BUSINESS PROCESS MODELLING NOTATIONS TECHNIQUES: A COMPARATIVE STUDY USING AHP

Abstract

The rapid evolution of information systems has triggered drastic changes in business schemes. This phenomenon has led to the rise of Business Process Management. Business Process Management consists of the concepts, methods, techniques and software tools that assist the life cycle of business processes. The implementation of BPM solutions is not an easy task due to the existence of different Business Process Modelling (BPM) techniques. Thus, organizations seek for BPM to make informed decisions about the appropriate technique that fits their needs. In this research, we proposed a new comparison model for selecting the most appropriate Modelling technique using a Multi-Criteria Decision Making Technique, which is Analytical Hierarchy Process (AHP). Precisely, we compare four BPM techniques: BPMN, RAD, IDEF3 and EPC in term of three main criteria which are: Direct Representation, Automation, and Open standards. The results show a ranking list of the selected techniques. According to our analysis, BPMN represents the best technique compared with the designated criteria, followed by Event-driven Process Chain, then RAD and finally IDEF3.

Keywords: Business Process Management, MCDM, Business Process Modelling Notation; BPMN; RAD; RPC; IDEF3

1.0 Introduction

Nowadays, rapid economic scenarios become a critical factor for the competitiveness of organizations. It emphasizes the need to identify the organizations' processes as important elements in reducing costs, improving productive quality, focusing on the operational dynamics to provide automated solutions for their processes (Mendling, 2016). During the last decade, many research efforts have been focusing on optimizing and providing constant innovation of these techniques, resulting in a significant competitive advantages for the organizations in their market (Krishna and Emmanuel, 2015, Spanyi, 2015, Conger, 2015, Duipmans and Pires, 2012). Organizations use Business Process Management to support and maintain their practices and solutions, which promote the integration of business processes with people and systems, through a continuous and transparent flow of information. Accordingly, Business Process Management is not a product or a tool or software, but an approach to achieve a business strategic objectives (Jeston, 2014).

A business process is defined as "A structured and measured, managed, and controlled set of interrelated and interacting activities that uses resources to transform inputs into specified outputs" (Kalpič and Bernus, 2006). Modelling business processes is the activity of representing the current state (As-Is) and the future state (To-Be) processes for comparison and contrast, so as to allow the analysis and improvement to reach the desired situation, these models are built by business analysts and managers (Kalpič and Bernus, 2006). This study defines a reference for decision makers to adopt the business Modelling technique that best suits their needs by assigning different weights to each of the criteria evaluated in this comparative study as a complement to the decision-making process.

The overall purpose of this work is to propose a new model for selecting the most appropriate BPM technique based on three main criteria which are: Direct Representation, Automation and Open standards. Specifically, this paper proposed model to evaluate the various techniques and compare them, then, draw conclusions from the comparison to determine what technique is best for the BPM of the organization.

The rest of this paper is organized as follows. Section 2 describes related works; Section 3 provides a description of the evaluated BPM techniques, Section 4 presents our comparison criteria in details. Section 5 involves the evaluation model, section 6 presents evaluation and results, and finally the conclusion and future work are made in Section 7.

2.0 Literature Review

In this section, we review related work in the areas of business process management that compare different Modelling techniques, as well as their methodologies and conclusions. Then we discuss the Multi-Criteria Decision Making techniques (MCDM). in terms of comparative studies, there were a limited recent papers which cover a large numbers of BPM techniques, in this section, we list some of these studies. Authors in (Weske, 2007) review only three BPM approaches, which are the Object Management Group (OMG) standard BPMN in its latest version 2.0, and the workflow models and their reference implementation Yet Another Workflow Language (YAWL). They show how the three methods fail to give practitioners a fitting exactly means and constantly to capture business scenarios and to examine, communicate and control the resulting models. On the positive side, they extract from their review six criteria which can support to identify effective tool-supported business process specification and Modelling techniques.

(Geambaşu, 2012) conducted a comparison study of the current BPM technique to in choosing the right choice. Their study comes to prove the previous researches that have assessed BPM techniques. The comparison presented in this work is concentrated only on two graphical techniques for business processes which are: BPM and Notation (BPMN) and Unified Modelling Language (UML). The comparison criteria selected for the study were the capacity of being easily understandable, the capacity of the graphical elements of BPMN and UML to describe the actual business processes of an organization and the ability to map with business process execution languages. The final results of comparison and evaluation between BPMN and UML AD against each of these three criteria conclude that both BPMN and UML AD were equally in terms of the ease of understanding by the stakeholders involved in BPM. in terms of the Workflow Patterns framework, both techniques showed that they provide similar solutions for most of the proposed patterns. The complexity of the graphical symbols utilized to describe the actual business processes of an organization, both of techniques use similar symbols to describe business processes.

