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Development of an Intelligent Maturity Model-Tool for Business Process Management

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Abstract

During the last years, the development of maturity models for business process management (BPM) has increased significantly. However, tools which support comprehensively BPM maturity models and, therefore, reduce the effort and the costs of a maturity level analysis do not exist at the moment. We want to close this gap by developing an Intelligent Maturity Model-Tool which uses already available data for its evaluation. This data was completed by an assessment of the involved employees. Another important point is that the developed tool should execute automatically the calculations of the analysis. 'Intelligent' in this context stands for the following three properties of the maturity model: Representation of different maturity models due to a generic structure, integration of the Intelligent Maturity Model-Tool with a BPM system, and the proposal of optimization recommendations provided by a special assistance function.

1. Introduction

The effectiveness and efficiency of processes became more and more important for companies because of the increased challenges due to stronger competition, more complexity and higher cost pressure. This effect led to the development of more than hundred maturity models during the last years [2, 14] and to a significant number of maturity models for business process management (BPM), too. In addition to a cost reduction, the BPM maturity models also aim to achieve an improvement of the quality and an optimization of time [3, 15]. With regard to the usage of a maturity model in a company, it has to be considered that a maturity analysis is linked with a considerable effort and high costs [8, 11, 20]. Corresponding tools which support a maturity analysis adequately do not exist at the moment. To close this gap, this article explains how to create an Intelligent Maturity Model-Tool. The development of the Intelligent Maturity Model-Tool has not to be mixed up with the design of a new maturity model meaning the creation of a catalogue of criteria and the respective guidelines for the assessment. With regard to the design of a new maturity model, we would like to refer to the multi-level design model of Becker et al. [1].

The Intelligent Maturity Model-Tool as described in this article is characterized by three properties: First, a generic data model enables that several different maturity models are supported by the Intelligent Maturity Model-Tool. Second, the Intelligent Maturity Model-Tool is connected to a BPM system. Due to this connection, it is possible that parts of the information needed for the assessment of the catalogue of criteria are automatically extracted from the BPM system and analyzed by the Intelligent Maturity Model-Tool. Third, the Intelligent Maturity Model-Tool offers an assistance function which recommends suggestions for improvements based on the deficits detected by the maturity analysis. These optimization recommendations aim to remove the current process weaknesses of companies. One important aspect of the Intelligent Maturity Model-Tool is that it is universally applicable and, in contrast to the BPM systems available today, it can be used independently from a customer specific implementation. In addition, the Intelligent Maturity Model-Tool supports a comprehensive analysis of the business processes and is not reduced to a simple flow and output analysis.

The approach of this article follows the design science approach and the guidelines with regard to the design of an artifact developed by Hevner, March and Park [6]. The research starts with a literature research and analysis which has already been described before [10]. An analysis of the requirements and of the technical and functional conditions which a BPM system and the Intelligent Maturity Model-Tool have to fulfill to be able to connect to each other is executed. The next step considers the conceptual design of the Intelligent Maturity Model-Tool and the resulting adaptions

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of the BPM system which are necessary for the connection. Finally, the designed Intelligent Maturity Model-Tool is implemented as a prototype and evaluated.

The article is structured in 4 sections. Following the introduction, section 2 gives an overview of the state of the art of how maturity models are supported by BPM systems. Section 3 is the main part of this article. This section is considered to be analytical and constructive. It explains the design of the Intelligent Maturity Model-Tool and its implementation as a prototype. Section 3 also includes two usage scenarios and a brief evaluation of the Intelligent Maturity Model-Tool. The last section gives a summary of the article and shows interesting research questions for the future.

2. State of the Art – Support of maturity models by BPM Systems

A BPM system is an information system which is the central place for the definition, application, execution, and control of business processes in a company [4, 18]. In addition to the design and management of processes, current systems offer additional functions like simulation and analysis functions to support the user to identify and eliminate process weaknesses [16].

During the last years, several manufacturers have released BPM systems that support process management. These systems follow a number of approaches and concepts, and generally cover the areas of goals, strategy, documentation, analysis, optimization, and automation. Maturity models can provide assistance in the design of processes.

