

A Literature Review on Business Process Management

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Abstract

Business Process (BP) is a set of coordinated tasks that define how to achieve organizational goals. It emerges as an efficient tool, whose main goal is supporting the design, administration, setup, disclosure and analysis of business processes, and organizations use it to identify opportunities to reduce costs, increase service or product quality, etc. The goal of BPM is to manage business processes. Organizations wish to manage perfectly these processes instead of fixing the non-ideal process setups or outcomes in a reactive manner. At present, variability management in the business processes domain is considered as a key of reuse. Process mining offers a set of techniques that retrieves information from event logs and gives companies a better understanding of their processes. Process mining has gained significant attention in both research and industry as a range of data mining tools has emerged. In this study, we will provide a systematic literature review from 2017 to 2021; we will use Kitchenham method to conduct this SLR. Data source as IEEE, ACM, Springer and ScienceDirect are used to obtain literature. We had, as a result, 51 papers from 3079 papers to complete this paper. This SLR had for objective to see the research trend on the topics of business process management, improvement, modeling and approaches using data mining.

Keywords: Business process management; modeling; process mining; data mining; systematic literature review.

1. Introduction

Business process management has been defined as a management discipline that focuses on improving the efficiency of an organization by managing its component processes [1]. With the growth of business process complexity, many organizations are using business process management (BPM) to build and improve their information systems as much as their efficiency [2]. BPM has become an effective mean for creating abstract representations of knowledge, providing formalized definitions of the different activities, evaluating the process executions and/or evolutions [3]. Its technologies support the management and digitalization of workflows and business processes by employing explicit process models, following a cycle of process (re)design, validation, execution and monitoring [4].

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When we talk about BPM life cycle [5], we mean • (Re) design and analysis of the business process which is the creation of a BP from scratch or simply re-configuring an existing model. • Configuration of the information system. • Execution and supervision of the business process and • Diagnosis: This phase consists of learning knowledge from the business processes in execution and using them as input for possible improvements in business processes. With the increase in size and complexity of process model repositories, it gets harder to manage them. The area of BPM addressing such challenge is called Business Process Architecture (BPA) [6]. The coordinated execution of activities is a fundamental principle from the viewpoint of Business Process Management, and it produces the change of data objects during process instantiating. In general, a BP can be implemented and operational by a business process management system [7].

Process mining technology is a branch of business process management technology. It can extract process knowledge or information from event logs and historical data of business processes to build process models, which helps to detect and improve business processes [8].

This information can help to improve the processes and is generally extracted after the process has been finished. However, the interest to apply process mining to running process instances is increasing [9].

There are different process mining techniques such as those which are used for predicting the remaining processing time of running BP instances, or others which focus on learning factors that influence decisions and the discovery of roles are integral parts of process mining [10].

A process mining is used for managing and continuous process optimization [11]. In order to increase the automation level and to reduce the human intervention, there are three axes of process mining [12]:

- Process model discovery from an event log saved in a Process Aware Information System (PAIS) that manages and executes operational processes relying on process models.
- Process model conformance checking of a process model to its event log and vice versa.
- Process model improving of an existing process model by adding a new perspective from the information stored in the event log.

During process mining, specialized data mining algorithms are applied to event log data, which are data logs that contain the history of a process instance, in order to identify trends, patterns and details of the underlying business process [13]. DATA MINING is described as the discovery of patterns in data joined with the execution of activities like data pre- processing, result interpretation and providing useful information to decision makers. The term was originally identified as Knowledge Discovery (KD) and the process to find data relationships was called KDD (Knowledge Discovery in Databases) process [14].

In this paper, we summarize the state of the art of business process field in the last five years. For this, we have conducted a systematic literature review whose objective is to collect the different contributions regarding BP, the main methodologies used for successful results and also to show the impact of data mining in improving

BPM. The remaining of this paper is organized as follows. Section 2 gives an overview of the background of our work. Section 3 presents the research methodology followed in the review. Section 4 answers the research questions by analysing and discussing the results of the review. Finally, Section 5 concludes the paper.

2. Research methodology

Several studies related to the business process management, have been proposed by researchers and practitioners. To analyze these studies, we have conducted a review of the literature by following the same protocol of a Systematic Literature Review (SLR) described in Kitchenham's guidelines [52]. This protocol contains the following steps : 1) Identification of research questions, 2) Research in Databases, 3) Data Selection which includes the definition of Inclusion and Exclusion criteria, 4) Data Extraction, and 5) Data Analysis. The rest of this section focuses on the first four steps, while the data analysis step is detailed in Section 4.

2.1. Research questions

The objective of our review is to find the different contributions proposed in literature in relation with business process management and to discuss the different topics describing the improvement of these BPs. We thus formulated the three following questions:

- RQ1. What are the types of contributions regarding business process management?
- RQ2. What are the different methodologies used to have successful results?
- RQ3. What are the recommendations and suggestions for better modeling?
- RQ4. What is the impact of data mining in improving business process management?

In order to answer the research questions defined above, we have constructed the research string using the keywords related to our topic.

The basic keywords are : business process, process models, process, management, BPM. To make the research more efficient, we defined a set of synonyms and alternatives for the different keywords. To link the alternative keywords, we used the Boolean "OR" and to interconnect the different parts of the string, we used the Boolean "AND". As a consequence, we obtained the research string presented below :

(Business process **OR** BPM **OR** business processes **OR** business processing) **AND** (Management **OR** modeling **OR** models **OR** engineering **OR** improvement) **AND** (data mining **OR** data process **OR** process mining).