(Pereira and Silva, 2016) conducted a state-of-the-art study of the related literature was made to provide a comparative study of five BPM languages to emphasize their strengths and significant weaknesses of each one, to draw a comparative view between them. Authors have produced a comparative framework in which each one of the languages is defined regarding a number of related criteria. Then, they developed a prototype to verify the proposed framework and to assist users in determining a suitable BPM language, based on their specific needs.

2.1 Multi-Criteria Decision Making

Multi-criteria Decision Making (MCDM) techniques aid decision-making process in examining different tools selection criteria, assessing CASE tools alternatives and making desired preferences (Majumder, 2015). There are numerous methods of MCDM, some of these methods have complicated mathematical models, which often depend on the termination of subjective parameters, or performing complicated mathematical routines. Because of this, many companies avoid using these methodologies and continue to use traditional methods of decision, which depend on the feeling and expertise of the decision maker, which have the probability of success of failure (Medineckiene et al., 2015). These traditional methods can be improved through the use of MCDM.

Due to the development of high-performance computing and usable software, the decision maker can now clearly express their preferences, without thinking of the mathematical algorithm behind these methods. Various MCDM techniques have been created for this purpose, include -but not limited to- The Analytical Hierarchy Process (AHP) and Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE) (Saaty, 2008, Behzadian et al., 2010). In this work, we choose AHP technique for its simplicity and accuracy. More details about this technique in section 5.

3. Evaluated BPM Techniques

BPM is an abstract representation of real business process. Stakeholders adopt business process models for various purpose such as; understanding, communicating, improving, developing, automating, managing or executing a process (Sadiq et al., 2007). The best BPM technique that enable and matches these focus or objectives should be designated, it should also be able to provide the required information elements to its users (Bandara et al., 2005).

Many popular techniques are available for the purpose of business processing Modelling. Some of the most common techniques are: BPM Notation (BPMN) (Bandara et al., 2005), Data Flow Diagram (DFD) (Kang et al., 2015), IDEF family of languages (IDEF0, IDEF3) , Role Activity Diagram (RAD) (Van Der Aalst, 2013), Activity Diagram and Event-driven Process Chain (EPC) (Riehle et al., 2016). In this study, we choose BPMN, RAD, IDEF3 and EPC to evaluate their strength in capturing informational process perspective along with other perspectives for a process, we intend to cover a wide range of techniques in the future work. The following section provides a brief description of the designated techniques.

3.1 BPM Notation

BPM Notation (BPMN) was developed by the Business Process Management Initiative (BPMI) which is a non-profit organization. The first specification of the BPMN standard was published in May 2004. Then in June 2005, the BPMI merged with OMG to work together on BPM issues.

BPMN defines a business process diagram based on a technique that utilizes flowcharts for creating graphical models of business process activities. A business process model is a network of graphic objects that represent these activities (e.g. tasks) and the flow controls define their order of execution (Bandara et al., 2005).

The primary goal of BPMN was to provide a notation that is readable and understandable for all business users, from the analysts who carry out the initial design process to the responsible of developing the technology to run these processes by business managers and control and monitor these processes. BPMN also supports an internal model to generate executable Business Process Execution Language for Web Services (BPEL4WS) (Betke et al., 2013). Thus, BPMN constructs a standardized bridge for the gap caused by differences between the business processes design and implementation.

3.2 Role Activity Diagram Language

Role Activity Diagram Language (RAD) was initially developed for Modelling work coordination in programming environments, but today it is most widely used in BPM for the existing process (As-is) and the future target process (To-be). RAD was created in 1986 by Ould and Roberts, who integrates the systematic technique roles and interaction models (STRIM) methodology. STRIM was also developed by Ould and Roberts research processes Modelling group. It identified five elements necessary for forming processes: roles, actors, interactions, activities and entities of the functions. Responsibilities assigned to an individual actor which is the process individuals or systems that perform specific functions at some point in time. Interactions are the elements responsible for synchronization, communication and data exchange between actors in the process. Activities are the elements that represent what and when a particular actor in performing its role. Finally, entities represent what objects send to each other through their interactions (Van Der Aalst, 2013).

