attribute that is too specific. Such primary studies are composed by 15 works, which represent 24% of the total: W06, W07, W11, C22, C24, C31, C32, C33, C36, C37, C39, C41, J05, J07, J09 and J10.

However, as additional information, of these 16 primary studies, eight are indeed related to a same group of papers according to Table 5, i.e., group G2, formed by the primary studies C22, C24, C33, C36, C37, J05, J07 and J10. Then, a final analysis could point out that nine paper groups – G01, G02, G03, G11, G12, G14, G25, G30 and G32 – could be considered the most significant in 33 paper groups, according to the previously defined criterion, which represents only 27% of the total of paper groups. The rest of the paper groups meet only a small part of the BPM lifecycle phases (only the first one or the first two) or only a few of the PL concepts, therefore they cannot be considered a comprehensive PL approach for BPM in terms of the criteria being considered in this SLR.

Q2.1. Are there DPL concepts being applied to the BPM domain?

The results also shown in Table 12 and Fig. 5 illustrate that only in 15 primary studies, from the total of 63, some level of application of DPL concepts was identified in the respective PL approach for BPM, which represents 24%. Moreover, the more detailed view presented in Table 15 shows that, even for these 15 primary studies, only a part of dynamic properties are being covered in such approaches, at least in terms of the nine properties presented by Hallsteinsen et al. [18]. These 15 studies vary from presenting one to a maximum of five properties, having 2.1 properties as an average (i.e. only 23% of the nine dynamic properties). And only one paper presents five properties – [W10], followed by only one paper that presents four properties – [C02]. No paper presented in a journal presents more than two properties, how could be expected considering the type of vehicle. Considering each one of the nine dynamic properties, only one of them was found in more than 50% of these 15 primary studies – (a) dynamic variability (configuration and binding at runtime), which was found in 12 of them 15 papers (i.e. 80% of them). The second property most found was – (c) variation points change during runtime, which was found in 7 of them 15 papers (i.e. 47% of them). All the other seven properties were found only in one to a maximum of four papers.

Such results are consistent with the initially defined hypothesis stating that "concepts specifically related to DPL were not yet being applied to the PL approaches for BPM or they were being applied in a very limited degree". Considering the results presented in Table 12, Figs. 5 and 15, the conclusion is that the application of DPL concepts in PL approaches for BPM is still very limited. When they exist, they are usually focused on dynamic variability management.

Corroborating to this analysis, according to Fig. 6, of these 15 primary studies, only four of them (i.e. 27% of 15) are related to all the first three phases of the BPM lifecycle. An additional analysis of data presented in Tables 11 and 12 allows to conclude that from these four studies, only one of them – the work [W11] – is included in the set of 16 most significant primary studies for this SLR (i.e., those addressing at least all the first three phases of the BPM lifecycle and at least all the first four PL concepts). However, as can be observed in Table 15, the work [W11] presents only one of the nine dynamic properties for DPLs. Therefore, we conclude that from those 16 papers considered the most significant for this SLR, no one of them, not even the work [W11], presents a wide DPL proposal for BPM. Of these results, it can be concluded that despite its great importance, much remains to be done in terms of application of DPL concepts in the BPM context.

Q3. Are the existing PL approaches for BPM all SOA-based approaches, with regards to the technology for application integration and process enactment?

The results shown in Table 13 and Fig. 7 illustrate that only 35% of the primary studies do not explicitly inform the type of paradigm or technology being used for application integration and process enactment in the respective PL approach for BPM; whereas the others 65% are explicitly related to SOA paradigm, having 44% specifically related to the web services technology for the SOA paradigm and 21% presenting the SOA paradigm in a generic way. These results are partially consistent with the initially defined hypothesis stating that "the vast majority of PL approaches for BPM would be SOA-based, if not all". They are not considered completely consistent with the hypothesis because 65% of the PL approaches for BPM explicitly using the SOA paradigm, although the majority, cannot be considered vast majority, much less the totality.

The results presented for Q1 already showed that the business process enactment as one of the BPM lifecycle phases is not yet a concern for all PL approaches for BPM, since 42 primary studies from 63 did not covered this phase. Corroborating with this conclusion, of the 22 primary studies for which no technology for application integration and process enactment is presented, 16 of them are primary studies in which the "Enactment" phase of the BPM lifecycle is not addressed.

Q4. Which are the limitations of PL approaches for BPM?

