Requirements Engineering approaches to derive Enterprise Information Systems from Business Process Management: a systematic literature review

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Abstract: The advent of Business Process Management offered a new approach to improve business and IT strategic alignment in organizations throughout development of process-aware Enterprise Information Systems. For that matter, extracting software requirements from business process models leverages engineering of adaptive information systems, which are able to adjust to changes in operation as of process redesign. This study describes a systematic literature review in Requirements Engineering approaches to derive Enterprise Information Systems from Business Process Management, aiming to provide the state-of-the-art academic overview on this research topic. Results reveal six different approach types, with variations on software development degree of automation, suggesting diverse strategies for process-oriented information systems adoption.

Keywords: Business Process Management, Requirements Engineering, Enterprise Information Systems

1   Introduction

Regardless of its origin in business reengineering as of [Da93] and [HC93] works, development of BPM (Business Process Management) as a management discipline has always been enriched by solid computer science field contributions, e.g. [Aa98], [Aa03], [AHW03] and [We10], which were decisive to develop required methods and technologies to enable modelling, analysing, simulating, implementing and monitoring operational business processes. In this regard, BPM plays an important role in bridging the gap between business and IT areas in organizations, providing support to strategic alignment of business processes, e.g. [Mo12] and [Ro15].

Indeed, BPM initiatives in organizations are not rarely associated to EIS (Enterprise Information Systems) adoption or adjustment, aiming to implement designed business processes, fully or partly automated, in order to enhance effectiveness of process improvement programs. This demands the deployment of process-oriented EIS that support business processes (e.g. [He14]) and are able to quickly adapt to changes in

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operations in a constantly changing business scenario. (e.g. [WSR09]). In this context, existing EIS can be considered in a broader view, e.g. [Xu11] and [AW04], and may or may not be originally designed from a process-driven perspective.

To design such systems, business processes must be taken into account during RE (Requirements Engineering) phase. This may involve deriving software requirements from business process models and proceeding with regular software development processes, but might also embrace adoption of commercial BPMS (Business Process Management Suite). In fact, according to [DAH05], any information system developed under process-driven orientation can be considered a PAIS (Process-Aware Information System), which suggests there may be different RE approaches to address process-oriented EIS. In any way, RE and BPM fields must be interrelated to address the design of EIS aligned to business context, e.g. [HKW14].

Discovering varied RE approaches to derive EIS may contribute to strategic alignment of organizations, since they can guide different strategies of PAIS adoption that can be considered to orient EIS to business processes. The main motivation of this study is to provide the state-of-the-art academic overview on how RE can be applied to derive EIS from BPM. The study describes a systematic literature review on this research topic, presenting the review phases and discussion of the results found.

2   Research methodology

To perform the SLR (Systematic Literature Review), guidelines from [KC07] were followed. To start planning the review, an initial mapping study was performed in order to expand research keywords used to search for primary studies. "Business process management" and "requirements engineering" main keywords were used as a starting point to search for article title, abstract and keywords in Scopus database [Sc17]. On 12/09/2017, this search produced 55 document results, whose metadata were exported to VOSviewer software tool [EW10]. A co-occurrence network of keywords was then created, based on the number of publications in which two keywords occur together in the bibliographic data. The keywords co-occurrence map can be viewed in Fig. 1. This initial mapping study resulted 395 keywords which were later analysed to compose SLR search queries.

SLR protocol items were defined as follows:

- Objective: to provide a background in order to appropriately position research activities in the field of BPM and RE for EIS.

- Research question: how RE can be applied to derive EIS from BPM?

- Keywords and synonyms: BPMN, BPMS, business IT alignment, business process management, information system, requirements analysis, requirements elicitation, requirements engineering, requirements gathering, requirements management,

requirements model, requirements specification, software engineering, software requirement, strategic alignment, system engineering, system requirement.