Gartner and Forrester examine independently from each other different BPM systems. Both analyses come to the conclusion that the following providers of BPM systems belong to the market leaders: Pegasystems, IBM Corporation, Appian, Software AG, Metastorm and Progress [17, 19]. The focus of the BPM systems is on process analysis and monitoring, process archives as well as on the support of employees concerning software development, integration and cooperation. Maturity models are not part of the BPM systems of the market leaders. Therefore, an analysis considering different aspects and points of view on a process is not supported by the market leaders. Having a closer look at the analysis services offered by the single BPM systems, it turns out that the analysis services are mostly reduced to an analysis of the process flow and the identification of bottlenecks in the process performance. As a consequence, the suggested optimization recommendations refer to the elimination of the identified bottlenecks. A holistic view of business processes does not take place, with the result that important aspects of business process management are not considered appropriately.

However, there are some special BPM systems which support maturity models. A study by the Fraunhofer Institute for Industrial Engineering examined these BPM systems with the result that maturity models are rarely included in the standard version of the systems. Among the examined systems, only one product, named TopEase by pulinco, provides support for several maturity models. Four products support one selected maturity model. With regard to all other products, a maturity assessment is only covered by the consulting services of the manufacturer or by an individual customizing [21].

The Fraunhofer Institute for Industrial Engineering also examined exemplarily the level of support offered by the selected systems. The criteria for the level of support were the existence of an evaluation scheme, the graphical representation of the maturity level and the documentation of the maturity level. The examined tools, ADONIS by BOC, ARIS by Software AG (formerly IDS Scheer), and TopEase by pulinco, offer all an evaluation scheme for the available BPM maturity models. The graphical representation and documentation of the maturity level are implemented in different ways in the BPM systems. The study of the Fraunhofer Institute draws the conclusion that the implementation of maturity models is realized "largely customer- and project-specific" [9].

Summarizing the above-mentioned facts, we come to the conclusion that the currently available support for the application of maturity models is inadequate. Therefore, a need is given to develop an Intelligent Maturity Model-Tool.

3. Development of an Intelligent Maturity Model-Tool

3.1 Motivation

The benefits of the Intelligent Maturity Model-Tool for the application of BPM maturity models in companies are described below. In addition, it is also explained which advantages are realized for the BPM system by the integration of the Intelligent Maturity Model-Tool.

- *Efficient execution of maturity level analyses* due to the automated extraction of the required data from the BPM system.
- *Execution of maturity level analyses to lower costs* due to the automation and, therefore, to lower the need of personnel resources and external experts.

- *Execution of regular maturity assessments* for a more time efficient and more cost-effective mode of operation. This has the consequence that business processes and business process management can be controlled more strongly.
- *Increased standardization of maturity assessments* due to the extraction of consistent data from the BPM system as a basis for the maturity level analysis.
- *Enhanced generation of optimization recommendations* due to the representation of the knowledge of a number of experts in the knowledge database of the Intelligent Maturity Model-Tool.
- *Direct access to the BPM system for analysis purposes*, e.g. usage of the simulation function of the BPM system.
- *Definition of the support processes* with the consequence that these processes are documented and executed according to the defined standard.
- *Enhanced user support in the BPM system* by using data from the Intelligent Maturity Model-Tool, e.g. proposal of best-practice processes from the database of the Intelligent Maturity Model-Tool in the Process Design Component or comparison of actual values of KPIs (Key Performance Indicators) with benchmark data of the Intelligent Maturity Model-Tool in the Process Analysis Component.
- *Risk minimization during the introduction of new processes* by a preliminary assessment of the new process drafts before the realization.
- *Comprehensive evaluation of business processes* instead of a simple flow or performance analysis.

The above-mentioned advantages have been identified by means of an iterative search process. This search process was characterized by several phases of development and returns. The development of Intelligent Maturity Model-Tool was designed as an open investigation. At the beginning, we have exemplarily tested a real system (ARIS Platform). It has been tested which data is stored in a BPM system by default, and what forms of integration are technically feasible.

3.2 Requirements

The requirements to the Intelligent Maturity Model-Tool are derived from the benefits for a company described in 3.1. In Table 1, all requirements are summarized. It is differentiated between the general, non-functional requirements and the required functions of the Intelligent Maturity Model-Tool. The functions must support the execution of a maturity level analysis, the adaptation of existing maturity models and the addition of new models. In addition, administrative functions for the tool have to be available, too.