2.2. Research in databases

Using the keywords above, we considered publications retrieved from IEEE Xplore, ACM Digital Library, ScienceDirect and Springer Link.

- **IEEE Xplore:** This database is very easy to manipulate. First, we entered the search string, and then we filtered the first result by date to obtain only the papers corresponding to our review.
- **ACM Digital Library:** In this database, we had to be more specific in the notation by adding two quotes to the keywords, otherwise, we come up with a big number of studies that have nothing to do with our topic.
- **ScienceDirect – Elsevier:** This database works in the same way as the ACM Digital Library in using the quotes. In ScienceDirect, we can refine our search through many filters like date, publication title, article type, etc.
- **Springer Link:** Springer link is also a database known for its diversity in studies. The only complicated issue we had to deal with in this database is the interconnection between some filters.

2.3. Data selection

To perform a successful literature review, the inclusion and exclusion criteria must be carefully defined in order to keep only the articles that are relevant to our search. The inclusion criteria we have defined are the following:

- **IC1:** The paper is a full article, a book, a chapter, a report, a thesis, a presentation.
- **IC2:** The title or the abstract of the paper contains the keywords of the search.
- **IC3:** The paper addresses the business process management using data mining.
- **IC4:** The paper addresses at least one method of data mining used in business processes.

And the exclusion criteria are the following:

- **EC1:** The publication date is previous to 2017.
- **EC2:** The paper is written in a language other than English.
- **EC3:** The paper is a short article, a standard, a poster, an editorial, or a tutorial.
- **EC4:** The title, the keywords and the abstract do not correspond to the research subject.
- **EC5:** The paper does not discuss the business process.

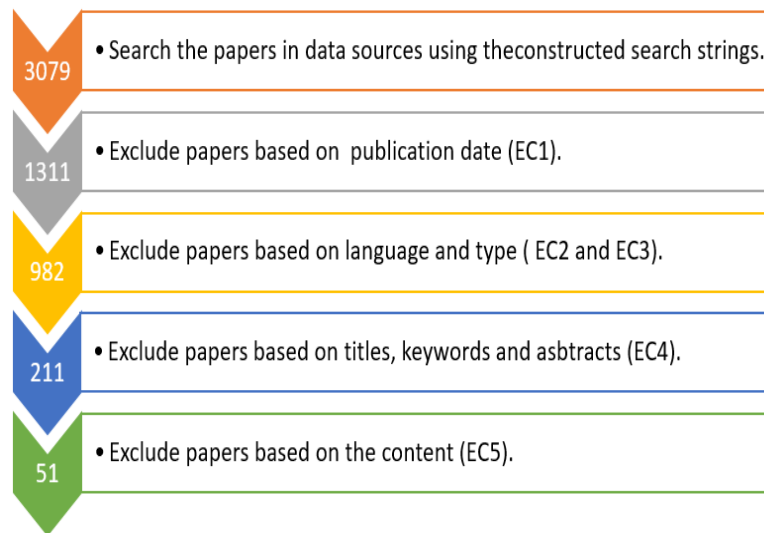


Figure 1: Data selection process.

The data selection activity was carried out in several stages as described in Figure 2.

The total number of papers initially retrieved is 3079, divided as follows: 1119 from IEEE Xplore, 721 from ACM Digital Library, 616 from ScienceDirect and 623 from SpringerLink.

After applying all the exclusion criteria, we kept only 51 papers at the end of the selection process.

2.4. Data extraction

In order to make a synthesis of the data collected and to be able to answer the predefined research questions above, we extracted a number of attributes from each selected paper, as described in Table 1 (Kitchenham, 2007).

Table 1: Attributes used in data extraction.

Title	Title of the paper
Year	Publication year of the paper
Type	e. g. Journal paper, conference paper, thesis, book, chapter, workshop paper.
Database	e. g. IEEE, ACM, Springer, Elsevier
Keywords	Keywords specified in the paper
Methodology	Methodology followed in the study
Contribution	e. g. Model, Framework, Tool, Method, Algorithm

3. Results and discussion

The objective of this step is to answer the research questions defined in the last section. The different papers we have judged relevant for our review were studied from different perspectives.

3.1. Metadata analysis

In our review, we analyzed many types of articles metadata, but we present in this article two main types, which are the Data Source and the Publication Year.

3.1.1 Data source

Figure 2 presents the percentage of papers from the four digital databases. The distribution of papers is the following: 37% of the selected papers belong to IEEE Explore (19 papers), 23% of papers from ScienceDirect (12 papers) and the lowest percentage of papers was retrieved from both ACM and Springer 20% (10 papers).

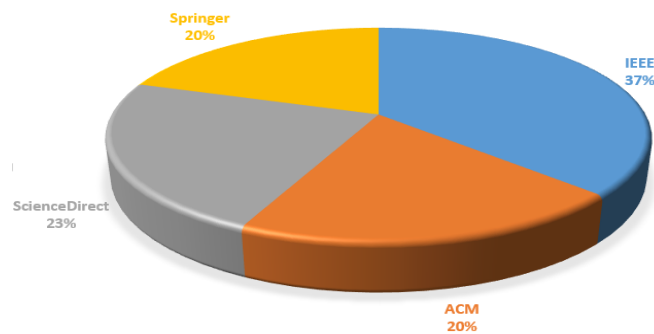


Figure 2: Pourcentage of papres in databases.

