Towards a thorough evaluation framework of Software Tools Suitable for Small and Medium size Enterprises focusing on Modelling and Simulating Business Processes

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Abstract: Although Business process modelling is an increasingly popular research area for both organisations and enterprises due to its usefulness in optimizing resources management, business reengineering and business performance, it is not yet widely accepted in Small and Medium size Enterprises (SMEs), which are vital for sustainable economy development. The understanding of Business Process is an essential approach for an Organization to achieve set objectives and improve its operations. It has been able to show Business Analysts, and Managers where bottleneck exists in the system, how to optimize the Business Process to reduce cost of running the Organization, and the required resources needed for an Organization. This is clear for large scale organizations and enterprises but under research investigation for SMEs. Business Process Modelling (BPM) is a representation of the processes of the Organization. Several modelling techniques have been proposed and used to capture the characteristics of business processes. However, limited guidelines exist for selecting appropriate modelling techniques based on the characteristics of the problem and its requirements. This is even more accurate in the case of selecting proper BPM software tools to achieve those BPM modelling and simulation goals. This paper aims at presenting a comparative analysis of some relatively popular business process modelling techniques focusing on the associated software tools. The comparative framework proposed is based on the following major criteria: data flow capability, logical reasoning and understandability, specification of roles, and capability of simulation, flexibility and ease of use, simulation support and scope. However, the emphasis of this investigation is put on SME applicability of these tools and techniques. Therefore, the first goal is to define proper selection criteria for the application of BPM tools to SMEs. The proposed framework can serve as the basis for evaluating further modelling techniques and generating selection procedures focusing on a comparison of existing tools to implement these techniques properly for SMEs.. This is to enable a potential user/modeller choose the right technique and tool in modelling critical SME Business Processes in order to analyse and optimize its operations.

Keywords: Business process, modelling requirements, SMEs, software evaluation, Business process modelling tools

1. Introduction

BPM has gained prevalence during the last decade. It evolved from a series of approaches to improving business performance including Total Quality Management, Business Process Reengineering and Six Sigma (Harmon 2010). The proliferation of Enterprise Resource Planning systems has been one major reason for BPM's increasing prominence (Al-Mudimigh 2007). While it has inherited many of the principles of the above predecessor approaches, BPM represents a more holistic discipline as opposed to a single structured methodology, toolset or software type (De Bruin and Rosemann 2005). Although BPM is a broad discipline, there are a small number of concepts at its core. BPM recognises the capacity to separate the definition, design, analysis and refinement of processes from their execution. While much of the available research provides good guidance to larger, established organisations, there is less commentary addressing the challenges of and approaches to adoption of BPM within Small Businesses in the early stages of their establishment. Small businesses often operate under considerable cost and time pressure, with constrained human resources and have limited access to skills (Fogarty and Armstong 2009). These characteristics can negatively impact the adoption of BPM within Small Businesses. On the other hand, Small Businesses often have tight integration of activities, a strong work ethic and rapid decisionmaking; factors that can positively impact BPM adoption and effectiveness (Kirchmer 2011b). Recently, a number of authors attempted to address this topic with case studies conducted in a number of small and medium businesses (SMEs). Chong (2007) conducted an exploratory study on barriers to adopt BPM techniques within SMEs in the wine industry in Australia. Imanipour et al. (2012a, b) looked into inhibiting factors for BPM adoption within the Iranian E-Retail industry. While Bazhenova et al. (2012) explored the use of BPM and adaptive technologies in SMEs in emerging economies.

Experts in Business analysis and Information System Analysis have both drawn the conclusion that the success of a system starts with a clear understanding and knowledge of the Business process of the organisation (Aguilar-Saven, 2003). The Business Process Model provides a platform for the analysis of the processes to be carried out. Business Process Modelling is a method commonly used in organizations to increase awareness of the business process, and to simplify the complexity of the organization by disaggregating the process (Recker, Indulska, Rosemann, & Green, 2009).

On its own, Business Process Modelling is not an improvement tool; it is simply a means to an end. It outlines the activities carried out in the organisation, providing a framework for improvement to be carried out. Business Process Modelling techniques are used to design of the process model; and are implemented using software tools.

With the rapid growth and embrace in IT from the 1990s to this present time, BPM has gained more popularity in organisations. This has led to the growing number of Business Process Modelling tools, techniques, and methodologies. These different techniques of Business Process Modelling have their distinct uses and purposes. Due to the lack of guide, and a numerous presence of approaches, selection of the right tool and techniques has become more complex for organisations. One of the major questions that should be answered by the ongoing research in this field is whether mainstream BPM tools, techniques and technologies could be successfully applied in a SMEs

Business environment and what are the advantages of applying BPM in SMEs Business.

In view of this, a critical comparison of the Business Process Modelling techniques and tools is attempted in this paper, towards an in depth analysis of their applicability in the SMEs business environment. This is to enable SMEs to understand the right techniques and tools to use, as well as the pitfall of these techniques. Modelling of a Business process is used in detecting constraints of a system and providing a framework for carrying out continuous improvement of an Organization. This is more relevant to large organizations but is yet to be defined in SMEs. This study aims at providing background knowledge on the Business Process Modelling Techniques and especially on the requirements and selection of proper software tools for SMEs. Moreover, it seeks to determine and compare the modern mathematical and Information Systems based techniques and tools of Business Process modelling applicable to SMEs. However, at this stage in the present paper, this investigation aims at providing a proper framework only for such a thorough analysis and not the complete analysis.

2   Business Process Models Comparative Analysis

A business model is a framework used to represent the complex reality of an organization. The business model is used to present a clear description of the objectives, strategies, organizational structure, and operations of an Organization. Business Models such as the Organizational Chart, and financial statements have been used by organizations for decades. In recent times, business models such as the Business Organizational Model, Business Rule Model, Business Motivational Models, and Business Process Model have been introduced (Bridgeland & Zahavi, 2009). These newer models do not displace the previous models, but to focus on other parts of the complex reality of a business.

The model of a business system can be classified into two categories (Kalnins, Kalnina, & Kalis) ;

i. As-is Model: This is a representation of the present state of the Business System which includes the Organizational Structure, the main operations of the organization, the logical behaviour aspects of the system – who carries out a task, when it is to be carried out, and what it aims to achieve

ii. To-be Model: This is an improvement of the As-Is Model after an analysis of the present state has been carried out. It is a representation of what the system can be and how the operations can be optimised.

