Business process maturity assessment: state of the art and key characteristics
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Business Process Maturity Assessment: State of the Art and Key Characteristics

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Abstract—Business processes are basic enablers in sustaining an organization’s existence in delivering high-quality products and services. A maturity model is an instrument to assess and continually improve business processes. For example, Capability Maturity Model Integration for Development (CMMI-Dev) in software domain has been used to assess and improve software processes in thousands of organizations worldwide since 1990s. Inspired by CMMI in the last decade, researchers and practitioners have proposed generic maturity models for business processes with varied focus and depth. However, the use of these models has not gained widespread acceptance in the Business Process Management (BPM) field. One of the reasons is the lack of a clear distinction between a maturity model and its assessment model. The objective of this study is twofold: First, to discuss challenges of business process assessment with regard to generic maturity models reported in scientific literature, and second, to identify key characteristics of a business process assessment model that would facilitate the use of maturity models in the BPM field.

Keywords—business process, process maturity, software process, process assessment, assessment model, assessment tool

I. INTRODUCTION

The notion of ‘maturity’ was first proposed by Phillip Crosby [1] and is defined as “the state of being complete, perfect, or ready” [2]. A maturity model is a conceptual model that consists of a sequence of discrete maturity levels for a class of processes in one or more business domains, and represents an anticipated, desired, or typical evolutionary path for these processes [3]. Maturity models can be used as an instrument to improve processes to achieve higher product and service quality [4][5][6], and there are many success stories in the use of such models in several domains. For example, Capability Maturity Model Integration for Development (CMMI-Dev) [7] in the area of software engineering emerged at the start of 1990s as a mean to improve software development processes to achieve higher quality, and has been used since then by thousands of organizations worldwide.

The success of CMMI inspired the development of several maturity models in other domains, including Business Process Management (BPM). In the last decade, researchers and practitioners in the BPM field have proposed maturity models with varied focus and depth [8][9]. However, the use of business process maturity models (BPMMs) has not yet gained widespread acceptance in practice [10] or in research [11][12]. Underlying challenges include the scarcity of empirical works confirming the validity and usefulness of the models, limited extent of prescriptive properties of the models impeding their applications, the lack of a clear distinction between a maturity model and an assessment model that is applied to evaluate the level of maturity, and the scarcity of practical guidance and/or supporting tools to motivate business process assessments and improvements.

In this study, we focus on the confusion between a maturity model and its assessment model in the BPM field with the suspicion that the lack of clarity between these concepts hinders the proper design and usage of BPMMs as the base to understand and improve the current state of maturity in the organizations. An assessment model is a well-defined guidance to assess the process maturity or capability based on a reference model [13], and the reference model is considered as a BPMM in our study. We examined the characteristics of maturity models that have been more frequently referenced in the BPM field as reported in the scientific literature, from an assessment perspective. We selected 9 BPMMs, which were characterized by our previous research as ‘leading’ when considering studies on their application and validation [11]. More specifically, we address two research questions (RQs) in our work: (1) What are the characteristics of leading BPMMs (and their suggested assessment models) from an assessment perspective? (2) What are the key characteristics of a business process assessment model that would foster the use of BPMMs in practice?

The remainder of the paper is organized as follows. Section 2 summarizes the maturity models and their assessment models in the software domain as successful examples that guide process appraisal and improvement. Section 3 overviews related work on the business process maturity models and their assessment methods and tools. Section 4 highlights the key characteristics of a business process assessment model as we propose. Section 5 concludes with the contributions and limitations of this study, and our plans for future work.

II. SOFTWARE PROCESS MATURITY AND ASSESSMENT

For the purpose of presenting an example domain in which there is a clear distinction between a maturity model and an assessment model, we overview two widely known models for software engineering: CMMI-DEV [7] and ISO/IEC 12207
processes are addressed by 22 process areas such as Project Development [7], all system and software development processes or the maturity of an organization. In CMMI for improving processes, and measuring the capability of products and services. This model could be used for Planning, Requirements Development, Technical Solution, maintenance activities applied to both system and software. Carnegie Mellon University. It addresses the development and development by the Software Engineering Institute (SEI) of and etc. under five organizational maturity levels.