Table 1. Requirements to the Intelligent Maturity Model-Tool

	Requirements	*Description*
Non-functional	Genericity	The tool requires a generic structure so that it is possible to show different maturity models, to change the maturity model data and to extend the maturity models without reimplementation.
	Support for different scale levels	The tool is able to work with different scale levels.
	Extensibility	The tool is designed in such a way that it can be easily adapted and extended to work with more maturity models.
	Assistance function	The tool provides an assistance function to eliminate identified process weaknesses.
	Knowledge database	The tool must have a knowledge base including optimization recommendations, best-practice processes and benchmarks.
	Simplicity	The tool is able to quickly and easily support regular assessments.
	Ease of use	The tool is designed in such a way that users with only basic training can intuitively perform an assessment.
Functional	Connectivity	The tool has an interface to connect to external applications.
	Create and delete user and client	The tool is able to manage multiple clients and users.
	Create, edit and delete objectives	The tool is designed in such a way that changes of the questions of the maturity model can be done fast and easily.
	Create, edit and delete answer options	The tool is designed in such a way that changes of the answer options of the maturity model can be done fast and easily.
	Create, edit and delete model results	The tool is designed in such a way that changes of the model results can be done fast and easily.
	Weight answer options	The tool is able to weight different answer options of the maturity model independently.
	Evaluate an assessment automatically	The tool is able to automatically determine the maturity level on the basis of the responses.
	Generate reports	The tool is able to generate result reports on the basis of the assessments.
	Compare assessments	The tool supports the automatic comparisons of assessments from different time points.

To a large extent, the requirements were taken from a previous research project focusing on the development of a generic tool for the application of maturity models [10]. This research project was characterized by an iterative search process, which identified most of the above-mentioned requirements. The requirements have been validated in the previous research project by the implementation of a prototype and its successful use in one of our projects for the German federal state government. The newly added requirements for this project "Knowledge Database" and "Assistance Function" were identified by the analysis of classical maturity level surveys. Since the Intelligent Maturity Model-Tool is supposed to replace a classic maturity level survey, the tool must be able to provide optimization recommendations comparable to the recommendations of an assessment manager. Therefore, the Intelligent Maturity Model-Tool requires a function (Assistance Function) that makes an appropriate optimization recommendation which is based on the results. Furthermore, the tool requires a database (Knowledge

Database) where the optimization recommendations can be stored.

Selected requirements that are critical for the success of the Intelligent Maturity Model-Tool according to our understanding are explained in detail in the following sections.

Genericity: According to the objectives, the Intelligent Maturity Model-Tool needs to represent different maturity models including their specific model components. As a consequence, the structure of the Intelligent Maturity Model-Tool must be adequately flexible to e.g. implement different structures of the criteria catalogue of a maturity model. Changes to existing models or the addition of new models should be possible without significant effort for adjustments.

Support for different scale levels: The single maturity models differentiate between several categories in the maturity assessment and the maturity evaluation. As a result, different types of scales (e.g. ratio scale, ordinal scale) have proven to be useful for the maturity evaluation. Therefore, the Intelligent Maturity Model-Tool must also be able to cope with different types of scales.

Assistance function: Another feature of the Intelligent Maturity Model-Tool is the proposal of optimization recommendations to eliminate the identified weaknesses. This feature requires the existence of an assistance function and of a knowledge data base which builds the basis for the optimization recommendations.

Simplicity: The Intelligent Maturity Model-Tool should be useable without any special training effort. Therefore, it must be simple and user friendly to operate.

Connectivity: The Intelligent Maturity Model-Tool aims to reduce the effort for a maturity analysis. An essential element of this feature is the automated extraction of data stored in a BPM system as basis for the execution of a maturity analysis. Consequently, the Intelligent Maturity Model-Tool must be able to communicate with the BPM system and to exchange data with it. The data exchange can also be used to achieve synergy effects in both systems. For example, the BPM system can use the best-practice processes stored in the Intelligent Maturity Model-Tool.

3.3 Conception

One main requirement of the Intelligent Maturity Model-Tool is the automated assessment of the catalogue of criteria. To realize this requirement, it is necessary to examine the criteria in detail. The result of this examination is that it is possible to categorize the criteria into two dimensions.

The first dimension refers to the kind of criteria. We differentiate between weak and hard criteria. A weak criterion is defined quite generally and/or unspecifically. An example is given by PEMM: “Employees are prepared for significant change in how work is performed“ [5]. A hard criterion describes a very clear and/or specific situation. An example can be found in the Maturity Model for Business Process Management by Schmelzer & Sesselmann: “Is the responsible person for the business process named?” [15].

The second dimension refers to the level of automation. A low level of automation stands for a manual assessment while a high level stands for the automated extraction and the assessment of data. The manual assessment is conducted by using an e-mail survey. The e-mail survey allows asking people for their assessment to lower costs compared to a classical interview.