A branch of Business Model which is considered to be an essential aspect of Business Process Management is the **_Business Process Model_**.

Business Process Model is used to represent a step-by-step approach in operations of an Organization. The Business Process model is a means to an end; showing what the series of activities aim to achieve, who/what department is to carry out the activities, and what stage the activity is to be carried out in the organizational operations process. The representation of the interactions between the tasks, operations, and processes provides a foundation for the improvement of the efficiency, effectiveness and business process of an organization (Business Process Modelling, 2007).

In present times, the research on Business Process Modelling is beginning to gain attention in both the academic and industrial environment. It is not just restricted to Business Process Management; it can be applicable to areas such as web development analysis, software development / engineering, and service-oriented structure (Prezel, Gašević, & Milanović). Business Process Modelling is not only used in conventional business environment, but also in government agencies, charity organizations, and all process-oriented systems. A Business Process Model can be used repeatedly for similar processes (Yamamoto, Yamamoto, Ohashi, & Inomata, 2005). The increasing awareness and embrace of Information Technology/Information Systems has heightened the demand for process improvement with the aid of Business Process Modelling. The top priority of modelling a Business Process is to improve the system's performance through the optimisation of the activities carried out to achieve set objectives. Figure 1 illustrates the representation of the present activities of a system (AS-IS), and what the process is to become (TO-BE) order to optimize production/services. Other purposes to model a Business Process includes; communication, training, process reuse, persuasion in sales (Bridgeland & Zahavi, 2009).
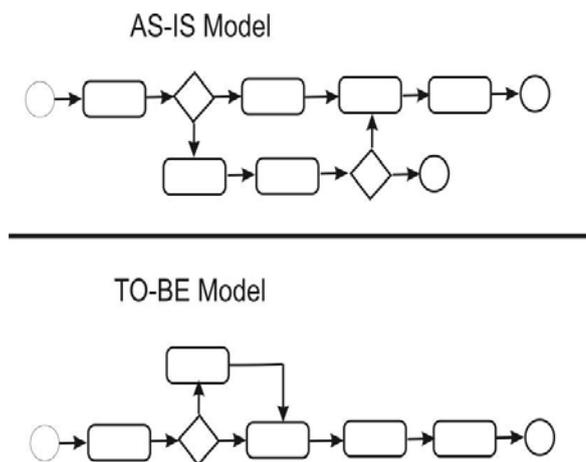
AS-IS Model

TO-BE Model

Figure 1: Example of an AS-IS and TO-BE Business Process Model

The increase in demand of process modelling has equally made it as relevant as existing process optimization tool such as Total Quality Management (TQM). To model a Business Process, different techniques can be used. These techniques have been developed for different purposes and are more suitable in various aspects. Business Process Modelling techniques are concerned with the mapping and workflow of activities in a system in order to be able to carry out analysis, and also provide a framework for change management (Business Process Modelling, 2013)

The techniques of Business Process Modelling can be classified into three different set based on their representation of a model (Vergidis, Tiwari, & Majeed, 2008);

- *Diagrammatic Model:* At the inception of Business Process Model, these techniques were being solely used. It is a simple and easy-to-communicate graphical

representation, originally developed for software analysis and development. Initially, the representation of these techniques was plain graphics.

- *Mathematical Model:* These are referred to as second generation of BPM techniques. These techniques are well defined and precise, and can be analysed mathematically to extract knowledge. Though these models are very appropriate in carrying out quantitative analysis and improvement of a process, they are not suitable in modelling complex constructs based on no emphasis on the diagrammatical representation of the process such as decision points. Representation of a Business process mathematically may prove to be much more complex than diagrammatic representation.

- *Business Process Languages:* The most recent set of BPM techniques to be developed. The development of these set of techniques, like the first generation set, was influenced by software development. Business process languages is an Information Technology based technique in used to represent Business Processes. This latest trend of BPM techniques is dynamic in nature and rapidly evolving.

This section provides a comparative analysis of modern Business Process Modelling techniques. In this chapter, a basis for comparing the techniques is developed; the techniques are reviewed, stating their strengths and weakness (if any). The chapter ends with recent methodologies used in modelling an Enterprise.

In the study carried out, ten techniques were selected. This selection was based on popularity on websites of reputable Business Process Management software developers, and few existing recent journals from publishers such as IEEE, Science Direct.

In carrying out the comparative study of Business Process Model techniques, the answers to the following questions provided guidelines on how to achieve the objective

- What are the bases for comparing the different Business Process Modelling techniques?
- What are the strengths and weakness in using the technique?
- What are the basic focuses of the techniques?

Past researchers have classified and compared the BPM techniques based on different views; in her article, Aguilar-Saven (2003) classified the techniques based on the purpose of the model and model change permissiveness (active and passive).

Another classification based on the representation of the techniques; Mathematical, Diagrammatical, and BP language (Vergidis, Tiwari, & Majeed, 2008).

However, most of these techniques make use of the conventional approach, representing Business Process (regardless of the form) as series of activities, emphasizing the structure of the flow of activities, and the resultant output from the activities; and also, used for similar purpose.

Hence, an approach for comparison is proposed based on the different techniques in this project to not only aid Academicians, but also aid BPM practitioners in selecting a technique.

In answering the research questions, four features were proposed; and the strengths and the weakness were stated. The features were based on intensive study of the general characteristics of Business Process Modelling techniques, and purpose of model classification by Aguilar-Saven (2003*): learning description; decision support for process design, control, and execution; Information Technology enactment support*

The table 1 below outlines and describes the features that were used in the comparison.

