

# A Systematic Approach for maintainable business Process Models

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**Abstract.** The BPM lifecycle brings incremental improvement to business process models. In this paper, we propose a systematic approach to promote the maintainability of business process models, which stimulates the ease of their modifications and reduces the difficulties of maintenance. The proposed approach is based on a new extension of the BPM lifecycle. In this regard, we considered a set of the maintainability metrics for business processes models. Particularly, these metrics are classified into two main categories: static maintainability metrics and dynamic maintainability metrics. We evaluate the static maintainability metrics in the modeling phase and the dynamic maintainability metrics in the execution phase in the BPM lifecycle. After both assessments, a set of recommendations is given to allow the designer to improve the maintainability of the considered models and facilitate maintenance tasks in the future. These phases are illustrated and validated through a case study from the health care sector.

**Keywords:** Approach for maintainable BPMN; BP maintainability; BPM lifecycle; maintenance lifecycle; metrics; recommendations.

## 1 Introduction

According to the IEEE Standard 1219 [1], the software maintenance is the modification of a software product after its delivery. It is used for several functions such as correct errors, improve the design, make improvements to better support the needs of users, adapt the system to various changes (for example changes to government rules, make changes to files or databases, etc.).

Nowadays, the business process is a very important concept in the information systems field. Business process management (BPM) brings incremental improvement to business processes using several methodologies, techniques, and tools, in order to guarantee the organization's competitive position in the market [2].

Based on the similarity between the software and the business process, the maintenance task presents the different modifications and changes that can be applied in the business process models [3]. In fact, it ensures the continuity of use of the process

model, their continuous improvement, the adaptation of the model to changes in the environment, and the satisfaction of different customer requests. The ease of maintenance is dependent on the evaluation of the characteristic "maintainability". For that, it is necessary to have business process models that are easy to maintain. According to Oktay [4] the business process maintainability is "the ease with which a single or a collection of business processes can be modified to correct faults, improve performance or other attributes, or adapt to a changing environment". Rolon et al., [5] suggests that the maintainability facilitates the maintenance task of business process models and it reduces their modification efforts. In fact, more maintainable models guarantee their simplicity and their understandability as they evolve. Besides, the authors add that business process metrics provide useful information about the level of maintainability of these models.

However, the software as well as the business process maintenance are characterized by their huge costs and time-consuming implementation. In reality, the business process lifecycles do not explicitly present the notion of maintenance. In this sense, we thought to propose an approach that integrates the concept of maintenance in the BPM lifecycle, which can be a solution to decrease the costs and the time necessary to carry out the changes and to obtain maintainable models (easily adapted to changes). The remainder of this paper is organized as follows. Section 2 summarizes recent related work based on similar concepts. Section 3 describes in detail our approach. Section 4 describes the application of our approach in the emergency care case study. Section 5 presents a discussion for comparing our approach to related work. The last section gives a brief conclusion.

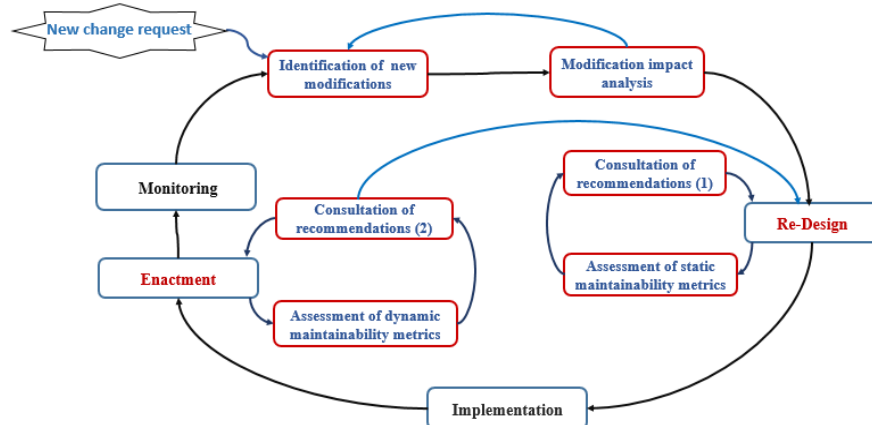
## **2 Related work**

To ensure the continuity of using business process models in a dynamic environment, they must be scalable, adapting to different changes, and be easily modified. For this reason, maintainability is important to the business process model. In addition, the modeling phase of the business process lifecycle plays a key role in obtaining a maintainable model with fewer errors and costs. Rolon and Sadowska [6] assess the complexity of the business process model of BPMN notation. The result of the analysis experience includes 13 metrics related to the understandability and 6 metrics related to the modifiability of business process models. In addition, Gruhn and Laue [7] adapt software complexity metrics to assess the complexity of the process. The purpose of evaluating these indicators is to indicate whether the model is structured and easy to understand and to check whether the model is divided into small modules. Lamghari et al., [8] propose a new method, based on the BPM lifecycle, to improve the quality of business processes to achieve acceptable performance levels. The work presented by Dumas et al., [9] focuses on the redesign phase in the BPM lifecycle by proposing four dimensions (duration, cost, quality, and flexibility) to quantify the performance of the designed model. To assess the structural complexity of BPMN. Aguilar et al., [10] adapted the framework (FMESP-Framework for the Modeling and Evaluation of Software Processes) for business process models. The goal of this framework is to

select the easiest way to maintain models. BPMN-CM (Business Process Modeling Notation Change Management) is another tool developed in [11] to manage the evolution of business process models. By analyzing the impact of changes, it allows checking the consistency of the model after each change. The work objective proposed by Sadowska [19] is to determine a set of indicators and thresholds indicating the quality level of the BPMN model by focusing on the four main quality characteristics namely: Modifiability, understandability, complexity, and correctness. The contribution of Abdul et al., [12] aims to adapt the complexity metrics of software programs to evaluate the complexity of business process models. To improve the quality of business process models, Kahloun and Ghannouchi [2] defined a set of recommendations for the modeler which appear after a comparison between the values of the quality metrics and the threshold values. The SIG (Software Improvement Group) maintainability model is another method to evaluate the quality of software based on the maintainability characteristic. In fact, Oktay, [4] adapts the SIG model of software maintenance to a collection of interrelated business process models. Always based on the similarity between the software and the business process, the author adapted a set of software maintainability metrics for evaluating business process models regarding for example coupling, duplication, volume, unit size, and unit complexity.