- Sources selection criteria definition: abstract and citation databases of peer-reviewed literature.
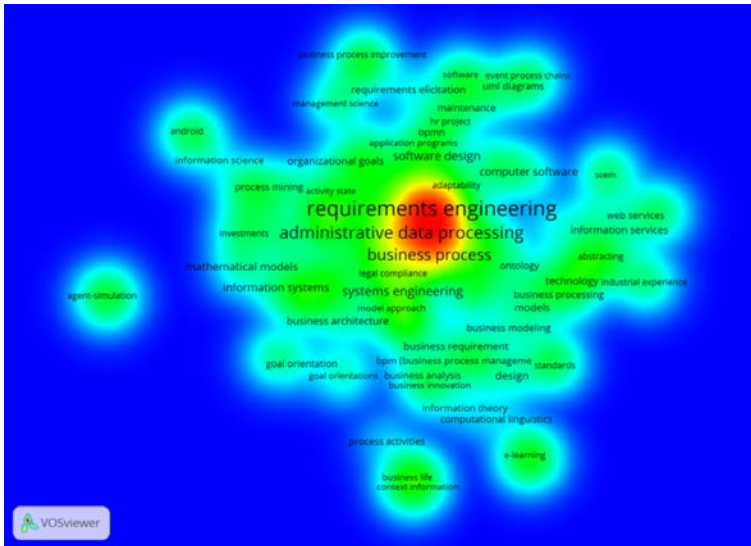

Fig. 1: Keywords co-occurrence map in VOSviewer

- Source search method: web search engines.

- Source list: Scopus [Sc17] and Web of Science [We17].

- Primary studies' language: English.

- Primary studies' document types: article or conference paper

- Study selection criteria (IC – Inclusion Criteria and EC – Exclusion Criteria):

    – IC1: BPM for requirements specification.

    – IC2: information system derived from business process artefacts.

    – EC1: information system not supporting business processes.

    – EC2: process artefacts not related to business.

    – EC3: date of publication before 2014.

    – EC4: full-text not available.

    – EC5: non-English language.

    – EC6: invalid document type.

- Data extraction criteria (AT – Approach Type):

  - AT1 – BPM4UML: process-oriented RE approach in which software artefacts, such as UML models, are derived from BPM artefacts, such as business process models.

  - AT2 – BPM4SOA: process-based approach to generate services-oriented information systems, usually under SOA (Service-Oriented Architecture) paradigm, handling different models and notations such as BPMN (Business Process Model and Notation), BPEL (Business Process Execution Language) and WSDL (Web Services Description Language) and conversion methods between them.

  - AT3 – BPM4APP: generation of application systems from business process models that are automated and executed by process engines.

These predefined approach types were adapted from the common framework for the concept of BPM in an EIS perspective from [MMT08].

3 Systematic literature review

To conduct the review, a search strategy was defined based on the relevance of each keyword and synonym in the keywords co-occurrence map identified during the initial mapping study. Expanded search queries for each source were developed as follows:

- Scopus: TITLE-ABS-KEY (("business process management" OR "BPMN" OR "BPMS") AND (("requirement*" AND ("business it alignment" OR "strategic alignment" OR "information system*" OR "system* engineering" OR "software engineering")) OR ("system* requirement*" OR "software requirement*" OR "requirement* engineering" OR "requirement* analysis" OR "requirement* elicitation" OR "requirement* gathering" OR "requirement* management" OR "requirement* model*" OR "requirement* specification*"))) AND (LIMIT-TO (DOCTYPE , "cp ") OR LIMIT-TO (DOCTYPE , " ar ")) AND (LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014)) AND (LIMIT-TO (LANGUAGE , "English ")).

- Web of Science: (TS=(("business process management" OR "BPMN" OR "BPMS") AND (("requirement*" AND ("business it alignment" OR "strategic alignment" OR "information system*" OR "system* engineering" OR "software engineering")) OR ("system* requirement*" OR "software requirement*" OR "requirement* engineering" OR "requirement* analysis" OR "requirement* elicitation" OR "requirement* gathering" OR "requirement* management" OR "requirement* model*" OR "requirement* specification*")))) AND Languages: (English) AND

Document types: (Proceedings Paper OR Article) Timespan=2014-2017.
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Some criteria (EC3, EC5 and EC6) could be included in the search strings. On
04/11/2017, search string execution produced 176 document results in Scopus and 78
document results in Web of Science. These results were then checked so that duplicated
papers were removed before studies selection. All steps of SLR are evidenced in Fig. 2.