The kind of criteria influences the level of automation. Weak criteria are linked with a low level of automation as they can only be assessed by people, e.g. using the e-mail survey. Hard criteria are linked with a high level of automation as they can be extracted from the BPM system and automatically assessed. Criteria which are between weak and hard can have different nuances. Criteria which are rather weak are also covered by the e-mail survey. Criteria which are rather hard can often be assessed by an automated extraction and assessment after special support processes have been stored in the BPM system.

Another important requirement on the Intelligent Maturity Model-Tool is the assistant function that is based on the identified weaknesses of the process optimization recommendations. The basis for this assistance function is the storage of one or more optimization recommendations for each criterion, which will be based on the results of the Intelligent Maturity Model-Tool. The quality of recommendations depends on the kind of criteria. It is possible to categorize the recommendations in three categories (see Figure 1).

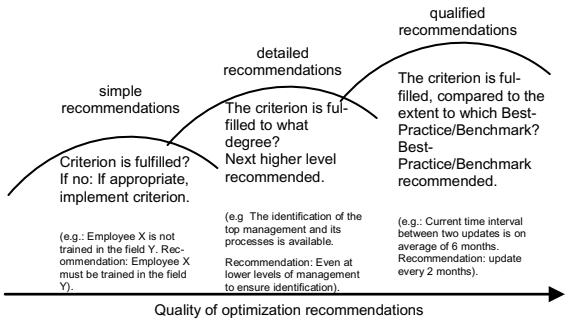

Figure 1. Quality of optimization recommendations

The first class includes all criteria for which only simple recommendations can be stored. These criteria

can be mainly assessed with "yes" or "no". As a consequence, the recommendation refers only to the implementation of the missing criterion. An example is given by the Maturity Model for Business Process Management by Schmelzer & Sesselmann: "Have process employees insight into the process reports?" [15]. If the answer to this criterion is "yes", no optimization recommendation is given. If the answer is "no", the optimization recommendation is to implement the criterion, e.g. "The process employees should have insight into the process reports. In addition, the process employees should be encouraged to use the process reports to understand the context and the issues of the business process in detail with the consequence that they can initiate activities to solve problems."

The second class includes all criteria for which detailed optimization recommendations can be given. The class includes especially the criteria for which different levels of implementation can be differentiated. An example from the Maturity Model for Business Process Management by Schmelzer & Sesselmann is: "Does the management support the responsible person for the business process in the realization of difficult process optimizations?" [15]. A detailed optimization recommendation provided by the Intelligent Maturity Model-Tool could be: "The management is involved in process optimizations, but in future, the management should support stronger the responsible person for the business process in the realization of difficult process optimizations."

All criteria for which qualified optimization recommendations can be given belong to the third class. These criteria often use a comparison of the actual data by the maturity analysis with the data from the benchmark or best-practice database. An example from the Maturity Model for Business Process Management by Schmelzer & Sesselmann is the question "Are process assessments done on a regular basis?" [15]. A possible result could be that process assessments are done every 18 months. The Intelligent Maturity Model-Tool can determine the adequate time interval between process assessments using its data base and compare the two values. An optimization recommendation could look like the following proposal: "Process assessments are done every 18 months. Based on experiences, it is recommended to repeat the process assessments every 8 months. Consequently, you should reduce the time interval between process assessments to 8 months."

3.4 Main functions of the Intelligent Maturity Model-Tool

The maturity assessment, the maturity evaluation and the assistance function are the main functions of the Intelligent Maturity Model-Tool. They are shown in the function tree (see Figure 2).

The *assessment* provides the automated assessment of the criteria catalogue of the maturity model. There are two options available. First, the required information can be extracted directly from the BPM system. Second, information which is needed but not stored in the BPM system can be collected via an automated e-mail survey. The e-mail survey is required for criteria that refer to a subjective perception and, therefore, cannot be stored appropriately in a BPM system. The obtained information is stored in the Intelligent Maturity Model-Tool. The executed assessments can be reviewed at any time and compared with other assessments.

The *evaluation* automatically calculates the maturity level based on the collected information. For this purpose, the information identified during the assessment is interpreted on the basis of the evaluation guidelines of the corresponding maturity model. With regard to the examined maturity models, it is possible to execute the evaluation on the basis of previously defined point scores which represent the respective degree of fulfillment of the criterion according to the given information. The result of the evaluation is stored in the Intelligent Maturity Model-Tool. In addition, former evaluations can be reviewed and compared with newer ones to track improvements or declines in the realization of the individual criteria.