SCAMPI (Standard CMMI Appraisal Method for Process Improvement) is a process assessment method designed to evaluate compliance with CMMI models and to perform assessments [15]. The SCAMPI process assessment includes three different methods; Class-A, Class-B, and Class-C. Class-A assessment is the most comprehensive SCAMPI assessment, and completely satisfies the requirements of CMMI assessment method [17]. In Class B assessment, interviews performed with people and documents are collected as objective evidence. Class C assessment is the least comprehensive SCAMPI assessment analyzing deficiencies within processes. In this class of assessment, only interviews performed with people or document may be classified as evidence. Certification is possible only at the end of SCAMPI Class A assessment.

ISO/IEC 12207 [14] is an international standard for software life cycle processes. It includes processes, activities and tasks to be implemented during acquisition, supply, development, operation, and maintenance processes of a software product that is stand-alone or a part of a larger system [14]. ISO/IEC 12207 is in full compliance with ISO/IEC 15288 [18] that describes system life-cycle processes. These two standards provide process reference models that support process assessments compatible with ISO/IEC 15504 [16].

ISO/IEC 15504: Information Technology - Process Assessment is an international standard created for process assessment [16]. It is designed to meet needs of process assessors, suppliers, and procurers. ISO/IEC 15504 defines the term process assessment as “the systematic evaluation of an organization’s processes against a process reference model” [13]. The standard makes a clear distinction between two terms below:

- A Process Reference Model comprises definitions of processes in a life cycle described in terms of process purpose and outcomes, together with an architecture describing the relationships between the processes.
- A Process Assessment Model is suitable for the purpose of assessing process capability, based on one or more Process Reference Models.

A PRM provides a framework for the establishment of processes in an organization by providing a list of processes and stating their requirements as specific to the domain of application. A PAM, on the other hand, is expected to describe the framework (e.g., procedure, role and responsibilities, criteria, and rating scheme) for performing the assessment with respect to the reference model [16].

The fundamental elements of a PRM are the descriptions of the processes within the scope of the model. The process descriptions in the PRM incorporate a statement of the purpose of the process which describes at a high level the overall objectives of performing the process, together with the set of outcomes which demonstrate successful achievement of the process purpose [16].

A PAM is based on the process descriptions provided in one or more PRMs. It forms the basis for the collection of evidence and rating of process capability. A PAM provides a two-dimensional view of process capability. In one dimension, it describes a set of process entities that relate to the processes defined in the specific PRM(s); this is referred to as the process dimension. In the other dimension, the PAM describes capabilities that relate to the process capability levels and process attributes defined in ISO/IEC 15504; this is referred to as the capability dimension. The relationship is shown diagrammatically in Fig. 1 [16].

A PAM contains a definition of its purpose, scope and elements; its mapping to the measurement framework and specified PRMs; and a mechanism for consistent expression of results. The PAM is based on a set of indicators that explicitly address the purposes and outcomes, as defined in the selected PRM. These indicators demonstrate the achievement of the process attributes within the capability level scope of the PAM, and focus attention on the implementation of the processes in the scope of the model [16].

![Process Assessment Model](image)

**Fig. 1. Process Assessment Model relationships [16]**
ISO/IEC 15504 also provides in its part-3 an exemplar documented assessment process that conforms to the requirements that are specified in part-2. This process includes the steps of: initiation, planning, pre-assessment briefing, data collection, data validation, process rating, and reporting the assessment result.

C. Software Process Assessment (SPA) Tools

There are several software process assessment tools reported in the scientific literature, and Gazel et al. provide a list of these tools in [19]. Reviewing the latest versions of the tools, we compared their attributes in Table I with respect to: assessment method supported, availability of free or demo version, type of the application (stand-alone or web-based), and support for self-assessment.