In RAD, a process is charted in columns. Each column describes a role. Multiple columns imply that many roles can perform simultaneously. The vertical dimension of every column represents temporal priority ordering. In each column, many steps are applied. A process step is an activity to be conducted by the role. Each role has technique presents a role-centric view of business processes. It does not provide detailed information of activities and objects.

3.3 Event-driven Process Chain language

Event-driven Process Chain language (EPC) is also one of the Modelling languages of business processes that is most used worldwide. EPC was developed in 1992 by researchers at the University of Saarland in partnership with SAP, one of the world powers in integrated software production management. This language has grown and expanded, even becoming one of the most recognized Modelling notations processes (Mendling, 2008). EPC is based on basic concepts of Petri nets (classic Modelling notation for distributed systems). Like most of the notations for Modelling processes, the EPC also utilizes the flowcharts to represent logical and temporal dependencies between activities in the construction of business processes (Riehle et al., 2016). The main focus of the EPC notation is to provide its users a graphical representation of organizational processes in an intuitive way, quick and easy understanding for the analysts and business personnel. In addition, the EPC is the main language for representation of business processes methodology of ARIS (Architecture of Integrated Information Systems), which combines the features relating to business (systems, data, etc.) and arranges them in order to ensure the development of activities sequences / tasks that produce value.

This notation is constituted by a set of basic and complex elements, the first set consists of functions, events, logical connectors and flow control, while the set of elements is represented by units/ functions, objects of complex information organization and delivery of objects. Events are responsible for carrying out the start of the process, which defines the state of the process or terminate the same preconditions mechanisms, which constitutes and post-conditions of a function. No situations can occur with two successive events and each event most have only one inlet and one outlet. Functions are elements that aim to represent the activities or tasks present in the business process. Generally, these activities are performed by people or systems. A function can be activated by an event of predecessor and may lead to one or more successors events.

3.4 Integrated DEFinition for Process Description Capture Method

Integrated DEFinition for Process Description Capture Method (IDEF) technique was specifically developed to describe the dynamic aspect of business processes and in order to facilitate the study and description of information systems. It is a technique that focuses on the temporal aspect of the process and to respond to the need identified previously in IDEF0 (Carnaghan, 2006). It describes two types of Modelling languages, one with the aim of describing the workflows of business processes and the other to define the state transitions of objects. Our research approach focuses more on the first type and for IDEF3 which describes a process as a sequence of activities. IDEF3 activities are recognized as units of behaviour, and relationships between activities are called precedence link. In addition there are also elements that control the flows which make divisions or seams along the workflow (Dumas et al., 2013).

This technique is very similar in composition elements to UML Activity diagrams, with the exception of events which do not have their own representation, for instance, there are no structures to represent the beginning and the end of the process explicitly. IDEF3 annotations are used to highlight the importance of functional decomposition processes and encourage their use. What is not always a good practice because if the process is long and complex it has to be divided into a lots of diagrams and sometimes it may be very difficult to understand and to get an overview of the process (although if the diagram root does not have great depth to give a highly structured process concept). For all reasons, IDEFs diagrams often accompanied with a tree diagram that describes the relationships between the various diagrams.

4. Comparison Criteria

As mentioned above, the BPM has a great impact on the success of any BPM project. For this reason, the choice of the appropriate Modelling language is not indifferent and must depend on the specific objectives of the Modelling project, which is to develop a simple documentation of business processes with a representation of their communication and dissemination among stakeholders.

Modelling processes also provides a further optimization of their operation. The four Modelling business processes languages succinctly presented in the previous sections have different characteristics, advantages and limitations. The important step now is to find a proper methodology and criteria to compare their differences and similarities in a systematic way. Our comparison criteria are defined in three categories that constitute the pillars of MDA (Model Driven Architecture). These criteria were proposed by IBM in MDA Manifesto (Selic, 2008). Which are: (I) Direct representation which focuses on the problem domain, (II) Automation of tasks and (III) Open standards that allow interoperability of tools and platforms. Table 1 presents a summary for these criteria with their acronyms.

4.1 Direct Representation

This main category refers to the reduction of semantic gap between the problem domain and their representation in a model, so that permits a direct coupling of the solutions to the problems which will be built. It contains the following sub-criteria:

4.1.1 Adoption of Computation Independent Model (CIM)

CIM refers to the Modelling from a computation independent viewpoint, CIM is a model of a system which represents the system in environment in where it will operate, and as such it helps to show what is expected from the final system.

4.1.2 Structure and Behaviour

The ability to represent the structural and organizational behaviour through business process views.

4.1.3 Business Rules

Support of business rules Modelling, due to the highly changeable nature of these elements in the evolution of business processes and models, users should be able to visualize and manipulate them clearly.