The *assistance function* identifies the vulnerabilities of the business processes based on the maturity evaluation. During the development of the Intelligent Maturity Model-Tool, general optimization recommendations have been stored for each criterion. These recommendations can be complemented with the information used in the evaluation (e.g. determined number of processes in a department). Depending on the

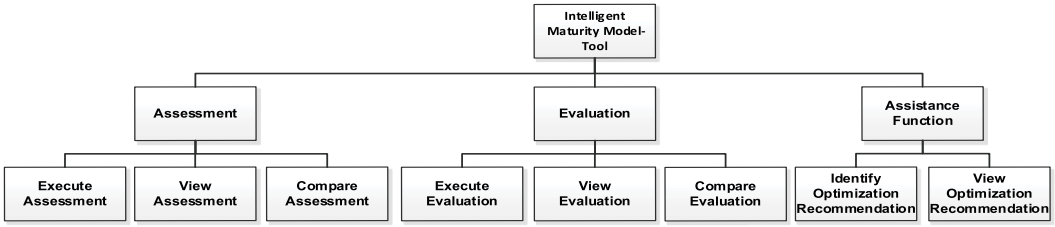

Figure 2. Function tree with the main functions of the Intelligent Maturity Model-Tool

result of the evaluation, the predefined optimization recommendations are used by the assistance function in order to propose a possible user action to eliminate the vulnerability. After the selection of the appropriate optimization recommendations, they can be reviewed at any time. If applicable, the optimization recommendations are also visualized directly in the process model of the BPM system.

3.5 Architecture and Implementation

The focus of this work lies primarily on the architecture of the Intelligent Maturity Model-Tool. In order to enable the integration between the Intelligent Maturity Model-Tool and a BPM system, certain technical requirements must be fulfilled. On the part of the BPM system, certain components and functions are required for the integration to enable e.g. the extraction of data from the BPM system. The following list of required components is done solely in the context of the integration: process design component, process analysis component, integration services and structured data management components.

Not only technical requirements, but also requirements with regard to the content must be met. It is assumed that the data in the BPM system is complete and well maintained. This means that all data and information that may be included by default in a BPM system is available and up-to-date.

A prototype of the system architecture of the Intelligent Maturity Model-Tool is illustrated in Figure 3. The system architecture distinguishes three levels of components. The lowest level is given by the data storage components. Here, the data which is needed by the Intelligent Maturity Model-Tool to assess and evaluate the maturity level is stored. The data includes also the knowledge base for the optimization recommendations, the best-practice processes and the benchmark values. The top level is the presentation layer. This level includes the user interface which supports the user to operate the Intelligent Maturity Model-Tool. The middle level contains the processing components. It includes all components that are required for the determination of the maturity level. These components are explained in detail in the following paragraphs.

IMM-Engine (1): The IMM-Engine (Intelligent Maturity Model-Tool-Engine) is the central component of the Intelligent Maturity Model-Tool. It is responsible for the management of the other processing components and for the distribution of the data. Once a maturity analysis has been started, the IMM-Engine loads the criteria catalogue and the evaluation guidelines of the maturity model from the data management component "Maturity Model Data" and the corresponding optimization recommendations from the “Knowledge Base”, and then forwards the data to the Assessment Component, the Assistance Component and the Evaluation Component. During the determination of the maturity level, the IMM-Engine is responsible to manage and to control the other components as well as for

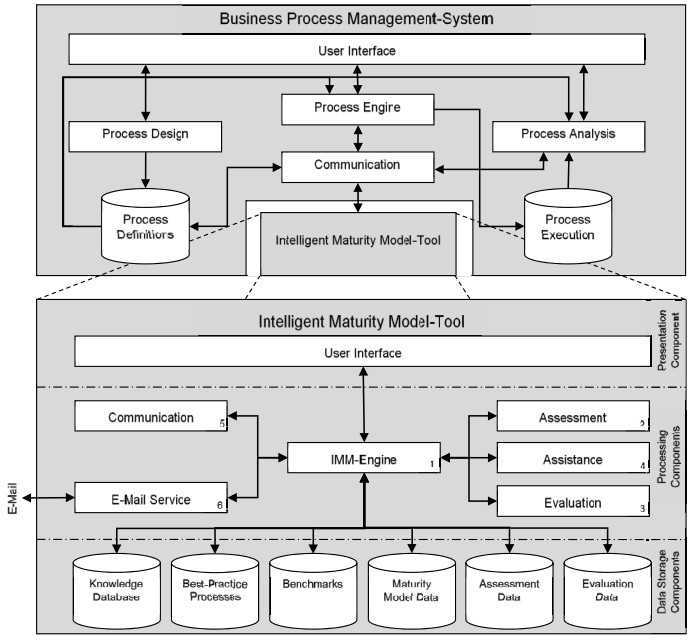

Figure 3. Architecture of an Intelligent Maturity Model-Tool (BPM architecture of the system is based on [18])