### TABLE I. A COMPARATIVE LIST OF SPA TOOLS

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Assessment method supported</th>
<th>Free (or demo) version?</th>
<th>Stand-alone or Web-based?</th>
<th>Support for self-assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appraisal Assistant</td>
<td>Developed by Software Quality Institute of Griffith University. Supports assessment of organizational maturity and process capability. Models and mapping data are stored in a Microsoft Access database.</td>
<td>SCAMPI, SPICE</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>No</td>
</tr>
<tr>
<td>CMMIFal v1.0</td>
<td>Developed by Chemturi Consultancy. Enables manual mapping of an organization’s processes to CMMI practices. Model and mapping data are stored in a Microsoft Access database.</td>
<td>Closers to SCAMPI</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>No</td>
</tr>
<tr>
<td>CMM-Quest v1.3</td>
<td>Developed by HM&amp;IT. Consulting to support process assessments based on CMMI-Dev v1.3. Provides functionalities for selecting process areas and target levels as preparation, text-based screens for data collection, graphics for data analyses, and Microsoft Word and HTML-based reporting facilities.</td>
<td>ISO/IEC 15504</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>Yes</td>
</tr>
<tr>
<td>SPICE 1.2-1</td>
<td>Developed by HM&amp;IT. Consulting to support process assessments in accordance with ISO/IEC 15504.</td>
<td>ISO/IEC 15504</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>Yes</td>
</tr>
<tr>
<td>SPICE Lite Tool</td>
<td>Developed by HM&amp;IT. Consulting to support process assessments in accordance with ISO/IEC 15504.</td>
<td>ISO/IEC 15504</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>Yes</td>
</tr>
<tr>
<td>Model Wizard</td>
<td>A Windows-based application developed by Integrated System Diagnostics Incorporated. Enables users to store their process models in a relational database.</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>No</td>
</tr>
<tr>
<td>Appraisal Wizard</td>
<td>A Windows-based product developed by Integrated System Diagnostics Incorporated. Can cooperate with Model Wizard. Aims to support management of planning, preparation, data collection, merging, and reporting activities as related to process assessments and process audits. Data from assessments and audits are stored in a relational database.</td>
<td>SCAMPI, SCL, CPA, IPI</td>
<td>Yes</td>
<td>Stand-alone</td>
<td>Yes</td>
</tr>
</tbody>
</table>

III. BUSINESS PROCESS MATURITY AND ASSESSMENT

A. Business Process Maturity Models and Assessment

The study by Röglinger et al. [9] provides a review of a set of BPMMs that focuses on their applicability and usefulness. It provides an in-depth analysis of a sample of ten BPMMs with respect to a framework of general design principles. Accordingly, these models sufficiently address the basic design principles as well as principles for a descriptive purpose of maturity model use. However, the design principles for their prescriptive use (which also covers assessment method) are largely unmet. The lack of prescriptive properties of the models causes difficulties in their applicability as a guiding approach. The study also reveals that the proposed BPMMs provide only limited guidance for assessment – i.e., identifying desirable maturity levels, and for implementing improvement measures.

The study by Van Looy et al. [8] compares and classifies 61 maturity models, some of which with a particular focus on different domains or fields, such as supply-chain management, logistics, collaboration, and software development, in accordance to a framework that they developed. The book authored by Van Looy [27] provides a comprehensive overview of the framework and the 69 maturity models. The study provides extensive reviews and comparisons of existing BPMMs, including their structural characteristics and point of focus, such as assessment and improvement.

Considering the two studies above and having an extensive search in basic digital libraries of scientific literature, we identified the generic maturity models that have been proposed for BPM. The literature search was performed for the studies published in academic journals and conference proceedings between the years 1990 and 2014 (October), as made available through the digital libraries of (in alphabetical order): ACM, EbSCO, Emerald, ScienceDirect, Scopus, SpringerLink, Web of Science, and Wiley. For retrieval from the digital libraries, the following string was taken as the basis, which was applied to the title, keywords, and abstracts of publications: (“business maturity” OR “process management maturity” OR “BPM maturity”) OR “process management capability” OR “BPM capability”) OR (business AND (“maturity model” OR “capability model”) OR (“business maturity” OR “business capability”) OR (business AND “process orientation” AND maturity)).