4.1.4 Roles

The ability to represent the different roles that perform different functions in business processes.

4.1.5 Business Objectives

Ability to represent business objectives, inputs and outputs information on the process activities, either in the form of documents (structured information) or messages (unstructured data).

4.1.6 B2B (business to business)

the ability to represent business to business (B2B) interactions, so that assuming collaborated external organizations as an external role in the process.

4.1.7 Usability

Usability for non-technical stakeholders, such as business analysts, managers or process designers. These stakeholders are the ones who know the business, and often is part of the same processes.

4.2 Automation

In this category, we measure the ability of business Modelling techniques to support the automation of software development tasks. It ensures how the productivity could increase, and the required effort is reduced. It is one of the fundamental purposes of the emerging discipline of engineering models. It involves the following sub-criteria:

4.2.1 Methodological support

Support for business Modelling and process execution to provide a clear and concise guidance on how to build a model that represents the business in all material respects.

4.2.2 Modelling-implementation gap

The gap between Modelling technique and execution of business processes. Business models must be ready to enable the automation of business processes.

4.2.3 Runtime

Existence of a runtime infrastructure environment or standard execution of business processes model. Process models should have a direct mapping to the production environment where they will maintain the processes.

4.2.4 Service Oriented Architecture (SOA)

Compatibility with current strategies for composite business applications architectures, such as SOA, which characterized as a distributed, loosely coupled and direct support for business processes.

4.3 Open standards

In this category, each Modelling technique assesses the ability to promotes the development of an ecosystem of interoperable tools for different purposes. It consists of the following sub-criteria:

4.3.1 Industrial Consortium Support

Support by a consortium of open standards recognized by the industry, by measuring the experience of the tool in the field.

4.3.2 Meta-model available

Existence and availability of meta-model which adopted by the OMG (Object Management Group) to enable the transformation of models.

4.3.3 Modelling Framework

Implementation of meta-model in a Modelling framework as proposed by (Behzadian et al., 2010), and the use of transformation tools to facilitate the mapping of other types of models on other levels of abstraction.

4.3.4 Open source tools

Existence of open source tools that support the technique to obtain the benefit of the communities that provide free software development.

5. Methodology

The rating given to the comparative study is based on the application of a case study developed by each of the techniques described in Section 2. the case study is regarding the Ph.D. Proposals Submission and Acceptance Process in Information System Department (IS-Dept.)- Computer and information systems College (CCIS), King Saud University. The business objective of this case study is to ensure effectiveness and efficient of the procedure. The main stakeholders identified in the business process are the Ph.D. Candidate, Advisor, IS-Dept. PhD. Committee, IS-Dept. Council, CCIS Ph.D. Council and Review Panel member. To evaluate the techniques, we collect and analyse judgments from ten BPM experts, which are members of King Saud University, Vice Rectorate for Planning and Development, Quality & Development Deanship to measure the relative importance of each criterion using ExpertChoice to calculate the final priority and check the consistency. Table 5 shows the total ranking of the criteria by the evaluated techniques while the average of the ranks illustrates the level of adoption of each criterion on a scale of one to five. The averages by category shows how the business Modelling techniques are evaluated concerning the direct representation, automation and open standards.

6. Evaluation Model

In this section, we will analyse the three BPM techniques to determine the most appropriate one among them. We will examine the three systems based on the proposed criteria. We applied a multi-criteria decision making (MCDM) technique.

Many MCDM methods can be used for the selection process; however, here we applied The Analytical Hierarchy Process (AHP). Although, some additional features working for choosing AHP for the selection process have also been considered. AHP is an appropriate technique, especially when a limited number of alternatives needs to be assessed (Saaty, 2008, Majumder, 2015).

The first phase is the to prepare an evaluation task in which we should analyse user needs, assumptions, and limitations associated with the three techniques. The second phase is to identify and select the evaluation criteria relevant to these techniques.