Table 1: Business Process general Comparison Criteria

Features	Description
Data Flow Approach	All techniques outline the flow of activities in the model; data flow description further explains what information is passed along. In some modelling techniques, text is combined with the visual representation of activities in the process flow. This approach is perhaps regarded as the most important form in the communication of process models to stakeholders. This feature explains the additional description offered by the techniques
Logical Approach	In this context, logical reasoning is the process of using statements/notations/ arguments in describing conditions which must be met for an activity to be carried out. This feature adds more structure in the process model, providing alternate routes in achieving the objectives of the process. This feature is highly relevant in making decisions in the Organization
Role Approach	In process modelling techniques, this feature is usually a secondary structure included. The use of roles in techniques gives a clear description of who is responsible for the different tasks in the process, providing organization distribution of activities. The role assignment feature targets analysis of administrative procedures, providing a guideline in carrying out structural change in Organizations
Simulation	Simulation is the act of imitating the behaviour or operations of real-world Business Process or systems. This feature is used to carry out virtual analysis of a process

3. Business Process Modelling Software (BPMS) Tools Requirements, Selection Criteria and Comparative Analysis

There are about 150 different BPM Software tools - and might there exist even more. One can get a nice overview at
www.businessprocessincubator.com/tools/bpms.html
and
https://www.businessprocessincubator.com/content/business-process-management-bpm-software-evaluation-report/
It is, therefore, important to define selection criteria in order to choose the appropriate tool from such a list. One of these criteria is BPMN 2.0 compliance.

Business Process Model and Notation (BPMN) is an ISO/IEC 19510:2013 standard and de-facto standard for business process modeling, which defines a graphical notation for representing business processes in the form of business process diagrams. In order to take the full advantage of the standard, the use of modeling tools is highly recommended. They enable easier and faster modeling, because they support a wide variety of features, such as enforcement of syntactic and semantic rules, support for team modeling, business process simulation, export and import in different formats and many more facilities. Before BPMN 2.0 (https://www.goodelearning.com/courses/business-process/bpmn-training), any tool

could claim BPMN compliance, since there was no official criteria. Consequentially, many BPM tools that provided "boxes and arrows" for modeling claimed to be compliant with BPMN. The standard states that the software "can claim compliance or conformance with BPMN 2.0 if and only if the software fully matches the applicable compliance points as stated in the International Standard". However, if the software only partially matches the applicable compliance points, it can only claim "that the software was based on this International Standard, but cannot claim compliance or conformance with this International Standard". Furthermore, the specification introduces four types of conformance: 1) Process Modeling Conformance, 2) Process Execution Conformance, 3) BPEL Process Execution Conformance, and 4) Choreography Modeling Conformance. Any tool that claims Process Modeling Conformance must support the elements and attributes of three subclasses, namely Descriptive, Analytical and Common Executable. The Descriptive and Analytical subclasses address the non-executable models and provide the information, necessary for visual representation of the diagrams (e.g. icons, markers, border styles, shape types). Any description of the data and the corresponding XML and meta-model is part of the Common Executable subclass. A study card of Process Modeling Conformance is available on the Good e-Learning website (https://www.goodelearning.com/downloads/business-process/subclassess-of-bpmn-process-modeling-elements).

A Process Execution Conformance tool must fully support and interpret the semantics and activity life-cycle, as well as fundamental meta-model. Besides, importing process diagrams must also be totally supported. Software claiming BPEL Process Execution Conformance must firstly fully support Process Execution Conformance. Besides, it must completely support mapping from BPMN models to BPEL, as defined in the specifications. Finally, tools that claim to support Choreography Modeling Conformance must provide BPMN Choreography types, elements, visual appearance, semantics and interchange in line with the BPMN specification. The official BPMN homepage (http://bpmn.tools/) listed more than 74 BPMN compliant tools after 2014. There are of course many more on the market, but are not formally registered in the previous list. Consequently, selecting the most appropriate BPMN modeling tool for a Business Process Modeling (BPM) project can be a laborious task having high risk factors in terms of time and cost.

While medium-to-large sized projects may conduct extensive studies to select such tools smaller modeling teams cannot afford such procedures and is more proper to have a less formal but swift tool selection process based on, however, a methodical procedure. To this end, in this section, we will present one of the suggested approaches (http://bpmn.tools/select-bpmn-modeling-tool/) adapted via the previous section concerning BPM comparison criteria that might be viable for application in SMEs. It should be emphasized that the table 2 below proposes a set of criteria focusing mainly on SMEs, extending previous evaluation methodologies (http://bpmn.tools/select-bpmn-modeling-tool/) and (Rolóna E. , Chaviraa, G. et al. (2015)),

Step 1: definition of functional and non-functional requirements
Both functional and non-functional requirements of a software tool in examination need to be specified. While BPMS functional requirements address BPM criteria defined in section 2, Non-functional requirements should address usability and user interface

friendliness, proper documentation, performance characteristics, minimal hardware considerations and of course cost etc., which are obviously vital for application of BPM techniques to SMEs.

Step 2: definition of selection criteria and their relevant weights

Step two, proper selection criteria must be defined to determine which BPMS tools satisfy SME requirements. Besides, we need objective criteria for measuring such characteristics and a threshold, beyond which BPMS tools are not appropriate for our needs. This threshold is of course user defined but for its full definition weights are needed for each criterion. The weighted sum of values from this table, that is, Sum_of(weight*Value) defines the score of each evaluated BPMS tool.

Table 2 below represents an example of selection criteria along with their corresponding definitions and example only proposed weights, proper for SMEs. As it can be seen from the table, each of the criteria is ranked from 0 (no support) to 100 (full support) per evaluated software. However, these values can take any given numerical range, depending on the decision maker's preferences. The relevant weights range from 0.0 to 1.0 usually and are given according to the experience of the decision maker.