The results shown in Table 14, and Fig. 8 illustrate that primary studies vary in meeting the quality criteria, mainly according to the attribute classes.

Most of the PL approaches for BPM satisfied the first three attributes, related to the "Reporting" issue – representing 98% of all primary studies (on average), and 100% of all studies published in journals. For the last attribute, related to the "Relevance" issue, all the PL approaches for BPM satisfied it – representing 100% of

all primary studies, not only for the studies published in journals in this case. Such information indicates that there is almost no limitation in terms of making clear their objectives and values in such studies.

The "Rigor" issue was the less satisfied category, not well satisfied even by the journal papers. On average, only 30% of the primary studies satisfied concomitantly the five attributes of this issue (4.4–4.8); taking into account only the journal papers, this rate increases to 51%. For the "Credibility" issue, 47% of the primary studies concomitantly satisfied (on average) the two attributes of this issue (4.9–4.10); taking into account only the journal papers, this rate increases to 59%. In both cases, such data indicate that these studies in general lack rigor and level of credibility quality. In summary, another important indication from these data is that a great number of works being carried out for PL approaches for BPM are not properly assessed in terms of formal or experimental evaluation. Therefore, this issue pointed out a general limitation of such primary studies.

7. Validity threats

Threats to the validity of this SLR were analyzed in accordance with the following taxonomies: "construct validity", "internal validity", "external validity" and "reliability". Threats to validity are influences that may limit the ability to interpret or draw conclusions from the study's data and hence should be minimized [111].

Construct validity reflects the relationship between the theory behind the study and the observations [112]. It reflects to what extent the study under development actually represents what the researchers have in mind and what is investigated according to the research questions. In this sense, to avoid threats to construct validity, the "product line" and "product family" terms, as well as the initialisms PL and SPL, were well established and are therefore sufficiently stable to be used as search strings. Similarly, "process" and "workflow" terms, and the initialism BPM, were also well established. Another point in this aspect is to ensure the discovering of all the primary studies in the theme chosen. For this purpose, seven reputable database were used, namely Scopus, ISI Web of Science, IEEE Xplore, ACM Digital Library, SpringerLing, ScienceDirect and Engineering Village. The wide list of different publication forums returned indicates that the search coverage was sufficient.

Internal validity regards establishing a causal relationship, whereby certain conditions are shown to lead to other conditions [32]. As a threat to the internal validity, some subjective decisions may have occurred during paper selection and data extraction since some primary studies did not provide a clear description or proper objectives and results, making difficult the objective application of the inclusion/exclusion criteria or the impartial data extraction. To minimize selection and extraction systematic mistakes, several meetings were held between the authors of this review work to discuss the type of proper treatment to the identified conflicts. In order to minimize internal validity threats regarding data analysis, this SLR uses some descriptive statistics techniques, such as: graphs to summarize data; tabular description; and, parametric description (average).

External validity concerns establishing the domain in which the results of a SLR can be generalized [111,32]. Regarding this point, it is considered that both scientific and industrial communities in the PL and BPM domains can benefit from the results of this SLR, and possibly the Software Engineering field as a whole. On the other hand, as a threat to external validity, the scope of this SLR might not generalize to broader primary study selections than peer-reviewed papers, basically conference and journal papers.

Reliability aims to verify whether the data collection and analysis was performed in such a way that it can be repeated by other researchers and reach the same results [32]. With this objective, the search string and procedures were defined so that they could be directly and objectively replicated by other researchers. Classification, however, is a source of reliability threat since evaluators inherently consider subjective factors during primary studies analysis, even if carried out by several evaluators in order to minimize distortions. Thus, there is no guarantee that other researchers could achieve the exact same result as the primary studies classification presented herein.

8. Conclusion

Through this SLR, it was realized that there is a significant number of research projects being conducted in this specific PL area targeting the BPM domain, however not yet reaching a solid maturity level in general. The high number of publications in conferences and workshops, which represents 83% of the primary studies, is substantial evidence of this. Moreover, the results of the quality evaluation undertaken in the primary studies show that the assessment of their proposals are still not satisfactory in terms of "rigor" and "credibility" criteria although can be considered adequate enough in terms of "reporting" and "relevance" criteria.