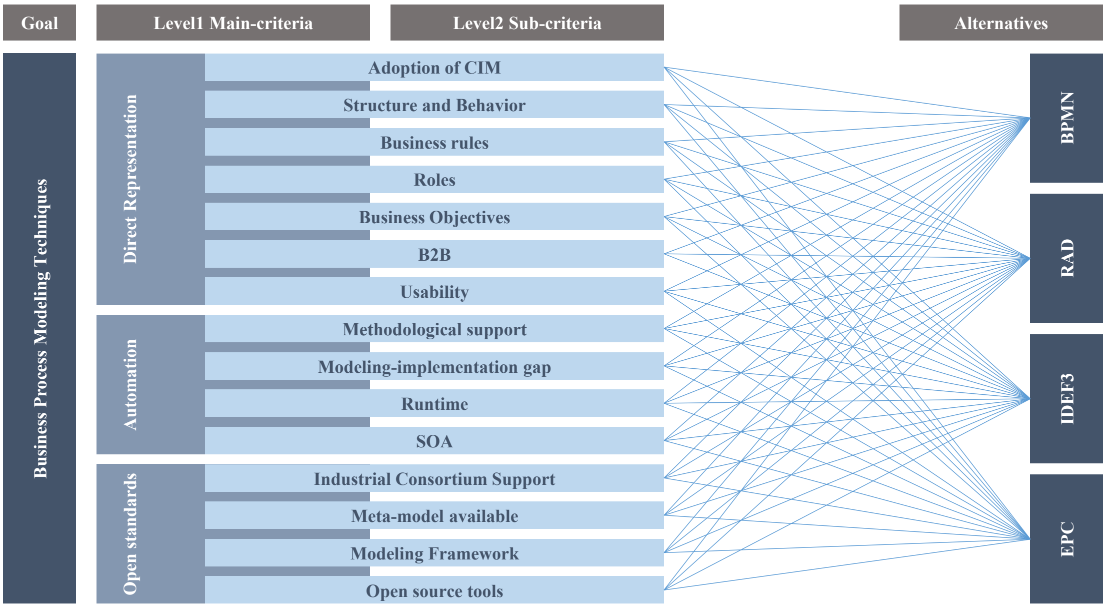

Figure 1. Hierarchy model for selecting the best BPM techniques.

In this respect, we developed the four main criteria and fifteen sub-criteria which discussed in section 4. Figure 1 presents the proposed hierarchy model for selecting the best BPM technique based on AHP technique.

6.1 Analytical Hierarchy Process (AHP)

AHP is a type of MCDM techniques, which break down a complex MCDM problem into a decomposed hierarchy (Saaty, 2008). Figure 2 shows the main steps of to apply AHP which usually consists of defining a goal, Structure elements in criteria, sub-criteria, alternatives, etc., Make pair-wise comparison of elements in each group Calculate weighting and consistency ratio, Evaluate alternatives according

to their weighting, getting ranking values, and making the final decision. AHP steps are discussed as follow:

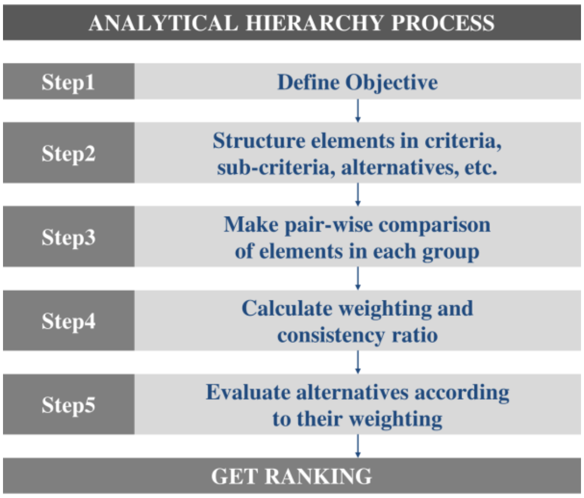

Figure 2. AHP Steps.

6.1.1 Modelling the Problem

AHP decomposes a complex MCDM problem into a hierarchy model as illustrated in Figure 1, with the goal of evaluating and selecting the most appropriate BPM technique at the left. The alternatives (BPMN, EPC, RAD and IDEF3) at the right, and the criteria (Direct Representation, Automation and Open standards) and sub-criteria (Adoption of CIM, Structure and Behaviour, Business Rules, ... etc.) in the middle.

Main Criteria	Acronyms	Sub-Criteria
Direct Representation	R1	Adoption of CIM
	R2	Structure and Behaviour
	R3	Business rules
	R4	Roles
	R5	Objectives and E/S
	R6	B2B
	R7	Usability
Automation	A1	Methodological support
	A2	Modelling-execution gap
	A3	Runtime
	A4	SOA
Open Standards	E1	Support Industrial Consortium
	E2	Meta-model available
	E3	Modelling Framework
	E4	Open source tools

Table1. Comparison Criteria.