Initial mapping study — 55 — Indentification of research — 254 — Duplicated papers removal — 192 — Study selection — 115 — Study quality assessment — 104 — Data extraction

Fig. 2: Number of papers throughout SLR steps

During study selection step, IC1, IC2, EC1 and EC2 criteria were applied based on
analysis of abstract, keywords and title of each paper. Afterward, during study quality
assessment, EC3, EC4, EC5 and EC6 criteria were applied based on full text analysis. At
last, data extraction was performed so that each paper was classified into one of the
approach type categories.

4   Review results

Review results encompasses not only accepted papers, but rejected ones which could be
grouped into subcategories for each exclusion criterium, based on similarity of subjects
covered. Tab. 1 presents SLR results for rejected papers.

Exclusion criteria	Results
EC1.1 – enterprise architecture	9
EC1.2 – management initiative	28
EC1.3 – process mining	6
EC2.1 – BPMN for software design	19
EC2.2 – modelling languages	15
EC3 – date of publication before 2014	0
EC4 – full-text not available	9
EC5 – non-English language	0
EC6 – invalid document type	2

Tab. 1: Papers rejected during SLR

Despite these papers were rejected, discussed subjects within each exclusion criterium
subcategory comprise solid research fields partially related to research question, which
may deserve deeper investigation as alternative approaches to those resulting from
accepted papers. The exclusion criteria subcategories are described as follows:

- EC1.1 – enterprise architecture: application of enterprise architecture frameworks
  such as TOGAF (The Open Group Architecture Framework) [Th11] or business

analysis practices such as those from BABOK (a guide to the Business Analysis Body Of Knowledge) [II15], which consider multiple perspectives to look at organizations (business, systems, data, processes, technology, among other ones), usually also related to business and IT strategic alignment. Enterprise architecture is a large and important research field, although not necessarily addressing information systems development. Additionally, it cannot be considered a process-oriented approach, even though some BPM methods and techniques may be eventually applied.

- EC1.2 – management initiative: application of BPM as a management discipline only, focused on business process improvement not related to information systems development. Some BPM tools such as business process simulation might be used, but not related to derivation of software requirements to develop enterprise information systems that support business process operations. Management initiatives may also apply software engineering methodologies such as elicitation, quality assurance or agile methods on business process discovery.

- EC1.3 – process mining: application of techniques to extract business process models from event logs of existing information systems. Process mining initiatives demands availability of enterprise information systems and proper data, which allows business process models to be derived from them. However, process mining might be used for system maintenance or continuous requirements engineering [AW04].

- EC2.1 – BPMN for software design: application of process modelling techniques or notations during software design or deployment, without focusing on requirements specification from business process models.

- EC2.2 – modelling languages: application of ontologies to create, evaluate or compare alterative languages or notations for process modelling, without focusing on requirements specification.

Even though EC6 had been included in the search strings, during full-text analysis 2 papers had invalid document types and were then rejected. No similar condition occurred with EC3 and EC5 which resulted in no rejections at this phase. EC4 was also applied during study quality assessment based on full-text availability, and 9 papers were rejected due to this criterium.

Analysis of accepted papers could also group similar papers into subcategories of each approach type. Tab. 2 presents SLR results for accepted papers. Specific approach types are described as follows:

Inclusion criteria	Results
AT1.1 – BPM4EIS	18
AT1.2 – BPMN4EIS	21
AT1.3 – goal2BPMN	13
AT2.1 – extended BPMN	14
AT2.2 – BPMN2services	8
AT3.1 – PAIS	8
AT3.2 – BPMS	22

Tab. 2: Papers accepted during SLR

- AT1.1 – BPM4EIS: this approach type distinguishes itself by application of BPM as a management initiative related to the development of enterprise information system able to support business processes and improve business and IT alignment [VSP08]. Papers using this approach usually present business process models in different levels of abstractions (notably business and IT levels) and describe how process models are considered during information system requirements specification.