The string aimed at retrieving all studies that refer to a BPMM (i.e., by proposing, applying, validating, classifying, or thoroughly analyzing that BPMM). In selecting relevant works, we targeted at studies using generic models proposed for business process maturity, business process management maturity, or business process orientation maturity.

Table II lists 9 maturity models that we selected out of 20 and considered ‘leading’ with respect to the attention they acquired in the academic research, as reported by a recent study of ours [11]. A BPMM is included in the table when the model is referred to (i.e. applied, validated, classified, or thoroughly analyzed) in at least two other articles with distinct authors that are different than those that have developed/released the model.
Taking the studies referenced in the rightmost column of Table II as the primary source, we evaluated the BPMMs and their suggested assessment models/methods for: prescriptive and descriptive properties they hold, characteristics of the maturity model, characteristics of the assessment model, the separation of the assessment model from the maturity model, empirical evidence of usage provided by the primary source, and weaknesses and strengths of the models. Considering the framework of general design principles suggested by Röglinger et al. [9], we rated prescriptive and descriptive properties of the studies within four values in ordinal scale: None, Weak, Medium, and Strong. Table IV provides details of this evaluation. From the table we infer the following findings:

- Only two studies (regarding BPMM-OMG and vPMM) make a distinction between the maturity model and the assessment model.
- Only two studies (regarding BPMM-OMG and PEMM) refer to models that are publicly accessible.
- Four studies (regarding BPMM-FIS, BPMM-HR, BPMM-OMG, and BPO-MM) do not present empirical evidence for application or validation of their models.
- Prescriptive properties of the models are weaker in comparison to descriptive properties of the models.
- BPMM-OMG is the only model that has strong prescriptive and descriptive properties.
- BPM-CF, BPMM-HR, and BPO-MM have no prescriptive properties, but imply process improvement through their maturity levels.
- Though BPO-MF proposes a theoretical construct for Business Process Orientation (therefore included in our review), it defines neither a maturity model nor an assessment model - hence, prescriptive and descriptive properties are not applicable.

When we review the primary sources of the BPMMs listed in Table II in detail, we derive the following findings as specific to their assessment models/methods:

- Self-assessment is supported only by PEMM.
- Results provided by the assessments do not imply a specific level of business performance.
- The way the assessments are carried out is highly related to the prescriptive and descriptive properties of the models. The more detailed descriptive properties are, the more straightforward it is to carry out assessments. The more granular prescriptive properties are, the more straightforward it is to use the models as the base to carry out not only assessments but also process improvements.
- As an extension of the previous finding, the value of the results generated by the assessments might vary. The results may serve to understand the current level of maturity only or to draw an improvement path towards target maturity level.
- Being strong in both prescriptive and descriptive properties does not necessarily result in an easier application of a model. For example, BPMM-OMG is strong on both prescriptive and descriptive properties, yet its use by an enterprise operating in a specific domain (such as healthcare, finance, or manufacturing) is challenging due to the size, extensive coverage and generic content and structure. A well-defined adoption and assessment guidance for different domains can help to reduce the effort required for its use and assessment. Likewise, rated as medium on prescriptive and descriptive properties, PEMM is easier to apply by using two questionnaires incorporated in the model, which are essentially used to assess the maturity of each process in the enterprise and the enterprise-wide characteristics (such as the culture and leadership) of the organization as a whole.

### B. Business Process Assessment (BPA) Tools

There are only few studies that report tools intended for business process assessment in the scientific literature. Table III summarizes the tools proposed by these studies with respect to: assessment method supported, availability of free or demo version, type of application (stand-alone or web-based), and support for self-assessment. The low number of studies that propose BPA tools can also be considered as an indicator of lack of assessment practice in the BPM field.