Table 2: Business Process Modelling Software (BPMS) Tools general weighted selection criteria for SMEs

Criteria	Definition	Weight	Value
Cost	All buying, maintenance and implied costs should be taken into account. Free/ Open Source, that is BPMS of minimal cost take on value of 100 (Moderate budget required for license, maintenance, support, training and implementation	0.9	0-100
Learning Curve	The easiest to learn building complex models take on values of 100	0.8	0-100
Usability	The ones having the most friendly user interface take on values of 100	0.9	0-100
Focus on SME market	The tool must be intended for the SME-market	0.9	0-100
Hardware and software Infrastructure requirements and ease of installation with minimal technical requirements	BPMS demanding minimal infrastructure and change of infrastructure, regarding both software and hardware, requirements take on value of 100. Minimal technical development expertise needed at workflow creation (forms, data definition, API)	0.8	0-100
Good documentation	The existence of suitable documentation for both advanced and novice users	0.6	0-100

Localization possibility	Availability in the English language and possibility of localization of the end-user interface	0.7	0-100
Possibility of adaptation to customer SME needs	Possibility to implement tool and adapt internal processes according to SME processes within very short time	0.6	0-100
Financial stability of the provider	Financial stability of the provider by a proven installed record (with references that can be contacted, especially from the SME market, not large scale organizations)	0.8	0-100
BPMN Syntax checking Errors	The software tool can parse and check the model for syntactical errors	0.7	0-100
BPMN agreement	Compliance with BPMN 2.0, or above, four types of conformance and preferably browser based modelling	0.9	0-100
Interoperability	Capability to import and export models in different formats	0.4	0-100
BPM simulation	Native execution and simulation of BPMN 2.0 modelled processes	0.9	0-100

Step 3: Identification of candidate BPMS tools

In Step three, identification of candidate BPMS tools must be performed by the decision maker. As already mentioned, the official BPMN homepage http://www.bpmn.org/ lists more than 74 BPMN tools. Evaluating each of those would be too time-consuming. There is, however, a shorter list of popular BPMN tools as defined in table 3 adapted from https://bpmnmatrix.github.io/. Even in this case, however, the identification of BPMS candidate task still remains laborious.

One of the methods that addresses these issues was proposed by (Kannengiesser, 2007). Author introduced a number of filters, which reduce the input to the full evaluation process. The method can be summarized as follows:

1. Acquire a demo or free version of a BPMS tool on the list of table 3 below or an extended list, e.g. from the site
   www.businessprocessincubator.com/tools/bpms.html
2. Evaluate the ease of installing the selected tool in light of installation or configuration problems and in general evaluate mainly usability.
3. Evaluate the operability and interoperability problems, in accordance with the ISO/IEC 9126-1 quality model.
4. Analyse the minimum support for BPMN in the tool. This is an essential prerequisite for accepting the tool for further evaluation.

After the initial input of BPMS tools has been reduced, the BPMS tool requirements are applied, which furthermore filter the number of candidate tools. The list of potential candidates should be reduced to a five or fewer software tools list in order to further proceed with the proposed evaluation process.

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Step 4: Evaluate best candidates according to table 2
In the fourth step, when a short list of candidates has been conducted, we can furthermore evaluate the BPMS tools. In this step, we systematically apply the weighted evaluation criteria we introduced in table 2 above

1) To ensure evenness across the selected tools, the same BPMN testing model should be used. It is recommended to use a model with moderate complexity, which consists of at least 100 activities, 20 data objects and 10 swim-lanes (Kannengiesser, 2007).

2) Additionally, all BPMN 2.0 diagram types defined in the BPMN specification should be involved. If all steps are conducted in accordance with this approach, we will end up with a list of maximum three software tools, that their weighted scores exceed the predefined decision maker's score threshold.

Step 5: Select the winner BPMS tool
The final step of the proposed procedure, the selection of the most suitable tool is performed. To achieve this, a fine-tuning of requirements and weighted evaluation criteria should be performed and applied to the existing short list of potential candidates defined after step 4.

However, should we decide that a criterion of table 2 is more important to our project than another, a fine-tuning of weights is necessary at this step. Therefore, step 5 herein involves a project based reconsideration of table 2 criteria. In such a case the general case weights proposed in table 2, could be increased, decreased or remain the same, as in table 2, accordingly, based on a careful attention to detail of current major SME project requirements.

Table 3: Popular Business Process Modelling Software (BPMS) Tools adapted from https://bpmnmatrix.github.io/, supporting and compliant to BPMN 2.0

Name	Creator	Platform /OS	First Release	Latest Release	Licence type
Activiti Modeler	Alfresco and the Activiti community	Cross-platform	2010-05-17	2014-12-18	Free, proprietary, Open Source
ADONIS (software)	BOC Information Technologies Consulting AG	Windows	1995	2012	Free, proprietary
ARCWAY Cockpit	ARCWAY AG	Windows, Mac (Linux unofficially)	2005	2014	Free, proprietary
ARIS Express	Software AG	Windows (and Linux, Mac unofficially)	2009-07-28	2012-12-19	free
AuraPortal	AuraPortal	Windows	2001	2016	Free, proprietary
BeePMN	ESTECO SpA	Cloud	2016-02-01	2016-04-11	Free, proprietary
Bizagi Process Modeler	Bizagi	Windows			free
bpmn.io	Camunda Services GmbH	Cloud	2014-02	2016-07-29	Free, Open Source

Bonita BPM	Bonitasoft	Windows, Linux,Mac	2001	2014-07-02	Free, Open Source
Camunda Modeler	Camunda	Cross-platform	2013	2014-03-31	Free, Open Source
Cubetto Toolset	semture GmbH	Windows, Mac,Linux	2003	2013-08	free
Eclipse BPMN2 Modeler	Eclipse.org. Eclipse SOA project.	Cross-platform	2011	2014	Free, Open Source
HEFLO	Venki Tecnologia	Cloud (browser based)	2015-10-15	2016-7-25	Free, proprietary
GenMyModel	Axellience	Cross-platform(browser based)	2015	March 2015	Free, proprietary
INNOVATOR for Business Analysts	MID GmbH	Windows	2010	2012	Free, proprietry
jBPM (6.5)	Redhat	Cross-platform (in java)		2016-10-25	free
jBPMN	NetBeans Community project.	Cross-platform	2013	2014	free
LucidChart	Lucid Software Inc	Cross-platform (browser based)	2011	twice a month	Free, proprietary

RunaWFE	Runa Consulting Group	Cross-platform	2004	2014-08-01	Free, Open Source
simpl4	transparent solutions GmbH	Java, Cloud-Platform PaaS/SaaS	2014-09	2016-05	Free, Open Source
SYDLE SEED Community	SYDLE Systems	Cloud (browser based)	2012-07	2012-07	free
Yaoqiang BPMN Editor	史耀强 (Blenta) (Sourceforge ID)	Java / Windows,Linux, Mac, Solaris	2010-05-27	2014-11-16	Free, proprietary, Open Source
yEd	yWorks	Windows, Mac,Linux/Unix		2016-07-15	free
yEd Live	yWorks	Windows, Mac,Linux/Unix	2016-07-25	2016-07-25	free

Brief Analysis of mainly Free Open Source BPM Platforms with suitability for SMEs

Business Process Modelling/ Management software is the platform used in the implementation of the techniques discussed.