If we assume that a PL approach for BPM should cover all four phases of the BPM lifecycle, then this SLR reveals that there is still no actual comprehensive PL approach for BPM. When considering a partial coverage, i.e., at least the first three phases of the BPM lifecycle, and also considering the application of all the PL concepts (i.e., the four wide concepts addressed in this review), 16 primary studies could be classified as partial PL approaches for BPM of the 63 initially selected ones (25%). Being more specific, nine paper groups could be classified as partial PL approaches for BPM of the 33 initially selected ones (27%), when considering groups of papers from the same authors as the same approach.

An expected yet disappointing number is the number of primary studies in which DPL concepts are being applied to address BPM. Only 15 primary studies out of 63, representing 24% of the total, are classified in this category. In addition to being few studies, the existing ones are very limited, covering few dynamic aspects of PL and addressing only some stages of the BPM lifecycle. The dynamic aspects are considered an important scenario in which PL concepts can be applied to the BPM domain in order to thoroughly address all of the lifecycle that has multiple flexible and dynamic needs, technologically based on the SOA paradigm, which in turn addressed the dynamic aspects very well.

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Appendix A. Definitions of the workshops, conferences, and journals initialisms and acronyms

This appendix presents, through Table A.16, the list of initialisms or acronyms of all the vehicles in which one of the 63 primary studies mentioned in this paper was published.

Table A.16
Definitions of the initialisms and acronyms for the Workshops, Conferences and Journals.

ID	Source title
BPM	Int. Conf. on Business Process Management
CAiSE	Int. Conf. on Advanced Information Systems Engineering
CEC/EEE	IEEE Conf. on E-Commerce Technology/IEEE Conf. on Enterprise Computing, E-Commerce and E-Services
CIT	IEEE Int. Conf. on Computer and Information Technology
COMPSAC	Int. Computer Software and Applications Conf.
CSWS	Canadian Semantic Web Symp.
DNCOCO	Int. Conf. on Data Networks, Communications, Computers
EA	Int. Workshop on Early Aspects
ECMDA-FA	European Conf. on Model Driven Architecture – Foundations and Applications
ECOWS	IEEE European Conf. on Web Services
FOSD	Int. Workshop on Feature-Oriented Software Development
HICSS	Hawaii Int. Conf. on System Sciences
I-ESA	Int. Conf. on Interoperability for Enterprise Software and Applications
ICACT	Int. Conf. on Advanced Communication Technology
ICCBSS	Int. Conf. on Composition-Based Software Systems
ICCIT	Int. Conf. on Convergence and Hybrid Information Technology
ICHIT	Int. Conf. on Hybrid Information Technology
ICSE	Int. Conf. on Software Engineering
ICSOC	Int. Conf. on Service-Oriented Computing
ICWS	Int. Conf. on Web Services
iiWAS	Int. Conf. on Information Integration and Web-based Applications and Services
IJBPIM	Int. J. of Business Process Integration and Management
IJCIS	Int. J. of Cooperative Information Systems
IJWET	Int. J. of Web Engineering and Technology
IJWGS	Int. J. of Web and Grid Services
IRI	IEEE Int. Conf. on Information Reuse and Integration
IS	Information Systems
ISCID	Int. Symp. on Computational Intelligence and Design
ITNG	Int. Conf. on Information Technology: New Generations
JRPIT	J. of Research and Practice in Information Technology
JSS	J. of Systems and Software
JSSSE	J. of Systems Science and Systems Engineering
JUCS	J. of Universal Computer Science
KOPLE	Workshop on Knowledge-Oriented Product Line Engineering
MDWE	Int. Workshop on Model Driven Web Engineering
PLEASE	Int. Workshop on Product Line Approaches
PoEM	IFIP WG 8.1 Working Conf. on The Practice of Enterprise Modeling
PROFES	Int. Conf. on Product-Focused Software Process Improvement
rBPM	Int. Workshop on Reuse in Business Process Management
SAC	ACM Symp. on Applied Computing
SBCARS	Brazilian Symp. on Software Components, Architectures and Reuse
SC	Int. Conf. on Software Composition
SCC	IEEE Int. Conf. on Services Computing
SEKE	Int. Conf. on Software Engineering and Knowledge Engineering
SERA	Int. Conf. on Software Engineering Research, Management and Applications
SPLC	Int. Software Product Line Conf.
TEAA	VLDB Workshop Trends in Enterprise Application Architecture
WICSA	Working IEEE/IFIP Conf. on Software Architecture
WM	Conf. on Professional Knowledge Management

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