<table>
<thead>
<tr>
<th>Tool Name</th>
<th>Published in</th>
<th>Assessment Method Supported</th>
<th>Free or Demo Version?</th>
<th>Stand-alone or Web-based?</th>
<th>Support for Self-assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>The CIRCA CI Self-Assessment Tool v3.0 [38]</td>
<td>Journal (1999)</td>
<td>Continuous Improvement (CI) Capability Model</td>
<td>No</td>
<td>Stand-alone</td>
<td>Yes</td>
</tr>
<tr>
<td>The Intelligent Maturity Model Tool [40]</td>
<td>Conference (2014)</td>
<td>BPM-OMG, PEMM, etc. (extensible)</td>
<td>No</td>
<td>Stand-alone</td>
<td>No</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Business Process Maturity Model (BPMM)</th>
<th>Primary Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) BPM-CF</td>
<td>Business Process Management Capability Framework</td>
<td>[28], [29]</td>
</tr>
<tr>
<td>(2) BPMM-FIS</td>
<td>Business Process Maturity Model</td>
<td>[30]</td>
</tr>
<tr>
<td>(3) BPMM-HR</td>
<td>Business Process Maturity Model</td>
<td>[31]</td>
</tr>
<tr>
<td>(4) BPMM-OMG</td>
<td>Business Process Maturity Model</td>
<td>[32]</td>
</tr>
<tr>
<td>(5) BPO-MF</td>
<td>Business Process Orientation Maturity Framework</td>
<td>[33]</td>
</tr>
<tr>
<td>(6) BPO-MM</td>
<td>Business Process Orientation Maturity Model</td>
<td>[34]</td>
</tr>
<tr>
<td>(7) PEMM</td>
<td>Process and Enterprise Maturity Model</td>
<td>[35]</td>
</tr>
<tr>
<td>(8) PMMA</td>
<td>Process Management Maturity Assessment</td>
<td>[36]</td>
</tr>
<tr>
<td>(9) vPMM</td>
<td>Value-based Process Maturity Model</td>
<td>[37]</td>
</tr>
<tr>
<td>BPMM Model</td>
<td>Prescriptive properties</td>
<td>Descriptive properties</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>[1] BPM-CF</td>
<td>None</td>
<td>Strong</td>
</tr>
<tr>
<td>[3] BPMM-HR</td>
<td>None</td>
<td>Medium</td>
</tr>
<tr>
<td>[4] BPMM-OMG</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>[5] BPO-MF</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>BPMM</td>
<td>Prescriptive properties</td>
<td>Descriptive properties</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>BPMM</strong></td>
<td>Prescriptive properties</td>
<td>Descriptive properties</td>
</tr>
<tr>
<td><strong>PEMM</strong></td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>PMMA</strong></td>
<td>Weak (maturity level 3 achievements are provided as an example)</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>vPMM</strong></td>
<td>Medium</td>
<td>Limited information is provided in [37]</td>
</tr>
</tbody>
</table>
key characteristics of BP assessment

As discussed in previous sections, the benefits of using process assessment in the BPM field have not yet been reaped. This is partly because the research on business process maturity is in its immature state and there is only few domain specific maturity models (e.g., supply chain management maturity model [42]) proposed in the BPM field. Another reason is the lack of practical guidance and/or tools for business process assessment or self-assessment. Considering the background provided in Sections 2 and 3 and specifically in Table IV, in this section we highlight the key characteristics of a business process assessment model/method and describe the basic requirements of an assessment tool that would facilitate business process assessments.

An assessment model should satisfy the needs of the assessors with diverse purposes. An assessment can be aimed internal or external to an organization (e.g., self-assessment vs. audit), planned as quick or detailed (e.g., half-day vs. a week), or carried out to evaluate high-level concerns or domain-specific ones (e.g., governance vs. healthcare process enactment). Therefore, such a model is expected to support assessments by considering different perspectives regarding assessment scope, body, and resources.