Data mining, or knowledge discovery in databases, is the process of extracting (unknown) patterns from data. In general, a data mining process includes several iterations of single data mining steps (algorithm executions) [7]. It has many goals where the most important ones are the verification of user's hypothesis because of the limitation of the system, and the discovery of new patterns that the system finds but can be subdivided into prediction and description. Which means predicting the future behavior of some entities and presenting it to the user in a simple and understandable form. Behalf of all the other authors.

3.1.2 Publication year

As mentioned earlier, the review was conducted for the period 2017-2021. Figure 3 shows the number of papers published in each year. The highest number of papers were published in 2017 and 2018 with 14 papers. 19 of the selected papers were published in 2020, 8 papers were published in 2019 and 6 papers in 2021.

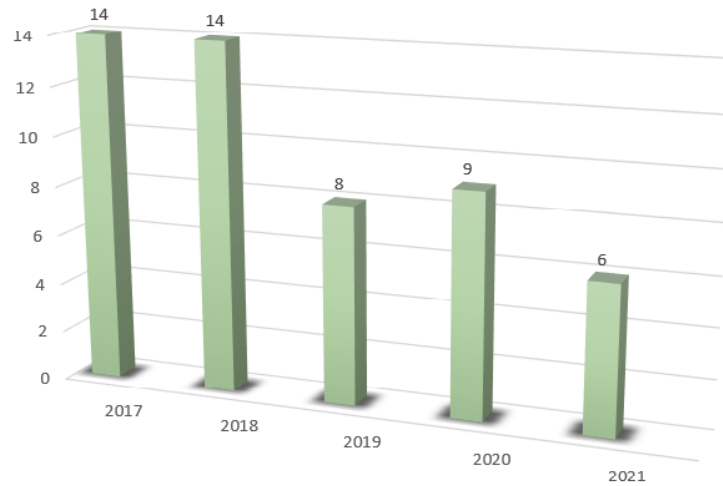


Figure 3: Number of papers per year.

In K-nearest neighbor (KNN) technique, nearest neighbor is measured with respect to value of k, that define how many nearest neighbors need to be examine to describe class of a sample data point . Nearest neighbor technique is divided into two categories, structure based KNN and structure less KNN.

The structure based technique deals with the basic structure of the data where the structure has less mechanism, which associated with training data samples. In structure, less technique entire data is categorized into sample data point, training data, distance is calculated between sample points and all training points, and the point with smallest distance is known as nearest neighbor [13].

3.1.3 Source avenue

Table 2 presents the different source avenues of the selected papers and their types as well as the number and percent of papers for each source. According to this table, there are 29 source avenues, 21 conferences and 8 journals. The number of papers published in conferences is 34, which represents 67% of the papers.

The conferences that contain the highest number of papers are the Springer conference « International conference on BPM », the ACM conference « international conference on subject-oriented BPM » and the ScienceDirect conference « International conference on Entreprise... ». The number of papers retrieved from journals is 17 (33% of total papers), with 6 articles published in IEEE ACCESS. All these findings are logical because the majority of papers are published in important journals and conferences that accept only complete works detailed methods and validated solutions.

Table 2: Source Avenue.

Source avenue	type	#papers	%
IEEE Access	Journal	6	11%
International Conference on Computational Science and its Application	Conference	1	2%
International Conference on Optimization and Applications	Conference	1	2%
IEEE Transaction on Knowledge and Data Engineering	Journal	1	2%
International Conference on Systems and Informatics	Conference	1	2%
International Conference on Smart Systems and technologies	Conference	1	2%
IEEE Transaction on Service Computing	Journal	1	2%
International Conference on Intelligent Engineering and Management	Conference	1	2%
International Conference on Cloud Computing, Data Science and Engineering	Conference	1	2%
International Conference on Big data an SA	Conference	1	2%
International Conference on Business Informatics	Conference	2	4%
IEEE Transaction on Software Engineering	Journal	1	2%
International Conference on Computer Science and Intelligent Systems	Conference	1	2%
Technological Forecasting and Social Change	Journal	3	6%
International Conference on Knowledge Discovery and Data mining	Conference	1	2%
Symposium on Information Systems	Conference	2	4%
Symposium on Applied Computing	Conference	2	4%
International Conference on Information Communication and Management	Conference	1	2%
Proceeding of International Conference on Big Data in Management	Conference	1	2%
International Conference on Business Process Management	Conference	7	13%
Computer Standards and Interfaces	Journal	1	2%
International Conference on Digital Economy	Conference	1	2%
International Conference Conceptual Modeling	Conference	1	2%
International Conference on Enterprise Information Systems	Conference	3	6%
International Conference on Subject Oriented BPM	Conference	3	6%
The Journal of Systems and Software	Journal	3	6%
World Conference on Technology, Innovation and Entrepreneurship	Conference	1	2%
International Conference on Business Information Systems	Conference	1	2%
Computers in Industry	Journal	1	2%
Total		51	100%

3.2. Contribution analysis

After analyzing the metadata of the selected papers, we moved to the study of the contents of each paper, the nature of the proposed contributions and the provided solutions. As a first observation we see that there are five types of contributions treated and 30% of papers are related to the framework. 25% is dedicated to the measurement type, the 20% are for the methodology type, 15% for the architecture and 10% for ontology type. In each research type, several contributions are proposed.