From researches on existing Business Process Modelling software available, BPM software are developed based on two distinct key functions:
1. Modelling of a Business Process
2. Simulation of Business Process Model.
   i. Analysis
   ii. Optimization

Based on researches carried out in this work, it has been observed that some BPM

software tools are just restricted to the design of the model, while some others have the capabilities of both functions. Some of the software applications have more than one technique embedded in them. In designing the Business Process Model, a modeller chooses the technique provided by the available software. For example, ARIS architecture discussed previously provides its own software which uses BPMN and EPC in the design of a Business Process Model. With the simulation function of the software, the results of the operations can be determined without necessarily spending huge capital of running the actual process in real-world. There are certain essential features which a Business Process Model should have;

- Complete Information: The resources, organizational units, idle time and operating time and everything related to the process should be stated.

- Realistic & Executable: The AS-IS model should be a real representation of the process, and also the TO-BE model should be achievable.

- Ability to be Partitioned: This is to enable analysis of a unit of a process to be carried out

- Traceability: No activity should be without a connection to the start event

Simulation mimics the actual process of a system. In Business Process context, simulation goes beyond imitating the system; simulation of a Business Process Model is carried out to achieve this given objectives in the Organization;

➢ Process and resource analysis and optimization
➢ Identification of Bottleneck
➢ Human resources planning
➢ Risk assessment and risk minimization.

The consideration whether Simulation of the Business Process is important in the organization is dependent of; the effort in preparing the process model and .the aims to be achieved from simulation. The output of the simulation is a result of the model designed.

In carrying out the simulation, the following pieces of information are first determined;

- Processing time per function/ activity
- Number of available resources / equipments
- Additional information in getting a precise result. E.g. interruptions due to pause in activities, parts replacement in the cause of the process.

The more detailed the information gathered, the more precise the simulation output.

In the search for Business Process software, at least fifty software applications were discovered. A question posed by Organization is "What is the best modelling software to choose?"

Based on researches carried out, below are different characteristics which are to be considered in choosing a business process modelling software;

Notation and Technique, Cost, Operating System Capability, Functionality and Documentation format

Discussed below is a brief summary of some BPM software. The software discussed here is a mixture of both freeware and commercial version, therefore not all were tested. For this reason, some pieces of the information here are retrieved from the BPM

software companies and third-party vendors. But we are focusing this analysis, mainly to usability for SMEs and whether they are free as well as open source BPM software tools.

1) Activiti (https://www.activiti.org/) is a lightweight workflow and Business Process Management (BPM) tool focused at business people, developers and system administrators. Its core is a fast and solid BPMN 2.0 process engine for Java. It's open-source and distributed under the Apache license. Activiti runs as a standalone Java application, on a server, on a cluster or in the cloud. It integrates perfectly with **Spring framework** (https://projects.spring.io/spring-framework/) and is based on simple concepts.

Activiti supports all aspects of Business Process Management (BPM) in the full context of software development. This includes analysis, modeling and optimizing business processes as well as aspects of creating software support for business processes. Activiti's primary purpose and focus is to implement the general purpose process language BPMN 2.0 but also, provides a Process Virtual Machine architecture where any custom process language can be build on top of it.

2) Bonita BPM (http://www.bonitasoft.com/) enhances business operations by connecting people, processes, and information systems into easily managed applications. SMEs could involve Bonita Studio to map their organization, define the data structure, build the user interface, and create actionable reports. Bonita Portal creates a central location to perform tasks, monitor case completion, search for information, and collaborate with peers.

3) Camunda (https://camunda.org/) is an open source platform for workflow and business process automation and management, where the decision maker could model and execute BPMN 2.0, CMMN 1.1 and DMN 1.1 It is very light-weight and scales very well. Camunda is written in Java and a perfect match for Java EE and the Spring framework (https://projects.spring.io/spring-framework/), while providing a powerful REST API and script language support. The decision maker can use Camunda BPM for system integration workflows as well as for human workflow and case management, adding Camunda to his Java application as a library, or using it as a container service in Tomcat, JBoss etc. So it can be used by multiple applications which can be redeployed without shutting down the process engine. Although very large companies in the world use it as well as most trusted public institutions rely on Camunda, it is not of prohibitive complexity for SMEs .

4) jBPM (https://www.jbpm.org/) is a free and flexible Business Process Management (BPM) platform. It makes the bridge between business analysts and developers. Traditional BPM engines have a focus that is limited to non-technical people only. jBPM has a dual focus: it offers process management features in a way that attracts both business users and developers. The core of jBPM is a lightweight, scalable workflow engine written in Java that allows executing business processes using the latest BPMN 2.0 specification. It can run in any Java environment, embedded in decision maker's application or as a service.

5) jSonic BPM (http://jsonic.org/) platform enables enterprise owners to align business processes with the dynamic market conditions, statutory compliances and, customer and partner requirements. It is a comprehensive solution that improves the bottom line of organization, even of small to medium scale organizations, but mainly of large ones, by increasing process efficiency, optimizing resource utilization and automating human workflow system. jSonic BPM suite, is a free and Open Source BPM Software that offers an integrated solution covering process designing, modeling, executing, automating and monitoring as per the business needs and desires. The major components of the suite include Process Management, Workflow Management and the Interface Designer.

6) Orchestra (http://orchestra.ow2.org/xwiki/bin/view/Main/WebHome) is a complete solution to handle long-running, service oriented processes. It provides out of the box orchestration functionalities to handle complex business processes. It is based on the OASIS standard BPEL (Business Process Execution Language). Orchestra's objectives: enhancement and control of processes, Services communication, Productivity and agility of the company. Orchestra is fully Open Source and is downloadable under the LGPL License.