the exchange of data. After completion of the determination of the maturity level, the IMM-Engine ensures that the resulting assessment and evaluation data is stored in the corresponding data storage components. Furthermore, the IMM-Engine initiates the generation of a result report of the maturity analysis which is forwarded to the appropriate employees of the company.

Assessment Component (2): The Assessment Component is responsible for the assessment of the single items of the criteria catalogue. At the beginning, the data needed to assess the criteria is requested from the IMM-Engine. The criteria are divided into two categories: The criteria of the first category can be assessed by the extraction of information from the BPM system. The criteria of the second category can only be assessed by using an e-mail survey. Both, the extraction of data from the BPM system and the execution of the e-mail survey are controlled by the IMM-Engine. After the IMM-Engine has forwarded the obtained data and answers completely to the Assessment Component, they are assessed by the Assessment Component. If required for the assessment, also relevant data from the "Best-Practice Process" database and from the "Benchmarks" database are loaded by the IMM-Engine to obtain a basis for comparison. At the end of the assessment, the results are transferred to the IMM-Engine which then stores the data in the "Assessment Data" database.

Evaluation Component (3): After completion of the assessment, the Evaluation Component obtains the result data from the IMM-Engine, evaluates the results based on the evaluation guidelines and determines the level of maturity. Following the evaluation, the evaluation result is transferred to the IMM-Engine which then stores it in the "Evaluation Data" database.

Assistance Component (4): The Assistance Component is responsible for the selection of appropriate optimization recommendations on the basis of the identified process vulnerabilities. The Assistance Component receives the results of the evaluation from the IMM-Engine and chooses appropriate optimization recommendations and suggestions for the identified vulnerabilities. At the beginning of the maturity determination, the available optimization recommendations are loaded in the Assistance Component by the IMM-Engine. After the selection of appropriate recommendations, the selected ones are transferred to the IMM-Engine which then stores them in the "Evaluation Data" database.

Communication (5): This component is responsible for the communication with the BPM system. The Intelligent Maturity Model-Tool can access the data and the functions of the BPM system by using this component. The other way round, the BPM system can access the data of the Intelligent Maturity Model-Tool. As an interface language, the Business Process Execution Language (BPEL) or the Extensible Markup Language (XML) Process Definition Language (XPDL) may be used, for example. Amongst others, BPEL is used by IBM and XPDL by ARIS [7, 13]. In order to avoid bottlenecks in data streams, a direct access to the "Process definitions" database and to the "Process Analysis" component is established within the BPM system.

E-Mail Service (6): The E-Mail Service is responsible for sending and receiving e-mails and has two additional tasks. First, the E-Mail Service sends the questionnaire for the automated e-mail survey to the corresponding employees. It receives the responses and transfers them to the IMM-Engine which forwards them to the Assessment Component. Second, the E-Mail Service is used to send the result report of the maturity level analysis to the corresponding employees.

For the purposes of mutual synergy effects, the BPM system can also benefit from the integration within the Intelligent Maturity Model-Tool. Two possibilities for benefits of the BPM system are presented below:

Process Design Component: The Process Design Component can visualize the optimization recommendations that have been identified by the Intelligent Maturity Model-Tool in the process model. Furthermore, it can refer to best-practice processes stored in the Intelligent Maturity Model-Tool (for example, this would be a way to an extension of the semantic checks on the ARIS Platform).

Process Analysis Component: The Process Analysis Component can extend the offered analysis functions by using the "Benchmarks" database and the "Best-Practice Processes" database of the Intelligent Maturity Model-Tool. With regard to the process monitoring and the business activity monitoring, reference values from the "Benchmarks" database of the Intelligent Maturity Model-Tool can be shown in addition to the measured values as well as differences in terms of an actual-target-comparison.