3.2.1 Measures

Papers in literature have proposed many measures in relation with recommendation systems like [4] proposed a set of metrics quantifying output quality. References [9] presented one of the interesting applications of process mining, which is the predictive monitoring of business process and the aim of it, is the prediction of quantifiable metrics of a running process instance with the generation of predictive models. References [26] discussed

quality metrics to decide which metrics must be used to express and measure conformance. As a conclusion, researchers have to find a balance between them for good process models. References [31] proposed an approach that extract cases descriptors from a stream of events and applied a density-based clustering to detect outliers. it used streaming clustering measures for evaluating performances. References [32] contributed in presenting a novel metric of pairwise similarity between process traces based on time warping.

3.2.2 Methodology

Several methods have been introduced in literature for example, [8] suggested a methodology that can predict the effects of changing business processes and organizational structures through the simulation and derive appropriate and practical organizational structures that execute current processes efficiently through the genetic algorithm. References [24] explored the use of methodologies to guide different types of data analytic projects to successful results in choosing the right methodology. References [25] discussed a methodology for applying recommendation patterns using BPMN model. References [44] described a methodology based on general qualities of a software product which has been applied to evaluate a single product as an example. References [45] presented a methodology that covers an extension of the existing models in order to combine KPIs, goals of the companies, and the decision variables together with business processes; and a methodology based on data mining analysis to verify the correctness of the enriched proposed model according to the data stored during business evolution.

3.2.3 Architecture

The third type that has been treated in the literature is the architecture. References [6] proposed an approach or automatically discovering a business process architecture from a set of event logs. References [7] integrated three models and the technologies that support them in an isolated way, and proposed an architecture that allows to query the three models even if they come from different technologies. References [8] simulated a BP to analyze and manage performance of an enterprise, and in his paper he presented the different architectures of the BP simulation system. References [10] shaped a road-map taking business process data intensive operation to the next level, in order to improve the efficiency and quality of various data intensive business operations using a wide spectrum of merging Big Data systems. References [16] discussed in his systematic review, different papers that treat architecture providing support to manage business processes in BlockChain [17]. proposed a concept of an integrated procedure model (BPMP-PM) for implementing PPM methods in practice, starting from business background analysis until deployment.

3.2.4 Framework

Framework is also an important type of contribution that was treated. [2] proposed algorithm framework discovers the process model and transforms it into a Petri network representation by calculating the distance between traces to build the minimum spanning tree. References [12] presented a Multi perspective configurable process discovery framework in order to enhance configurable process mining, especially the discovery issue. References[19] proposed a framework where mining techniques can be used for identifying abnormal

conditions, and demonstrated the use of process mining for detection of anomalies in the machine breakdown and repair process. References [40] built a seven-dimension framework to develop and guide a review on Process Mining in Business Management. References [42] developed an integrated framework for using data mining techniques and ontology concepts for process improvement.

3.2.5 Ontology

The last type contribution of our study is the ontology, even if it is not treated as much as the others, but some papers were interested in it, like [3] that presented a new ontology based on a real business process to create semantic relationships between all terms. After that, he was based on data mining technique to extract the most important information from data measurement. The approach in [47] relied on the projection of the generic processes along the REA business ontology which focuses on key business abstractions such as resource exchanges and conversions.

Figure 4 shows the distribution of the papers by type of contribution.

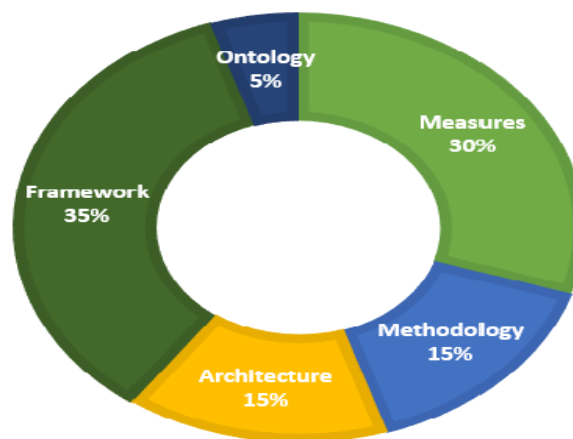


Figure 4: Percentage of contribution types.

3.3. Analysis aspects

There are different aspects identified in the 51 papers treated, which are Analysis and review, design and modelling, implementation and finally verification.

3.3.1 Analysis review

This category corresponds to the papers dealing with the review and analysis of existing studies or the evaluation of new approaches. For example, [1] presented the research results for the bio metric analysis of the evolution of business process management. References [9] joined the analysis of many approaches to provide an overall view of them as well as identify new challenges in the field of predictive monitoring of business processes. References [26] presented a state of art that outline existing concepts and techniques by revealing

aspects of conformance checking to set the theoretical framework and described each of the identified articles key concepts. References [27] conducted an explorative mapping study to analyze the fitting S-BPM for digitalization using a framework. References [29] Related and contributed to the previous researches being conducted in the field of technological development, like examining the Big Data with IA affecting trends, leading to new business strategies and methodologies to regulate the business environment and regulate favorable market conditions. [10] Highlighted several business process data intensive operations along the process lifecycle and discussed BigData system-based solutions to a subset on those analytics operations, by shaping a road-map towards taking business process data intensive operation to the next level. References [16] Presented a systematic literature review in area of Collaborative Business Processes in Blockchain technology domain to identify opportunities and gaps for further research, because it aimed to know what proposals exist to improve any stage of business process management using BCT. References [9] Included a summary of the basic concepts, as well as a global overview of the process predictive monitoring area.