7) ProcessMaker (http://www.processmaker.com/) is a cost effective and easy to use open source business process management (BPM) or workflow software application. Workflow software such as ProcessMaker can assist organizations of any size with designing, automating and deploying business processes or workflows of various kinds. We consider it well suited for SMEs. ProcessMaker workflow software features an extensive toolbox which provides the ability to easily create digital forms and map out fully functioning workflows. The software is completely web based, making it simple to manage and synchronize workflows throughout an entire organization of any size– including user groups and departments. ProcessMaker workflow software can also interact with other applications and systems such as ERP, business intelligence, CRM and document management. Therefore, we think that Processmaker needs further analysis and elaboration for SMEs.

9) Red Hat JBoss BPM platform (https://www.redhat.com/en/services/training/jb427-developing-workflow-applications-red-hat-jboss-bpm-suite#) is the JBoss platform for Business Process Management (BPM). It enables enterprise business and IT users to document, simulate, manage, automate and monitor business processes and policies. It is designed to allow business and IT users to collaborate more successfully, so business applications can be changed more easily and quickly. Create, test, deploy and monitor BPMN2-based business processes to optimize enterprise workflows and automate critical processes. Red Hat JBoss BPM includes all the business rules and event processing capabilities of Red Hat JBoss BRMS. Easily create real-time dashboards to monitor key performance indicators for running processes and activities. It is well suited for large scale organizations but further investigation is needed for its suitability for SMEs with no IT department.

10)   **Eclipse   STP   BPMN   Modeler/   Intalio   Designer**
(https://eclipse.org/proposals/bpmn-modeler/), was developed in 2006 by Intalio which
donated the BPMN modeler to the Eclipse foundation. The main website of the project
is http://www.eclipse.org/bpmn/ but so far the modeler is not automatically integrated
into Eclipse and the installation needs to be done via the STP site, fully described on
the projects website. As alternative to the BPMN modeler plugin for Eclipse 3.5.1 the
company Intalio offers community edition of its commercial BPMN modeler which
already included the needed Eclipse runtime files (http://www.intalio.com/downloads).
All versions are available for Windows, Linux and Mac. The installation is not too easy,
however.

11) **TIBCO Business Studio** (http://www.tibco.com/products/ automation/business-
process-management/activematrix-bpm/business-studio), is neither open source or
under an open license like the GPL, but the tool is at least free. The official website of
the   tool   is http://www.tibco.com/products/bpm/process-modeling/business-studio/
default.jsp where it is available as a download for Windows and Linux after completing
a short registration form. Again, there are some difficulties in the installation process
due to not full documentation but it seems very powerful, although not designed as a
pure modeler, supporting additional diagrams within the BPMN project. e.g.
organizational structure. However, Drawing is very difficult, all icons have by default
a given color (yellow) and there is no graphical export functionality for BPMN
diagrams

12) **Yaoqiang BPMN Editor** (https://sourceforge.net/projects/bpmn/), is a very small
java application especially designed to support BPMN 2.0. The project is hosted on
SourceForge.net: http://sourceforge.net/projects/bpmn/. The application looks a little
like MS Visio regarding the layout of the modules of the GUI and the idea to display
and draw processes. It presents some advantages : very small application, No
installlation needed, Exports diagrams into a lot of different graphic formats, it's Open
Source, with Clear colors for the different symbols. But, on the other hand, all symbols
are displayed on the same level, there is no real control of connections and lines from
one symbol to another and there are limitation of a process drawing size, limited by
page size.

13) **Aris Express** (http://www.ariscommunity.com/aris-express) is the light version of
the classic Aris BPMS Tool. Aris Express is not available under an open source and
open license but the usage is free and supported by a community. Aris Express is written
in Java and starts everytime via Java Webstart.

Investigating many BPMS tools from the lists above, a decision maker would not find
the perfect BPMN modeler/ tool. However, some important characteristics of the
software described so far are:
open source and free software, the majority using an open license like GPL, Apache,
BSD, CDDL, etc., Support of BPMN 2.0, Graphical modeler which support BPMN
diagrams and does the syntax check, Visual presentation of drawing shall be nice; good
looking diagrams, Easy to go, Windows or/and Linux support

In the sequel some BPMS tools brief description is provided, which are mainly commercial.

1. **ADONIS:** This software was created and first released in 1995 by BOC Information Technologies Consulting, supporting Business Process Management based on a framework – BPMS which was developed at the University of Vienna. This software is free but a closed source which makes use of BPMN tool and with the commercial version providing simulation function. ADONIS software is created in an easy-to-use style so a beginner can easily understand how to use.

2. **Enterprise Architect Suite:** This software was developed by Sparx Systems based on UML. The Enterprise Architect was initially released in 2000 and supported just UML, but subsequent releases has seen it supporting basically all Object-Oriented technique – UML,BPMN, BPEL, SPEM. Aspects covered by this software not only include Business Process Modelling design, but also Simulation, Development Lifecycle, requirements management, project management. The software is a complete BPM suite which can be useful for software developers, modellers, Business Analyst, and other Organization entities.

3. **Microsoft Visio 2013:** The Microsoft Visio is more of a diagramming application which supports the design of a Business Process Model. This application first developed in 1992 by Shapeware Corporation, the product was later acquired by Microsoft. Microsoft Visio is not particularly based on a particular notation or technique. It provides different notation and techniques like IDEF0, BPMN2.0, UML; its own flowchart technique – Microsoft SharePoint workflow; and different software and database diagrams. Using the Microsoft Visio, a modeller can decide to also design his notations.

4. **BIZAGI BPM Suite**: Bizagi BPM Suite was developed by Bizagi Ltd., a privately owned company founded in 1989. Bizagi BPM Suite consists of three tools – Process modeller, Studio, and Server. The Business Process are drawn and documented in the Process Modeller; the process applications are built in the studio and stored in a database, the execution and control of the built Process application takes place in the server. This all-in-one suite provides a graphical real- time tracking, simulation and monitoring of the process, providing Business Process management to companies such as Schlumberger, Adidas Group, Audi, and Petrobas. Bizagi supports BPMN, and also compatible with XML Definition Process Language (XPDL).

5. **Enterprise Dynamics:** The Enterprise dynamics software was developed by InControl Simulation Solutions. This application is a platform for carrying out simulation of a Business process. Models in this application are built by a drag- and-drop method. This software does not necessarily make use of any of the notations discussed, but it supports the model of Business Process through workflow technique. The main function of this software is to carry out simulation of a serial model. Though it is mainly used in the manufacturing sector, it can also be useful in other aspects of Industries. In the Enterprise Dynamics, the activities and roles are represented as servers. When simulated, the efficiency of the server (in %) is shown. Representing how the performance of each activity. A graph and simulation report is generated to carry out analysis.