3.6 Application and Evaluation

This section illustrates two examples for the application of the Intelligent Maturity Model-Tool with the ARIS-Platform. Both examples are taken from the Maturity Model for Business Process Management by Schmelzer & Sesselmann [15]. In the prototype, ARIS Platform by Software AG is used as the BPM system. It is explained how the examples are implemented and which possible optimization recommendations are given. The first example uses the automated extraction and analysis of data from the BPM system as the basis

for the assessment. The second example uses the automated e-mail survey to obtain the required information. Furthermore, at the end of this chapter, the implementation capability is examined by a number of criteria to evaluate the tool.

Example 1: "Are Balanced Scorecards for business processes created and updated during the strategic business planning?" [15]

Automated extraction and analysis: The Intelligent Maturity Model-Tool accesses the data base of the BPM system via the Communication Component and verifies if Balanced Scorecards for business processes are available. By comparing the number of stored business processes with the number of defined Balanced Scorecards, an assessment concerning the existence and the completeness of Balanced Scorecards is possible. The update interval can be determined on the basis of the creation date and the modification date. The Intelligent Maturity Model-Tool can contain a benchmark value for the recommended update interval so that it can be compared with the average update interval of a Balanced Scorecard in the BPM system. The result of the analysis is stored in the database of the Intelligent Maturity Model-Tool.

Optimization recommendation: The optimization recommendation of the Intelligent Maturity Model-Tool could inform about missing Balanced Scorecards compared with stored business processes using the difference between the number of existing business processes and the number of stored Balanced Scorecards. For example, the Intelligent Maturity Model-Tool can point out that there are three business processes for which no Balanced Scorecard is available. In addition, the Intelligent Maturity Model-Tool can give the suggestion that Balanced Scorecards should be updated about every 9 months if the current mean time for updates is 11 months, for example.

Example 2: "Are the process employees informed about the causes for errors and the corresponding corrective measures?" [15]

Automated e-mail survey: The criterion assesses the information culture in a company. The information needed to assess the criterion cannot be adequately stored in the BPM system. Therefore, an automated e-mail survey is sent to the employees who should be informed about causes for errors and the corresponding corrective measures. The survey consists of predefined questions with associated answer options. To achieve a result for the determination of the degree of maturity level, there is no restriction on the sample size for the automated e-mail survey. This has two reasons. First, the number of employees which are familiar with a process is highly dependent on the company's size and structure. In smaller companies, it is often the case that only one employee or a small group of employees is familiar with a process. If a restriction on the sample size existed, it would be possible that smaller companies could not use this function of the tool and, instead, would have to change to a classic maturity level survey. Then the cost savings and the speed of the tool would become irrelevant. Second, in a classic maturity level survey a restriction on the sample size does not exist. In the classic maturity level survey, the information is usually obtained by means of interviews. During these interviews, it often occurs that only one of the participants can make qualified statements about a process. In these cases, the individual statements are used for the outcome of the investigation. Therefore, we decided not to implement a restriction on the sample size.

The communication concerning recent process changes can, for example, be assessed by using a corresponding list of questions. By asking the questions as concretely as possible, the objectivity of the answers can be improved. After receiving the responses, the Intelligent Maturity Model-Tool calculates the average value of the responses and stores it in its database for later determination of the maturity level.

Optimization recommendation: With regard to this criterion, the Intelligent Maturity Model-Tool can recommend, for example, that the causes for errors and the corresponding corrective measures should be communicated better. However, the Intelligent Maturity Model-Tool cannot propose detailed suggestions which weaknesses of communication should be addressed with priority.

To prove that the approaches described above can be realized in general, more criteria from the Maturity Model for Business Process Management by Schmelzer & Sesselmann [15] were selected and these criteria were implemented in the prototype of a previous study on the development of a generic tool for the application of maturity models [10]. Since this tool has a generic structure and was specifically designed to represent different maturity models, it provides an ideal basis for a first evaluation. The prototype was modified in such a way that the data, which was imported with the XML export function from the sample database "DEMODB-United Motors Group" of the ARIS Platform, can be evaluated automatically. Thus, it was shown in a first attempt that imported data from a BPM system could be used for the automated evaluation of corresponding maturity model criteria.

A further evaluation of the Intelligent Maturity Model-Tool has been accomplished by the examination of its implementation capabilities of all criteria of the Maturity Model for Business Process Management (BPMR) by Schmelzer & Sesselmann [15], all criteria of the Process Enterprise Maturity Model (PEMM) by Hammer [5] and the criteria of the 2nd Maturity level

of the Business Process Maturity Model (BPMM) by the Object Management Group (OMG) [12]. These three models were chosen because of their different priorities in the determination of the level of maturity of business process management.