3.3.2 Design and modelling

The modeling aspect is the aspect studied in almost 50% of our papers. References [4] Proposed a process mining algorithms for the identification of the process models from process logs, supporting both process design and compliance monitoring. References [30] Created a pyramid model to depict the trade-off between generalization and specification, in order to understand what is the essence of the context concept in the business process field. References [31] Addressed the problem of finding anomalous cases from an event log at run time, based on different algorithms. References [25] Presented the idea of imperative modeling recommendation patterns in order to tackle the issue of correct process models. References [5] Proposed a general model for collaborative learning processes, and presented a new e-learning system based on BPM. References [6] Provided an approach for discovering a business process architecture from set of event logs. References [34] Discussed insights and challenges for an integrated modeling approach of processes and discussions. References [7] Proposed the use of meta-models, related to the business process, business process instance and business data viewpoints, and the combination between them. References [35] Addressed the problem of multi-instance and item-dependent process modeling, by proposing an algorithm. References [15] discussed free-choice nets in the context of process mining and business process, introduced results for this important class of process models and presented new results for free-choice nets particularly relevant for process mining. References [3] Exploited the knowledge of the domain for business process improvement by using Data mining knowledge and domain knowledge in order to make crucial business decisions. References [17] Proposed a procedure model, which can serve as a step-by-step framework during the implementation and application of PPM.

3.3.3 Implementation

The implementation is also a crucial aspect in our paper. The writer of paper [8] implemented the proposed methodology which of simulating business process with effects of organizational structure and deriving the process-oriented organizational structure, in order to overcome the limitations of existing business process researches and systems that did not reflect effects of organizational structure. References [28] Discussed and analyzed the available tools that can help on detect and react to an unexpected change of behavior in a certain

process, by applying those tools in a real-life environment. References [24] Developed a framework that shows what project methodologies are most useful when considering the motivation of the project and the deployment of the outcome. References [32] Presented a framework uses the associations between similar historic process performances and contextual information to determine the prototypical way of enacting the process.

3.3.4 Verification

This aspect is slightly discussed in our selected papers, but it is also vital and essential. References [23] proposed four approaches treating the similarity measures in a process based on both, models and logs, at the same time, in order to better character business processes. The study in paper [19] depicted the way in which mining techniques can be used for identifying abnormal conditions. It demonstrated the use of process mining for detection of anomalies in the machine breakdown and repair process. References [49] Proposed BProVe, a novel verification approach for BPMN collaborations BProVe that is an approach that relies on a direct formal semantics for BPMN models, avoiding typical problems of approaches based on intermediate encodings.

Figure 5 shows the aggregation of papers per aspects.

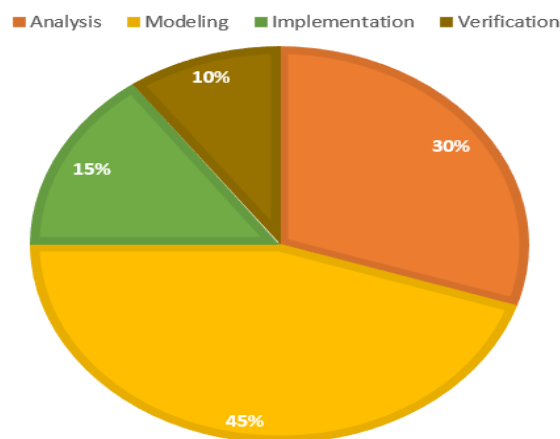


Figure 5: Percentage of adressed aspects.

4. Limitation of the review

In our review, we tried to sort out the most pertinent studies and papers treating business process management and the impact of data mining on it. However, some limitations could have affected the study, like the accuracy and reliability of the research system, because many papers could have not matched the keywords and the title. In order to perform a successful literature review, we have applied exclusion and inclusion criteria, in the data selection process; we created a research string and performed additional actions to have equivalent results at the end. Moreover, search in databases is generally based on keywords existing in the title or the abstract. Some papers could have been missed even if they are dealing with business process management, because they might not be using the same keywords defined in the search string, or simply, they are published in short papers, or because the corresponding papers are written in a language other than English, etc. The result of this review

was retrieved from four database. Thus, we may have missed papers published in other digital libraries like Citeseer or Web of Science; otherwise, they have been ignored because they are certainly not indexed.

5. Conclusion

Business Process Management (BPM) has gained great importance in the last decade and is increasingly used in several contexts (marketing, E-Commerce, E-Health, E-Learning, E-Government ...). Especially, it is important to efficiently manage these processes vital for the organizational performance in order to continually improve, therefore increasing productivity and competitiveness within the organization, and data mining is playing a more and more important role in developing and improving BPM nowadays. The proposed literature review reveals that both BPM and data mining are the primary domains of this study.

