



A systematic literature review on the architecture of business process management systems



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ABSTRACT

Due to the high complexity of modern-day business, organizations are forced to quickly adapt to a wide range of cutting-edge developments. These developments influence the structure and behavior of the business processes that represent the work and of the Business Process Management Systems (BPMS) that support them. Consequently, the architecture of BPMS has changed a lot over the past two decades. However, there is no systematic overview of the research done in this area since the Workflow reference model first set the standard for BPMS architecture in 1995. To bridge this gap, this paper presents a Systematic Literature Review (SLR) of BPMS architectures, by analyzing 41 primary studies taken from a gross collection of 608 research papers. The BPMS architectures that served as primary studies were compared with respect to the reference architecture that they are based on, the level of elaboration at which they are described, the architectural styles that they use, the means with which they are evaluated, and the functionality that they support. The resulting comparison provides an overview of and insights into the current body of knowledge on BPMS architectures.

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1. Introduction

Business Process Management Systems (BPMS) are information systems that interpret business processes to ensure that the activities specified therein are properly executed and monitored by an organization [1]. Such systems have seen significant industrial adoption and, therefore, their architectures are rapidly evolving in order to fulfill ever-expanding business requirements. Consequently, the architecture design of BPMSs has become an important development activity in the research community [2–12].

The study of existing architectures of BPMSs can provide a useful account of how such systems should be structured in order to support the intended functionalities. Therefore, this paper provides a comprehensive overview of the state-of-the-art by surveying existing Business Process Management System (BPMS) architectures and systematically identifying, classifying and analyzing them. For this purpose, a Systematic Literature Review (SLR) methodology was used, because that provides a means of identifying, interpreting and evaluating the existing body of knowledge in a specific research discipline [13,14]. In particular, since we seek to provide

insight into existing BPMS architectures, our study is considered a mapping study (a.k.a. scoping study) [15]. As such, this SLR contributes to research in the area by providing a structured and comprehensive overview of available BPMSs architectures and by identifying future research opportunities.

Against this background, the remainder of this paper is organized into four sections as follows. Firstly, Section 2 presents the review protocol that was employed as a basis for conducting our survey. Secondly, Section 3 discusses the evaluation methodology that was used for classifying and analyzing the selected studies. Subsequently, Section 4 reports on the obtained results. Then, Section 5 presents some possible research directions and, Section 6 concludes the paper.

2. Review protocol

The review protocol, used to conduct our SLR study, specifies the *research questions* (Section 2.1) as well as the *search protocol* (Section 2.2) and the *selection criteria* (Section 2.3), which were employed to select relevant primary studies.

In order to ensure the quality of the study, the guidelines proposed in [13,15–17] were followed. Accordingly, the involved researchers were organized into two groups, namely a *review team* and an *evaluation team*. The review team, which consisted of two

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researchers in the domain of Business Process Management(BPM), was responsible for:

- formulating the research questions,
- developing the review protocol,
- searching and selecting the primary studies,
- developing a classification framework,
- extracting data from the selected primary studies, and
- synthesizing and reporting the outcomes of the review.

The evaluation team, which consisted of two researchers in the domain of BPM and information system architecture, was responsible for:

- evaluating the research questions,
- evaluating the review protocol,
- evaluating the final list of the selected primary studies,
- evaluating the final classification framework, and
- evaluating the final content of this research.

2.1. Research questions

This SLR study set out to acquire knowledge about existing BPMS architectures within the research communities. This goal can be achieved by answering the following central research question (RQ).

RQ Which relevant primary studies were published in the area of BPMS architecture?

In order to properly assess the relevance of primary studies, we decompose the central research question into five sub-questions. In particular, these sub-questions investigate the design, evaluation and provided functionalities of the architectures in the selected primary studies.

The first research sub-question seeks to find the foundation (i.e., where is the starting point) for the design and development of the identified architectures in the primary studies. Thus, RQ1 has been formulated as follows:

RQ1 To what extent were the architectures in the primary studies built upon existing (reference) architectures?

The second and third research sub-questions are used to analyze the structure of the identified architectures in the primary studies (i.e., how these architectures have been presented). To this end, RQ2 examines the level of detail that has been provided by the identified architectures in the primary studies. Thus, this research sub-question has been formulated as follows:

RQ2 To what extent were the architectures in the primary studies elaborated upon in terms of details and technologies?

RQ3 explores the high-level decision decisions that have been made to describe the overall structure (i.e., the architectural style) of the identified architectures in the primary studies. Thus, this research sub-question has been formulated as follows:

RQ3 Which architectural styles have been followed by the architectures in the primary studies ?

The fourth research sub-question focuses on how the identified architectures in the primary studies have been evaluated. Thus, RQ4 has been formulated as follows:

RQ4 How were the architectures in the primary studies evaluated?

Finally, the fifth research sub-question considers the functionalities that are addressed by the identified architectures in the primary studies. Therefore, RQ5 has been formulated as follows:

RQ5 Which main functionalities have been addressed in the primary publications?

2.2. Search strategy

The main strategy employed in our SLR study was to find as many scientific publications as possible and, subsequently, the results were narrowed down by applying predefined criteria. In this section, the search strategy, used to identify the preliminary set of primary studies, is discussed. We, firstly, provide a set of search strings in Section 2.2.1, and, then, we present the search sources (i.e., on-line databases) that were employed to conduct the search in Section 2.2.2.

2.2.1. Search strings

The first action in the search strategy was formulating a set of search strings. In order to develop the search strings we followed the guidelines suggested by Kitchenham et al. [17] and, consequently:

- (i) the terms “BPMS” and “architecture” were derived from the research questions as the main search terms in this study;
- (ii) “Business Process Management System”, “workflow management system”, “orchestration execution system” “choreography execution system” were utilized as alternative terms (i.e., alternative spelling or technical synonyms) for “BPMS”;
- (iii) the Boolean AND was used to connect the search terms identified in step (i) in order to narrow down the search results (e.g., we employed “BPMS” AND “architecture” as a group of search strings in our study);
- (iv) the Boolean OR was used to incorporate alternative terms in step (ii) in order to provide a wider range of search results (e.g., “BPMS” OR “Business Process Management Systems” was employed as a part of the search strings in this study);

All the mentioned alternative terms in step (ii), in constructing the final search strings, were shortened in order to retrieve as many results as possible. For example, the term, “system” was removed from the end of the alternatives. The term, “workflow” was used instead of “workflow (management) system” since it has been used to refer to the same concept in the literature, whereas “business process” and “Business Process (management) System” refer to different concepts (i.e., business process, usually, has been used to refer to a business process model and not business process system). Where complex Boolean search strings were not supported by a database, a designated search string was used for that database. These guidelines, thus, led to the following search strings:

- ST1 (“architecture” AND “bpm”) OR
- ST2 (“architecture” AND “business process management”) OR
- ST3 (“architecture” AND “workflow”) OR
- ST4 (“architecture” AND “orchestration”) OR
- ST5 (“architecture” AND “choreography”)

It should be noted that a synonym for the term, “architecture” (i.e., system structure) was not considered since no results were found for the constructed search strings with the term, “system structure” instead of “architecture” (e.g., “system structure” AND “bpm”).

2.2.2. Search sources

The second action in the search strategy was choosing the search sources. This action allows other researchers to obtain the same search outcome as that which we gathered from the mentioned search strings. Based on [18] and [19], scientific search engines and indexing systems in the field of computer science were used as preliminary sources. Table 1 shows the databases that were considered in the search strategy.

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