This software makes use of a petri net - like and workflow technique in the representation of processes carried out, the blue circles represents the nodes in this process, moving

from one server to another as the Business Process takes place.

This software is best suitable if a modeller is just concerned about the serial flow of activities and not concerned about the roles in carrying out the activities. Depending on the number of employees in carrying out tasks, the modelling of a process using this software can be very complex.

6. **Accuprocess Modeller:** The Accuprocess software is developed as an Easy-to- Use application compared to most other process modelling software. Accuprocess makes use of only one notation, BPMN 1.0 (similar to the flow chart) which has few notations in carrying out a modelling exercise. This software provides free documents and trainings in which a new user can quickly learn how to use the software.

7. **ARIS Toolset**: Relevant to Aris Express, the ARIS toolset is made up of different products developed by IDS Scheer, a company established by Prof. August-Wilhem Scheer, whose academic research brought about Architecture of Integrated Information Research (ARIS). IDS Scheer was developed to in1984 to market the ARIS reference framework, but the company was later acquired by Software AG in 2010. The ARIS product was first released in 2009. Business Process Modelling on ARIS products is based on BPMN2.0 and EPC.

To further explain the techniques and tools of Business Process Modelling based on the above comparative analysis, the modelling and simulation process in this subsection is carried out using software which makes use of a technique easily communicated and with simulation capability. Compared to other Business Process Software, Accuprocess Modeller provides full functionality (modelling & simulation) in its trial version.

4. Preliminary Case Study and Simulation Scenarios

In this case scenario, only the activities directly involved with the receipt of goods of an organization are modelled. Ten actions are carried out with two decision points to determine the path to take. The scenario is outlined in table 4. In the decision points, probability of getting a defective batch is 20 %, good batch 80%; second decision point, probability of being damaged after being received (due to poor handling) is 10%, and being the fault of the supplier, 90%. The average time for the longest activity is 20 minutes, while the least activity takes 2 minutes. This process runs 600 times (i.e. 600 batches of goods are received)

	Notation/ Techni-ques	Functio-nality	Opera-ting System	Appli-cation Mode	Docu-men-tation Format
Adonis (Commu-nity Ed.)	BPMN 2.0	Model Design, Simulation	Windows	Stand-alone	Pdf, html
Enterprise Architect 11.1 Suite (Ultimate)	UML, SysML, BPMN 2.0, BPEL	Model Design, Simulation, Code Execution	Windows, Linux, Mac	Web, Stand-alone	Pdf, html, docx, rtf

Microsoft Visio 2013 (Professional)	BPMN 2.0, UML, IDEF0, Flowchart	Model Design, Simulation	Windows	Web, Stand-alone	vsdx, vsdm
Bizagi BPM Suite	BPMN 2.0	Model Design, Simulation, Code Execution.	Windows	Web	docx, xlsx
Enterprise Dynamics	Workflow, Petri net	Simulation	Windows	Stand-alone	Mod, bmp
ARIS Express	BPMN 2.0, EPC	Model Design	Windows, Linux, Mac	Stand-alone	Adf, pdf, rdf
ARIS Business Simulator	BPMN 2.0, EPC	Model Design, Simulation	Windows, Linux, Mac	Stand-alone, web	Adf, pdf, rdf
Accupro-cess (Profes-sional Ed.)	BPMN 1.0	Model Design, Simulation	Windows, Mac	Stand-Alone	Pm, Html, pdf, docx, jpg

Table 4: Business Process Modelling Software comparative characteristics evaluation

Accuprocess Modeller. The Accuprocessor modeller is divided into two aspects; modeller and Simulation. In the modeller section, all the necessary notations to model the system are provided in a canvas. The modelling of the system is done by a drag-and-drop method.

A drag-and-drop canvas is provided, selecting the different objects to use in mapping the Business Process. In the Accuprocess, the simulation is further sub-divided into two areas; the resource area, where the Organizational unit in which the roles can be assigned to are situated – and the scenario- in which the simulation is to be carried out. Each activity is assigned to a role which is in the simulation resources. The vital activities to be part of the simulation exercise are included in the scenario, the execution time of each of these activities are further specified. Accuprocess gives the modeller option to specify the type of distribution, for purpose of the simulation carried out, a normal distribution is used.

After the AS-IS configuration has been completed, a simulation is run to determine the state of operations in the Organization. A brief simulation run summary is displayed on the application interface. To view a detailed report to carry out analysis, an html file is generated displaying all the parameters and configurations. The complete steps in modelling and the simulation of the Business Process using the Accuprocess Modeller are discussed in (Papademetriou, Karras, 2016)

Graphs generated from the simulation run are shown in figure 2 depicting the result of the simulation carried out after 600 runs. The first graph shows the average utilization of the different units of the process in percentage, with Incoming Goods unit being more utilized. The run time graph depicts the maximum, minimum, and average time taken for one run to be completed in hours.
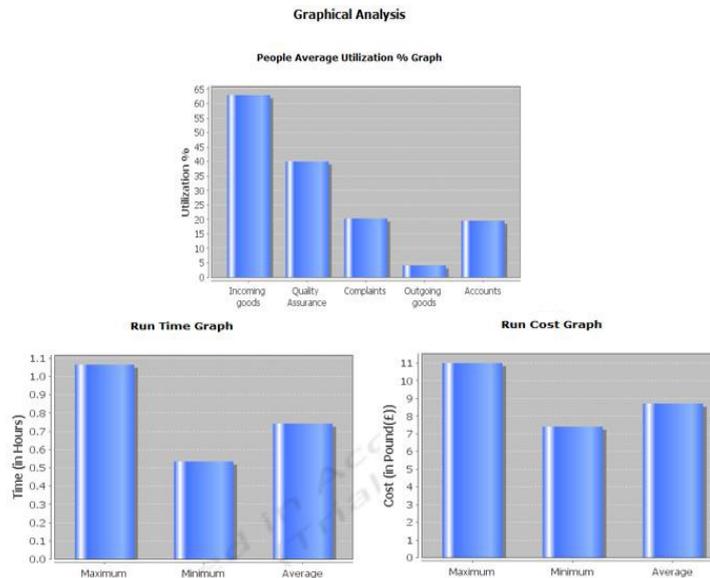
Graphical Analysis