Applying pair-wise comparison

In this step, we compare all the items of each level in the hierarchy. This comparison produces a matrix of relative rankings for each level. This matrix usually called "judgment matrix". The matrix satisfies the relation = 1/aji as follows:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \qquad (1)$$

The order of the matrix is dependent on the number of elements at its connected lower level. The pair-wise comparison is conducted based on Saaty scale described in Table 2.

Computing Eigenvector

Once pair-wise comparison is completed, eigenvectors are calculated. The eigenvector is measured by dividing each element of the matrix by the sum of its column elements. It is important to notice that the eigenvectors represent the relative weights between the alternatives (BPMN, EPC, RAD and IDEF3).

Computing Consistency Index

Consistency Index (CI) of matrix order n represents the size of the matrix. It can be computed using the formula 2, where λmax is the largest eigenvalue of matrix order n:

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (2)$$

Computing Consistency Ratio

The Consistency Ratio (CR) compares the consistency index with the Random Consistency Index (RI). It can be computed using formula 3. As shown in Table 3, RI is generated from a sample size of 500 matrices:

$$CR = \frac{CI}{RI} \qquad (3)$$

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equality to the objective
3	Moderate importance	Slightly favouring one over another
5	Strong importance	Strongly favouring one over another

7	Demonstrated importance	Dominance of one demonstrated in practice
9	Extreme importance	Evidence favouring one over another of higher possible order of affirmative
(2, 4, 6, 8)	Intermediate value	When compromise is needed

Table 2. Saaty's scale for pair-wise comparisons.

Reciprocal (1/3, 1/5, 1/7, 1/9) If attribute i has one of the above numbers assigned to it when compared with attribute j, then j has the value 1/number assigned to it when compared with i. More formally if $nij = x$, then $nji = 1/x$.

No.	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Table 3. Random index values for matrices of different orders.

If the value of consistency ratio is smaller than or equal to 10%, the inconsistency is acceptable. For $n = 3$, the threshold is set to 0.05 and, for $n = 4$, threshold is set to 0.08. For $n \geq 5$, if the Consistency ratio CR is greater than 10%, the judgment needs to be revised (Ergu et al., 2011).

Computing Final Ranking

The final ranking is calculated using the following formula:

$$Pi = \sum_{i=1,j=1}^{i=n,j=m} Wij * Ci \qquad (\mathbf{4})$$

where *n* is the number of criteria and *m* is the number of alternatives. The alternative with the greatest priority value is considered as the most appropriate solution for a decision problem while the alternative with the lowest priority value is the least appropriate for the given decision problem.

Comparison Scale

Table 4 shows the scale of values used in the comparative analysis. The scale is based on the level of support of the techniques for each comparison criteria.

No.	Name	Support Level
1	Null	Not supported, not documented

2	Poor	Supported with little or no documentation
3	Regular	Supported and documented, but hardly applicable
4	Good	Supported, documented and readily applicable
5	Excellent	Supported, documented and easily applicable

Table 4. Comparison Scale.

No.	Criterion	BPMN	EPC	RAD	IDEF3	Total
R1	Adoption of CIM	5	4	5	5	4.75
R2	Structure and Behaviour	4	4	4	3	3.75
R3	Business rules	3	3	1	1	2
R4	Roles	5	2	5	1	3.25
R5	Objectives and E/S	4	5	2	1	3
R6	B2B	5	3	3	1	3
R7	Usability	5	3	3	3	3.5
Direct Representation Criteria Avg.		4.4	3.4	3.3	2.1	13.2
A1	Methodological support	3	4	3	4	3.5
A2	Modelling-execution gap	5	3	1	1	2.5
A3	Runtime	5	2	1	2	2.5
A4	SOA	5	1	1	2	2.25
Automation Criteria Avg.		4.5	2.5	1.5	2.3	2.7
E1	Support Industrial Consortium	5	3	4	4	4
E2	Meta-model available	5	3	1	3	3
E3	Modelling Framework	5	2	1	1	2.25
E4	Open source tools	5	3	1	1	2.5
Open Standards Avg.		5.0	2.3	1.8	2.3	2.85
Final Ranking		69	43	36	33	45.25

Table 5. Comparative analysis.

7. Analysis and Results

We attempted to utilize AHP technique for the selection one of the most appropriate BPM technique that we investigate in this work. We explained the analysis through AHP. Figure 1, presents the hierarchy model for our criteria of selecting BPM technique consisting of 4 levels. Level 0 represents the goal of our study, "selecting the most appropriate BPM technique". Level 1 consists of 3 main criteria which are Direct Representation, Automation, and Open standards. Level 2 contains the sub-criteria, and the last level is the alternative techniques.