As a result of searching studies in four digital libraries, we identified at the beginning 3079 papers. Based on a set of exclusion criteria and quality assessment criteria, 51 relevant papers were selected. The reason we used the four electronic library because they have the biggest repository for academic study and most widely used by researchers. The main objectives of this review was to investigate the different approaches proposed with respect to business process management and the impact of data mining on it , to identify the nature of contributions in this area, to determine the different aspects concerned by this issue and to enumerate all the issues addressed in literature. The analysis of the papers shows that the business process management topic is more oriented design, modeling implementation and analysis where almost 50% of the selected papers were more interested in then modeling aspect. 30% have given more importance to the analysis, 15% implemented their contributions and only 10% payed attention to the verification aspect, which is slightly ignored. In our review, many works have been excluded because they do not validate their contributions, even if the solutions they propose can be potential. To overcome this problem, researchers and practitioners need to collaborate seriously to work on the verification aspect and develop more solutions to increase the chance of having better results. Moreover, this review was limited to business process management and most of the papers, shows the application of data mining techniques in BP, but a more general review of literature could help bring ideas and solutions from other fields and apply them to business process. According to this analysis, we propose as a future work to give more importance to the verification aspect, which has been less addressed in literature, compared to the other aspects like the analysis, the design and the implementation. Moreover, to do so, we need to incorporate recommendation systems for optimizing the results.

References

- [1] H. L-Mora and P. R.P-Sanchez, "The Evolution of Business Process Management: A Bibliometric Analysis," School of Business Administration, Technological Institute of Costa Rica, Cartago 30101, Costa Rica, vol. 9, April2021.
- [2] W. Li, H. ZHU, W. LIU, D. CHEN , J. JIANG , AND Q. JIN, (Senior Member, IEEE), " An Anti-Noise Process Mining Algorithm Based on Minimum Spanning Tree Clustering." *IEEE ACCESS* Shangai, China, 2018, vol6.
- [3] E. A. El H. Amor and S. A. Ghannouchi, "Toward an Ontology-based model of key performance

- indicators for business process improvement " \emph{ IEEE/ACS 14th International Conference on Computer Systems and Applications}, Sousse, RIADI Laboratory-ENSI Manouba, Tunisia, 2017
- [4] S. Debois, T. T. Hildebrandt, P. H. Laursen and K. R. Ulrik, "Declarative Process Mining for DCR Graphs" \emph{the ACM Symposium on applied computing},IT University of Copenhagen, Copenhagen, Denmark, 2017.
- [5] S. Azzouzi, S. A. Ghannouchi and Z. Brahmi, "Modeling of a Collaborative Learning Process with Business Process Model Notation" \emph{International conference on Biomolecular Engineering},Laboratory RIADI-GDL, ENSI, Mannouba, Tunisia, 2017.
- [6] D. Bano, M. Weske and A. Nikaj, "Discovering Business Process Architectures from Event Logs," Hasso Plattner Institute, University of Potsdam, Potsdam, Germany, 2021.
- [7] M. T. G-Lopez, A. M. R. Quintero, L. Parody, J. M. P. Alvarez and M Reichert "An Architecture for Querying Business Process, Business Process Instances, and Business Data Models," Institute of Databases and Information Systems, Ulm University, Ulm, Germany,2018.
- [8] S. Lee, I. Choi, H. Kim, J. Lim and S. Sung "Comprehensive Simulation and Redesign System for Business Process and Organizational Structure"\emph{IEEE ACCESS}, Department of Industrial and Management Engineering, Pohang University of Science and Technology (POSTECH), Pohang 36763, South Korea, vol8, 2020.
- [9] A. E. M-Chamorro, M. Resinas and A. R.-Cortes "Predictive monitoring of business processes: a survey"\emph{IEEE Transaction on Service Computing}, Dpto. de Lenguajes y Sistemas Informaticos, University of Seville,Spain, 2017.
- [10]S. Sakr, Z. Maamar, A. Awad B. Benatallah, W. M. P. Van Der Aalst, "Business Process Analytics and Big Data Systems: A Roadmap to Bridge the Gap"\emph{ IEEE ACCESS} , University of Tartu, Tartu, Estonia, 2018
- [11]A. Djedovic, E. Zunic and A. Karabegovic, "A Combined Process Mining for Improving Business Process"\emph{ICSST}, Sarajevo, Bosnia and Herzegovina, 2017
- [12]R. Sikal, H. Sbai and L. Kjiri, "Configurable Process Mining: A Comparative Study", \emph{ International Conference on Optimization and Application}, AlQualsadi research team, ENSIAS, Mohammed V University of Rabat, Morocco, 2018.
- [13]J. Brunk, "Structuring Business Process Context Information for Process Monitoring and Prediction", \emph{IEEE 22nd Conference on Business Informatics (CBI)}, University of Muenster - ERCIS Leonardo-Campus 3, 48149 Munster, Germany, 2020
- [14]M. O. S. Escobar, R. L. Espinosa, J. M. M. Espinosa, J. J. N. Monroy and G. V. Solar, "Applying Process Mining to Support Management of Predictive Analytics/Data Mining Projects in a Decision Making Center", \emph{ The 2019 6th International Conference on Systems and Informatics (ICSAI)}, 2019.
- [15]W. M.P. van der Aalst, " Free-Choice Nets for Process Mining and Business Process Management" \emph{International Conference on Smart Information and Society}, Process and Data Science (Informatik 9), RWTH Aachen University, Aachen, Germany and Fraunhofer-Institut für Angewandte Informationstechnik (FIT), Sankt Augustin, Germany, 2021.
- [16]J. A.G-Garcia, N. S.-Gomez, D. Lizcano, M. J. Escalona and T. Wojdynski, "Using Blockchain to