People Average Utilization % Graph

Run Time Graph

Run Cost Graph

Figure 2: Graphical Analysis of the Model

Advantages and disadvantages of Accuprocess Modeller are discussed in (Papademetriou, Karras, 2016)

ARIS Business Simulator. A similar process is being modelled and simulated using ARIS Business Simulator. This is done to show the ability to optimize process automatically. The optimization aim is to determine the least number of employees to carry out each run of the process at a faster time with less cost. It should be noted that the simulation exercise using the ARIS Business Simulator was not carried by the author. It was obtained from the ARIS forum to carry out the comparison. Therefore some parameters and configurations will have some slight changes, but still similar approaches.

The type of Business Process Model technique is specified, in this case EPC is used; the database to use is selected; and the model in which to carry out the simulation is defined. In carrying out the experiment, the attribute of the objects are varied, the highest and lowest limits of the objects (in this case, all the Organizational Units) are specified; the low and high text field. This is referred to as Factor Variation.

Depending on the configuration in the Factor Variation, many scenarios are created discussed in (Papademetriou, Karras, 2016)

The next step is to specify the responses to be saved, in this case scenario, the throughput time for the model (Receipt of Goods), and the idle time cost for the objects (the Organizational units).

In carrying out the simulation, the optimization configuration has to be specified according to what is to be achieved. In this case, minimization of the model and objects is specified.

In the ARIS software, one of the documentation format used is Microsoft Excel; this makes the analysis to be carried out easier. After all parameters has been set in the

simulation the output format- Excel- is specified, and a file is created for the result to be viewed and saved.

The generated output Microsoft Excel file of the simulation is displayed, showing the values for the different objects, the factors, and responses based on the amount of possible configuration being run.

The optimization configuration is compared from the values in the objective column which is generated automatically. These values are further compared to idle time cost of the different responses. This process can be made easier by sorting the values according to ascending or descending order, or by generating a graph based on the values.
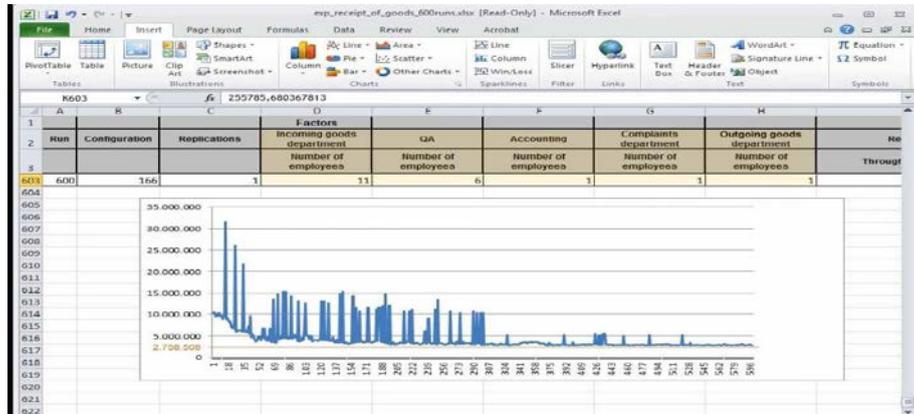

Figure 3: ARIS software provided Optimization graph

The lowest objective value which is the idle time cost provides the result for the factors. From figure 3 above the result was gotten. Advantages and disadvantages of ARIS Modeller are discussed in (Papademetriou, Karras, 2016)

5. Discussion - Conclusions

Business Process Model as a topic aims at improving the operations of an Organization. However, the presence of numerous techniques and tools has created a setback to modelling a Business Process. In this study, a comparison have been carried out to enable a potential user understand the usability of these techniques and tools.

The techniques were compared using features necessary for having a complete Business Process Model; *data flow, logical reasoning, specification of roles, and capability of simulation*. A technique possessing all the features will be effective for use in these four target areas of an Organization;

- Production Planning: Goods/services to be produced – the conversion of the input into output.
- Organizational Structure: With the structural view, the management determines the relationship between the tasks and equipment/personnel/units; useful for the Human resource unit of an Organization.

- Logistics: The flow of products; not only how it's being produced in the Organization, but also to the point of consumption, how the requirements are met.
- Strategic Planning: The strategic planning involves a futuristic plan for the Organization. Using the techniques and tools, the AS-IS model is analysed, improved upon to generate the TO-BE model. Simulation is carried out to determine the result of the future plan. This is done to reduce cost of actually implementing a plan that might be a failure.

Though techniques such as EPC, IDEF, WORKFLOW, and BPMN all have the features mentioned, it is necessary for a modeller to consider one which is easily understandable to stakeholders; easy in the communication of processes involved in the business, and to also facilitate learning. From the study, the EPC and the BPMN technique clearly states the activities, roles, the flow of messages (in BPMN), documents to be read, and requirements for a task to be carried out. These two techniques also give a clear outline of the structure of an Organization ranging from large scale ones to SMEs.

Apart from the discussion of BPMN techniques, however, a major contribution of this paper is an investigation of selection criteria for BPMS tools focusing on SMEs. Actually, a new framework has been proposed, targeted on SMEs aiming at evaluating proper BPMS tools.

Some major software tools were analysed in this study to determine what requirements to look out for in choosing Business Process software, especially for SMEs, focusing on free and open source software but , also, on some classic commercial software. The comparison showed that most software packages make use of BPMN technique in the modelling of a Business Process. Judging from the outcome of this study, it is best to choose a software tool which not only models a system, but, also, it is able to carry out its simulation. It was shown that some software tools with the simulation functionality do provide only analysis of the AS-IS model, while others go further to enable optimization of the Business Process to be carried out producing the TO-BE Business Process Model. Then relevance to SMEs should be further explored.

This study ended with simple simulation scenarios carried out to show the importance of modelling and simulating a Business Process to improve the operations of an Organization. However, this study is incomplete and needs improvement with more comparisons targeted to SMEs.

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