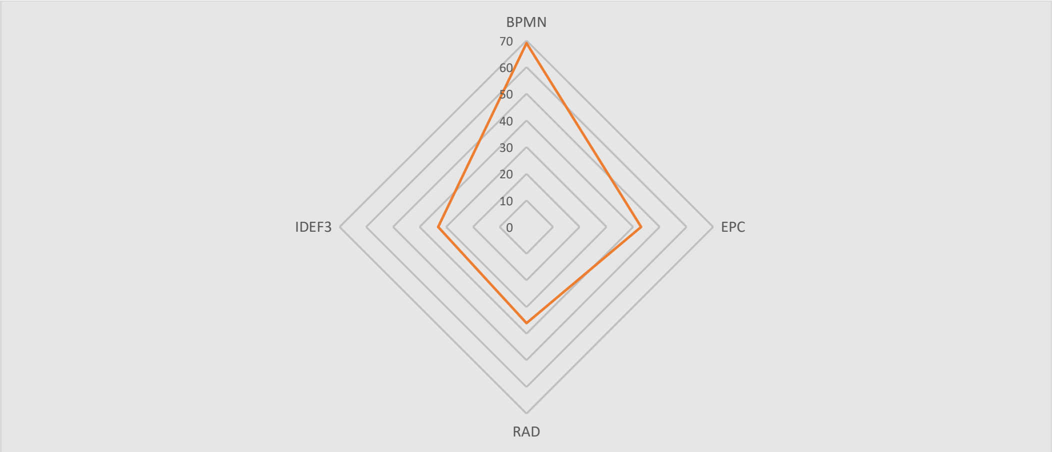

Figure 3. Final Ranking.

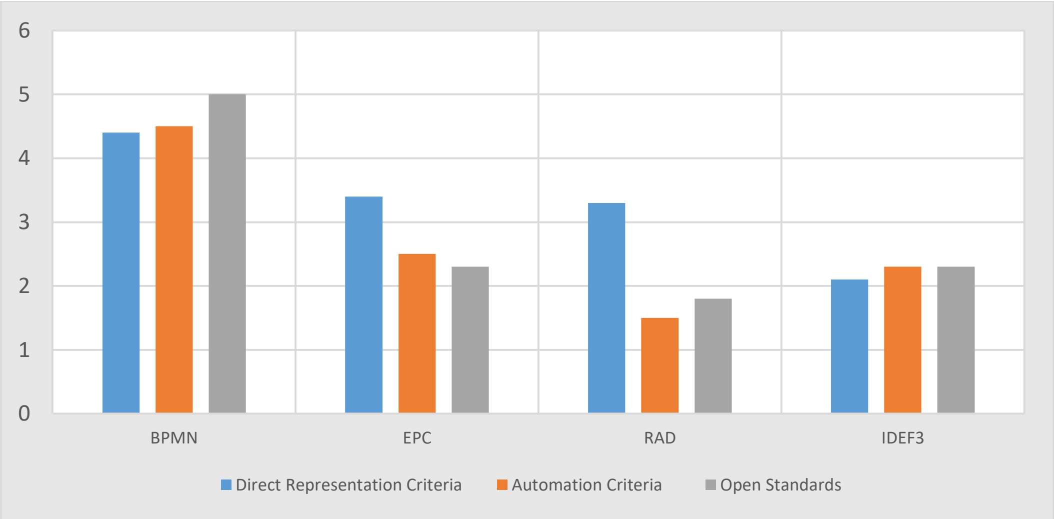

Figure 4. Ranking of techniques based on main criteria.

Figure 3 presents a radar chart for the final ranking of the alternatives which were BPMN (69) represents the most preferable BPM technique, followed by EPC (43) with a priority vector of (43). RAD gets the third place with priority vector of (36), and finally with priority vector of IDEF3 (33). The table also shows the relative importance of the main criteria and the sub-criteria. The total of average values of direct representation criteria is (13.2), followed by Open Standards (2.85) and finally, automation criteria with total average of (2.7). In terms of main-criteria. Figure 4 shows that the top values are for BPMN. While EPC and RAD where almost equally in the direct representation criteria and open source standards, finally, IDEF3 have equal ranking for automation and open standards criteria. In terms of sub-criteria and based on table 5, the top values are for the Adoption of CIM criterion with total value (4.75), followed by structure and behaviour (3.75) and Roles (3.25).