- Improve Collaborative Business Process Management: Systematic Literature Review", \emph{ IEEE ACCESS }, August 2020.
- [17] J. Becker, J. Brunk, W. Ding, M. Niemann, "Conceptualization of an Integrated Procedure Model for Business Process Monitoring and Prediction", \emph{ IEEE 22nd Conference on Business Informatics (CBI) }, University of Muenster - ERCIS Leonardo-Campus 3, 48149 Munster, Germany, 2020.
- [18] S. Bharara, A. S. Sabitha and A. Bansal, "A review on Knowledge extraction for Business operation using data mining", \emph{ International Conference on Data and Software Engineering }, Computer science and engg. department, Amity University Uttar Pradesh, Noida, India 2017.
- [19] R. Bhogal and A. Garg, "Anomaly Detection and Fault Prediction of Breakdown to Repair Process Using Mining Techniques", \emph{ International Conference on Intelligent Engineering and Management (ICIEM) }, Department of Computer Science & Engineering, Amity School of Engineering & Technology, University Uttar Pradesh, Noida, India, 2020.
- [20] L. G-Banuelos, N. R.T.P van beest, M. Dumas, M. La Rosa and W. Mertens, "Complete and Interpretable Conformance Checking of Business Processes", \emph{ IEEE Transactions and Software Engineering }, 2017
- [21] F. M. Plumed, L. C. Ochando, C. Ferri, J. H. Orallo, M. Kull, N. Lachiche, M. J. R. Quintana and P. Flach, "CRISP-DM Twenty Years Later: From Data Mining Processes to Data Science Trajectories", \emph{ IEEE TRANSACTIONS ON KNOWLEDGE AND DATA ENGINEERING }, 2021.
- [22] Q. Zhou, B. Xia, W. Xue, C. Zeng, R. Han and T. Li, "An Advanced Inventory Data Mining System for Business Intelligence" in \emph{ IEEE Third International Conference on Big Data Computing Service and Applications, } Automation Department, Xiamen University, Xiamen, Fujian, 361005 China, 2017.
- [23] C. Zhou, C. Liu, (Student Member, IEEE), Q. Zeng, Z. Lin and H. Duan, in \emph{ IEEE ACCESS }, College of Economics and Management, Shandong University of Science and Technology, Qingdao 266590, China, vol 7, 2019.
- [24] J. Baijens, R. Helms and R. Kusters, "Data Analytics Project Methodologies: Which One to Choose?", in \emph{ International Conference on Big Data in Management }, Department of Information Science Open University Heerlen, The Netherlands, 2020.
- [25] M. B. Costa, D. Tamzalit, "Recommendation Patterns for Business Process Imperative Modeling", \emph{ Symposium on Applied Computing }, Software Eng. and e-Commerce Lab. – SEEC Informatics - Federal I. of Espírito Santo Serra – ES, Brazil, 2017.
- [26] S. Dunzer, M. Stierle, M. Matzner and S. Baier, "Conformance checking: A state-of-the-art literature review", Friedrich-Alexander Universität Erlangen-Nürnberg, Nürnberg, Germany, 2019.
- [27] M. Lederer, S. Betz and W. Schmidt, "Digital Transformation, Smart Factories, and Virtual Design – Contributions of Subject Orientation", in \emph{ ICSO conference }, ISM International School of Management Karlstr. 35 D-80333 Munich, 2018.
- [28] N. J. Omori, G. M. Tavares, P. Ceravolo and S. B. Jr., "Comparing Concept Drift Detection with Process Mining Tools", in \emph{ symposium on information system }, State University of Londrina (UEL), Londrina, Brazil, 2019.