The flexibility mentioned above, however, comes with a trade-off and a related issue to consider is the degree of the independence of the assessment model from the attributes to be evaluated. These attributes are being called factors, levers, enablers, dimensions, categories, capability areas or process areas in the leading BPMMs shown in Table II. The more independent the assessment model from the attributes being evaluated, the more generic it is and the more challenging its usage would be. For example, SCAMPI is a generic assessment method suggested to carry out business process assessments based on OMG’s BPMM. This makes the method flexible for different purposes of use, but also makes its understanding and adaption difficult in practice. The usage of a domain-specific maturity model might be helpful in this regard. Our proposition is that the more dependent the assessment model to the attributes being evaluated, the more specific it is for the intended purpose and also the easier it is to understand and use.

A business process assessment model should define and guide through the basic steps of process assessment to be carried out. Existing tools typically support the process artifacts as evidences of a particular capability but fail to provide guidance regarding the overall flow of the assessment process. Relevant assessment steps that can potentially be supported include the initiation, planning, preparation, data collection, data validation, attribute rating, gap analysis, results reporting, and information sharing. The granularity of data collection and attribute rating can influence the reliability of the results (e.g., the results driven by the process enactment data vs. by expert judgement). We propose that the rating scheme should be specific enough to support not only objective evaluation but also pragmatic use. We also propose that the reporting of the results with respect to the attributes in question is best represented using different abstraction layers, from high-level to the evidence-based views.

Practical self-assessment of the business processes by the organizations themselves is another feature that should be considered for an assessment method. The organizations should be able to self-assess the maturity of their specific processes or the overall organization pragmatically with limited effort and without the need of external expertise. This would provide significant help in overcoming the initial resistance and barriers towards adopting business process maturity models in practice. The pre-requisites of the self-assessment should be carefully investigated and addressed by additional mechanisms for information sharing and process automation.

Although the term performance is used regularly in the leading BPMMs, the relation between BPA results and business performance is not directly addressed [11]. We find the consideration of this issue important while defining a BPMM and its BPA method to advocate the benefits of process assessments. The assessments and performance measurements can be repeated at different points in time, and the business performance in relation to the improved maturity can be established as a justification of the maturity model-based process improvement initiatives.

Since the practice and theory are interdependent in the process management, we argue that a tool that addresses the characteristics and concerns discussed above would facilitate and improve the state of the assessment practice in the BPM domain. Based on the discussions above, we provide a list of basic tool features as a continuation of our discussion:

- Maintain general assessment info (date, sources, etc.).
- Maintain the information regarding the organization/org. unit being assessed.
- Support the planning of the assessment.
- Support the mapping of organizational attributes to the attributes of the maturity model.
- Support self (quick) assessment.
- Support elaborated assessment.
- Support effective and practical rating of attributes.
- Support the gap analysis between the current state of the org. attributes and the attributes of the maturity model according to the targeted maturity level.
- Report assessment results at different levels of detail.
- Support the sharing and discussion of the assessment results within the organization.
- Provide overall guidance on the assessment process steps and artifacts.

V. Conclusions and Future Work

Process-orientation helps organizations to improve the effectiveness and efficiency of their business practices. Business process assessment is a step to take in order to understand the current maturity level of these practices prior to drawing a roadmap for improvement. In this study, we outlined the current state of the process assessments as reported in the studies in the scientific literature; and as a response to our RQ1, we concluded that process assessment...
in the BPM field is in its immature state. We identified key characteristics of a BPA method as a response to our RQ2, and provided a set of basic characteristics and features to consider when defining the basic requirements of a BPA tool.

A limitation of our study is that we based our analysis on the studies retrieved for the empirical applications of generic maturity models and their assessment methods in the BPM field, and not directly on the studies retrieved for business process assessment. However, we think that the existence of the studies that report maturity assessments of business processes are highly dependent on the maturity models used as the base for their assessments.

Our future work will involve the requirements specification and development of a business process assessment tool, and the verification and application of its usability and efficacy in different business domains.

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