- AT1.2 – BPMN4EIS: application of business process modelling to support requirements engineering and information systems modelling, as described in BABOK [II15], SWEBOK (guide to the Software Engineering Body Of Knowledge) [BF14] or REBoK (Requirements Engineering Body of Knowledge) [Pe13] guides. Papers using this approach also cover ontologies for business process application to requirements engineering, notably the development of methodologies, languages and heuristics to derive software requirements from business process models (such as UML artefacts from BPMN models, for example).

- AT1.3 – goal2BPMN: emergent research field with applies goal frameworks such as KAOS (Knowledge Acquisition in autOmated Specification) [Da97] and i* [Fr16] for GORE (Goal-Oriented Requirements Engineering) [La01], which develops software requirements engineering oriented to organizations strategic goals, in order to improve business and IT strategic alignment. Papers using this approach use business process modelling notations (such as BPMN) to formalize software requirements.

- AT2.1 – extended BPMN: this approach type benefits from native extensibility of BPMN to improve requirements specification. It acknowledges notation power to capture software requirements and extends its elements to model specific requirements, notably non-functional ones [BD11], such as those related to security, risk, ubiquity, and others. Usually, extension proposal includes methods to convert models using extended notations to software design/deployment artefacts.

- AT2.2 – BPMN2services: semiautomatic generation of information systems from process-based requirements using SOA. This approach type is built upon MDA (Model-Driven Architecture) paradigm [OM14], in which software design is independent on the technology or programming language and involves CIM

(Computation Independent Model) to PIM (Platform Independent Model) transformations.

- AT3.1 – PAIS: academic research field for business process automation [WRR08], this approach type covers the development of technologies such as ACM (Adaptive Case Management) [HK11] and others that allow automatic generation of process-oriented applications.

- AT3.2 – BPMS: commercial suites for application generation from automation of business process modelled in the software platform [Re06].

Analyzing review results, it can be noticed that process-oriented RE approaches for EIS range from little software development automation (AT1.1) to almost zero-code generation of BPM applications (AT3.2). Such approaches may be applied in different ways, being manually deriving software requirements from business process management artefacts and following a traditional software development process, or automatically generating process-oriented applications based on business process models. SLR discussion of results is presented in Tab. 3.

Approach type	Subcategory	Description
AT1 – BPM4UML	AT1.1 – BPM4EIS	Management initiative including deriving EIS requirements
	AT1.2 – BPMN4EIS	Business process modelling for RE and information systems modelling
	AT1.3 – goal2BPMN	GORE
AT2 – BPM4SOA	AT2.1 – extended BPMN	Extension of business process modelling notation for specific requirements specification
	AT2.2 – BPMN2services	MDA
AT3 – BPM4APP	AT3.1 – PAIS	PAIS technologies development
	AT3.2 – BPMS	Business process automation for application generation

Tab. 3: SLR results summary

5   Conclusion

It is worth mentioning that findings on this study address an interdisciplinary research gap between operations management and computer science fields, by bringing together strategic alignment approaches that can be considered from BPM or RE perspectives.

Referring to the research question, this SLR provided a comprehensive academic overview on how RE can be applied to derive EIS from BPM, exposing the various existing approaches in the current academic literature. Content analysis of selected papers allowed identification of six subcategories of approach types, extending initial data extraction criteria and unveiling emergent research fields that had not been considered previously. For that matter, it can be claimed that the objective defined in the SLR protocol has been successfully fulfilled.

Also, discovering different approach types that vary depending on software development automation degree they demand, suggests that PAIS adoption for EIS goes beyond a build-or-buy decision, but may embrace different strategies for different organizations (e.g. varying on size, BPM maturity, business process' characteristics, IT budget or other aspects). These findings can guide further research activities, providing a base framework to support surveying RE approaches to derive EIS from BPM in the practice of organizations.

It is important to remark the contribution of initial mapping study based on keywords co-occurrence map to the research methodology, which expanded the research search and enabled such broad overview as a result. However, the SLR results offer only a first approach to the research topic and therefore a wide but limited knowledge about the subject. Further research including a detailed analysis of the literature must be carried out in order to reference findings and enable proposal of a research framework.

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