- [29] S. Chaveesuk, B. Khalid and W. Chaiyasoonthorn, "Emergence of New Business Environment with Big Data and Artificial Intelligence", Faculty of Administration and Management, King Mongkut's Institute of Technology King, Ladkrabang, Bangkok, Thailand, 2019.
- [30] R. Song, J. Vanthienen, W. Cui, Y. Wang and L. Huang, "Towards a Comprehensive Understanding of the Context Concepts in Context-aware Business Processes" in \emph{ ICSO conference} Department of Information Management Beijing Jiaotong University & KU Leuven Beijing, China, 2019.
- [31] G. M. Tavares, V. G. T. da Costa, V. E. Martins, P. Ceravolo and S. Barbon Jr., "Anomaly Detection in Business Process based on Data Stream Mining" in \emph{ symposium on information system}, State University of Londrina (UEL) Londrina, Brazil, 2018.
- [32] S. Yeng, X. Dong, L. Sun, Y. Zhou, R. A. Farneth, H. Xiong, R. S. Burd and I. Marsic, "A Data-driven Process Recommender Framework", in \emph{ KDD 2017 Applied Data Science Paper}, Halifax, NS, Canada, 2017.
- [33] D. Bano and M. Weske, "Discovering Data Models from Event Logs", in \emph{ international conference on conceptual modeling}, Hasso Plattner Institute, University of Potsdam, Germany, 2020.
- [34] F. Hasic, L. Devadder, M. Dochez, J. Hanot, J. De Smedt and Jan Vanthienen, "Challenges in Refactoring Processes to Include Decision Modelling", in \emph{ International Conference on Business Process Management}, Leuven Institute for Research on Information Systems (LIRIS), KU Leuven, Leuven, Belgium, 2018.
- [35] E. Marengo, W. Nutt a,d M. Perktold, "Construction Process Modeling: Reresenting Activities, Items and Their Interplay", in \emph{ International Conference on Business Process Management}, Faculty of Computer Science, Free University of Bozen-Bolzano, Bolzano, Italy, 2018.
- [36] S. Pauwels and T. Calders, "Bayesian Network based Predictions of Business Processes", in \emph{ International Conference on Business Process Management}, University of Antwerp, Antwerp, Belgium 2020.
- [37] N. Rizun, A. Revina and V. Meister, "Method of Decision-Making Logic Discovery in the Business Process Textual Data", in \emph{ International Conference on Business Information Sytem}, Gdansk University of Technology, 80-233 Gdansk, Poland, 2019.
- [38] W. Rizzi, F. M. Maggi and C. Di Francescomarino, "Explainability in Predictive Process Monitoring: When Understanding Helps Improving", in \emph{ International Conference on Business Process Management}, Free University of Bozen-Bolzano, Bolzano, Italy, 2020.
- [39] M. Weske, M. Montali, I. Weber and J. V. Brocke, "BPM: Foundations, Engineering, Management", Hasso Plattner Institute, University of Potsdam, Potsdam, Germany, 2018.
- [40] P. Zerbino, A. Stefanini and D. Aloini, "Process Science in Action: A Literature Review on Process Mining in Business Management", in \emph{ technological forecasting and social change }, University of Pisa, Department of Energy, Systems, Territory and Construction Engineering, Largo Lucio Lazzarino, 56122, Pisa, Italy, 2021.
- [41] W. Kbaier, S. A. Ghannouchi, "Determining The Threshold Values Of Quality Metrics In BPMN Process Models Using Data Mining Techniques", in \emph{ International Conference on ENTERprise Information Systems}, Higher Institute of Management of Sousse, University of Sousse,

Sousse, Tunisia, 2019.

- [42] M. Khanbabaei, F. M. Sobhani, M. Alborzi and R. Radfar, "Developing an integrated framework for using data mining techniques and ontology concepts for process improvement", in *The journal of Systems and Software*, Department of Information Technology Management, Science and Research Branch, Islamic Azad University, Tehran, Iran, 2017.
- [43] N. Saab, R. Helms and M. Zoet, "Predictive quality performance control in BPM: proposing a framework for predicting quality anomalies", in *International Conference on ENTERprise Information Systems*, Open University, Heerlen, The Netherlands, 2018.
- [44] A. Meidan, J.A. Garcia-Garcia, M.J. Escalona, I. Ramos, "A survey on business processes management suites", in *Computer Standards & Interfaces journal*, 2017.
- [45] J. M. P-Alvarez, A. Mate, M. T. G-Lopez and J. Trujillo, "Tactical Business-Process-Decision Support based on KPIs Monitoring and Validation", *Computers in Industry Journal*, Universidad de Sevilla, Escuela Técnica Superior de Ingeniería Informática, Dpt. Lenguajes y Sistemas Informáticos, Av Reina Mercedes s/n, 41012 Sevilla, Spain, 2018.
- [46] C. Metallo, R. Agrifoglio, F. Schiavone and J. Mueller, "Understanding business model in the Internet of Things industry", in *technological forecasting and social change*, Department of Sciences and Technology, University of Naples 'Parthenope', Centro Direzionale – Isola C4, 80143 Naples, Italy, 2018.
- [47] A. Leshob, H. Mili, J. G-Huerta and A. Boubaker, "A value-oriented approach to business process specialization: principles, proof-of-concept, and validation", in *The journal of Systems and Software*, LATECE Laboratory, University of Quebec at Montreal, Montreal (Quebec) H2X 3Y7, Canada, 2017.
- [48] F. Aydemir, Y. U. Pabuccu and F. Basciftci, "A Hybrid Process Mining Approach for Business Processes in Financial Organizations", in *3rd World Conference on Technology, Innovation and Entrepreneurship*, Dept. of Computer Engineering, Graduate School of Natural Sciences, Selcuk University Konya, Turkey, 2019.
- [49] F. Corradini, F. Fornari, A. Polini, B. Re, F. Tiezzi and A. Vandin, "A formal approach for the analysis of BPMN collaboration models", in *The journal of Systems and Software*, University of Camerino, Via Madonna delle Carceri 7, 62032 Camerino, Italy, 2021.
- [50] A. Hassani, S. A. Ghanouchi, "A framework for Business Process Data Management based on Big Data Approach", in *International Conference on ENTERprise Information Systems*, Laboratory RIADI-GDL, ENSI, Manouba, Tunisia, 2017.
- [51] T. Abbate, F. Cesaroni, M. C. CINICI and M. Villari, "Business models for developing smart cities. A fuzzy set qualitative comparative analysis of an IoT platform", in *technological forecasting and social change*, Department of Economics, University of Messina, Piazza Pugliatti, 1, 98122 Messina, Italy, 2018.
- [52] B. Kitchenham, O. P. Brereton, D. Budgen, M. Turner, J. Bailey and S. Linkman, "Systematic literature reviews in software engineering – A systematic literature review", *the journal of Information and Software Technology*, Software Engineering Group, School of Computer Science and Mathematics, Keele University, Keele Village, Keele, Staffs, ST5 5BG, UK, 2008.