As a result of the appraisal of the examined criteria, an automatic evaluation was feasible for approximately 36% of the criteria, without requiring an e-mail survey (compare Table 2). Overall, it was found that the degree of automation is very dependent on the maturity model. Based on the exemplary study of BPMR and BPMM, maturity models which evaluate the quality aspects of business processes or which evaluate the business processes from the management point of view can be automated to around 40-50%. In contrast, models that focus on the process environment and the conditions are very difficult to automate (nearly 8%). Concerning these models, the list of criteria is formulated very soft and spacious. Furthermore, these models require information for the assessment of the criteria that is not available in a BPM system. This information can only be collected through observations and interviews with the involved people.

The automation of optimization recommendations behaves in a similar manner compared to the automated evaluation. It strongly depends on the used maturity model and its criteria whether optimization recommendations can be identified and how qualitative they are. For the examined maturity models BPMR, PEMM and BPMM, optimization recommendations could be shown automatically for approximately 77% of the criteria (compare Table 2).

4. Summary and Outlook

The aim of this study was to clarify whether it is possible to develop an Intelligent Maturity Model-Tool for business process management or not and to what extent an Intelligent Maturity Model-Tool has advantages in comparison to the traditional methods of maturity analysis. The essential results of this study are summarized below:

- The development of a generic tool which can be used for the application and presentation of different maturity models is possible by using an appropriate design and by the configuration of the structure and the database of the tool.
- The data required for the maturity analysis can be extracted directly from a connected BPM system and can be automatically assessed. Additional information can be determined by an automated e-mail survey containing a choice of predefined response options. The answers of the e-mail survey are automatically assessed by the system. The evaluation of the information to determine the maturity level according to the evaluation guidelines of the maturity model can be done automatically by the Intelligent Maturity Model-Tool.
- Suitable optimization recommendations based on the maturity evaluation can be generated automatically from the knowledge database by the assistance function of the Intelligent Maturity Model-Tool and then shown to the user.
- An assessment of the maturity level which is based only on the automated extraction of data from the BPM system is not possible because most maturity models include criteria which capture the subjective perceptions of employees. This type of information is not available in a BPM system.
- To sum it up, we consider the Intelligent Maturity Model-Tool as a valuable instrument to facilitate the maturity level analysis and, therefore, to support companies in the optimization of their business processes. The objectives described in 3.1 can be achieved.

For further evaluation, especially in terms of completeness and efficiency, the prototype should be extended. The extension should include the implementation of two to three full maturity models. It should also include the replacement of the manual import of the BPM system's XML files by the described automated communication interface between the tool and the BPM system. As a qualified research method, we would choose real case studies. With these case studies we could determine the degree of innovation and the efficiency of the tool. Furthermore, the completeness of the method could also be evaluated by the real case studies. The requirements would be processed through these case studies and the concept would be completed after all requirements would have been covered.

Table 2. Results of the assessment and optimization investigation.

Maturity Model	Number of analyzed criteria	auto. Extraction & Analysis		auto. e-mail Survey		auto. Optimization recommendation possible		not auto. Optimization recommendation possible	
		absolute	percentage	absolute	percentage	absolute	percentage	absolute	percentage
BPMR	146	73	50.0 %	73	50.0 %	120	82.2 %	26	17.8 %
PEMM	104	8	7.7 %	96	92.3 %	46	44.2 %	58	55.8 %
BPMM (2nd level)	151	64	42.4%	87	57.6 %	141	93.3 %	10	6.6 %
Total	401	145	36.2 %	256	63.8 %	307	76.6 %	94	23.4 %

The findings of this study provide interesting opportunities for further research. After completion of the implementation of the prototype and its further evaluation, strengths and weaknesses of the Intelligent Maturity Model-Tool could be worked out in detail based on different laboratory tests. Another interesting point is the development of a BPM maturity model that is dedicated to the needs of an automated assessment of the criteria. This means that the catalogue of criteria of the maturity model should be designed in a way that the majority of the required information can be extracted automatically from the BPM system and can be evaluated automatically.

In summary, the research results of this study and the additional research ideas described above contribute to lower the barriers of a maturity analysis and to perform the determination of a maturity level with less effort and lower costs. Thus, the applicability of this important instrument for process analysis and optimization has been improved significantly.

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