Conclusions and Future Work

Due to the existence of different business process modelling techniques that are available, organizations seek for to make informed decisions about the appropriate technique that fits their needs. In this paper, four business process modelling techniques were compared according to three criteria: Direct Representation, Automation and Open Standards. According to our analysis, BPMN represents the best technique compared with the designated criteria, followed by Event-driven Process Chain, then RAD and finally IDEF3. As a future work, we intend to cover more business process modelling techniques, apply it into more general case study, involve a larger number of BPM experts and enhance the comparison criteria.

References

BANDARA, W., GABLE, G. G. & ROSEMANN, M. 2005. Factors and measures of business process modelling: model building through a multiple case study. *European Journal of Information Systems*, 14**,** 347-360.

BEHZADIAN, M., KAZEMZADEH, R. B., ALBADVI, A. & AGHDASI, M. 2010. PROMETHEE: A comprehensive literature review on methodologies and applications. *European journal of Operational research*, 200**,** 198-215.

BETKE, H., KITTEL, K. & SACKMANN, S. Modelling Controls for Compliance--An Analysis of Business Process Modelling Languages. Advanced Information Networking and Applications Workshops (WAINA), 2013 27th International Conference on, 2013. IEEE, 866-871.

CARNAGHAN, C. 2006. Business process Modelling approaches in the context of process level audit risk assessment: An analysis and comparison. *International Journal of Accounting Information Systems,* 7**,** 170-204.

CONGER, S. 2015. Six sigma and business process management. *Handbook on Business Process Management 1.* Springer.

DUIPMANS, E. & PIRES, D. L. F. 2012. Business process management in the cloud: business process as a service (BPaaS). *University of Twente*.

DUMAS, M., LA ROSA, M., MENDLING, J. & REIJERS, H. A. 2013. *Fundamentals of business process management*, Springer.

ERGU, D., KOU, G., PENG, Y. & SHI, Y. 2011. A simple method to improve the consistency ratio of the pair-wise comparison matrix in ANP. *European Journal of Operational Research,* 213**,** 246-259.

GEAMBAŞU, C. V. 2012. BPMN vs UML activity diagram for business process Modelling. *Accounting and Management Information Systems,* 11**,** 637-651.

JESTON, J. 2014. *Business process management,* Routledge.

KALPIČ, B. & BERNUS, P. 2006. Business process Modelling through the knowledge management perspective. *Journal of Knowledge Management,* 10**,** 40-56.

KANG, P. S., ABOUTALEB, A., SILVA, C. U., DUFFY, A., ERHART, A. & TODESCHINI, V. Process control parameters evaluation using discrete event simulation for business process optimization. 2015. Proceedings of the 64th IWCS Conference.

KRISHNA, T. P. S. & EMMANUEL, M. 2015. Optimizing business processes using process mining techniques. *Data Mining and Knowledge Engineering,* 7**,** 39-41.

MAJUMDER, M. 2015. Multi criteria decision making. *Impact of urbanization on water shortage in face of climatic aberrations.* Springer.

MEDINECKIENE, M., ZAVADSKAS, E. K., BJÖRK, F. & TURSKIS, Z. 2015. Multi-criteria decision-making system for sustainable building assessment/certification. *Archives of Civil and Mechanical Engineering,* 15**,** 11-18.

MENDLING, J. 2008. Event-driven process chains (epc). *Metrics for process models.* Springer.

MENDLING, J. From Scientific Process Management to Process Science: Towards an Empirical Research Agenda for Business Process Management. ZEUS, 2016. 1-4.

PEREIRA, J. L. & SILVA, D. 2016. Business process Modelling languages: a comparative framework. *New Advances in Information Systems and Technologies.* Springer.

RIEHLE, D. M., JANNABER, S., KARHOF, A., THOMAS, O., DELFMANN, P. & BECKER, J. 2016. On the de-facto Standard of Event-driven Process Chains: How EPC is defined in Literature. *Modellierung 2016*.

SAATY, T. L. 2008. Decision making with the analytic hierarchy process. *International journal of services sciences,* 1**,** 83-98.

SADIQ, S., GOVERNATORI, G. & NAMIRI, K. Modelling control objectives for business process compliance. International conference on business process management, 2007. Springer, 149-164.

SELIC, B. 2008. MDA manifestations. *The European Journal for the Informatics Professional,* 9**,** 11-16.

SPANYI, A. 2015. The governance of business process management. *Handbook on Business Process Management 2.* Springer.

VAN DER AALST, W. M. 2013. Business process management: a comprehensive survey. *ISRN Software Engineering,* 2013.

WESKE, M. 2007. Business Process Management–Concepts, Languages, Architectures, Verlag. Berlin.