### 3 Proposed Approach

Our approach allows maintenance to be considered during the BPM lifecycle. In our work, the maintainability assessment includes two phases (redesign and execution) of the BPM lifecycle. These evaluations are based on a comparison of maintainability indicators with thresholds selected from the literature. If the value of the maintainability metric exceeds the threshold, one or more suggestions will be generated to improve the BPMN model, the ease of change, and to favor their maintainability. Concretely, we have created a new extension of the BPM lifecycle (Fig.1).



**Fig. 1.** Extension of BPM lifecycle for maintainability support

In fact, we proposed to add two sub-cycles for evaluating maintainability metrics. The first sub-cycle is for the design phase, and the second one is for the execution (enactment) phase. Then, based on the maintenance lifecycle proposed by IEEE, we have included the two new phases “identification of new modifications” and “modification impact analysis” to consider the maintenance tasks for business process models.

### 3.1 Assessment of static maintainability metrics

Several metrics were selected. For this reason, we divide them into two categories, namely complexity indicators and coupling indicators. For the complexity category, we have selected the following metrics:

- NOA (Number Of Activities) and NOAJS (Number of Activities, Joins, and Splits) : Vanderfeesten et al., [3] adapted this metric for the business process models and they proposed the metric NOA and NOAJS.
- CFC (Control-Flow Complexity) : Cardoso [19] proposed a metric for measuring the complexity of the control flow in the business process model. CFC assesses the complexity of the process introduced by gateways such as "XOR-Split", "OR-Split" and "AND-Split".
- HPC (Halsted-based Process Complexity): Vanderfeesten et al., [3] proposed the HPC (Halsted-based Process Complexity) metric for the assessment process: length, difficulty, and volume.
- IC (Interface Complexity) : Vanderfeesten et al., [3] proposed the IC for evaluating the complexity of processes.
- Modularity (M): Modularity presents the degree of decomposition of the model into sub-processes [7].

In this category, Mendling proposed also a set of structural metrics to assess the models of business processes. Later, from this set, Sadowska et al., [13] selected the metrics of modifiability and understandability for the BPMN. In our solution, we used  $S_n(G)$  metric to calculate the number of structural nodes in a model. For the evaluation of the complexity of a graph (G), Mendling defines  $CNC(G)$  (Coefficient of network complexity) metric for evaluating the complexity of a graph G. Rolon and Sadowska, [6] have approved a set of metrics of modifiability of business process models. Based on these related work, we have used for the complexity metrics: The TNG (Total Number of Gateways) which counts the number of gateways in the model. In fact, the higher gateway heterogeneity is, the more difficult modification in the model becomes; the TNDO (Total Number of Data Objects) which represents the sum of the number of input and output data objects; and the TNE (Total Number of Events) which counts the number of events used in the process model.

For the coupling metrics: we have chosen the following metrics.

- Coupling: for measuring the number of interconnections between the modules of the model [3].
- ICP (Imported Coupling) and ECP (Exported Coupling): ICP counts the number of messages or sequence flows sent by the activities of the process or by the sub-process for each activity. ECP counts the number of message flows received by the activity or sub-process for each activity [14].

- RFP: Response For a Process metric is used to calculate the coupling in terms of control flows [14].
- CLP and CLA: CLP (Connectivity Level Between Pools) and CLA (Connectivity Level Between Activities) deal with the modifiability of the model [6].

### 3.2 Consultation of recommendations (1)

Recommendations are at this stage mainly related to complexity metrics and coupling metrics. Recommendations of the complexity metrics include for example:

- CFC: Minimize gateways such as: OR-split-join to reduce the complexity of the control flow in order to have a more understandable process, and avoid using the OR Gateway whenever possible.
- NOA: Create sub-processes and reduce the number of tasks.
- NOAJ: Reduce the number of activities or gateways (joins/splits) and create sub-processes.

Recommendations of the coupling metrics include for example:

- CP: Reduce the number of interconnections between activities in a process model. In fact, the higher the coupling value is, the more the change is difficult.
- ICP: Create processes/sub processes with a limited number of control flows and incoming message flows to reduce the likelihood of error, and to reduce service time and modification costs.

### 3.3 Assessment of dynamic maintainability metrics

After the execution of the BPMN models, the dynamic metrics are compared with threshold values. If there are unacceptable values, a set of recommendations is given to the expert to correct and modify the model. The dynamic maintainability metrics are the following:

- Process Duration (MIN, MAX, AVG): This metric has three measures such as: Minimal process execution time (MIN), Maximal process execution time (MAX), Average process execution time (AVG).
- Activity duration: This metric count the average duration of an activity.
- Activity waiting time: This metric allows measuring the waiting time to execute an activity.
- Total duration for 2 (or more) activities without waiting time: This metric counts the sum of the average execution time for a fragment without taking into account the time lost between two activities or between three activities (or more).
- Waiting time for 2 (or more) activities: This metric counts the average of the waiting time between two or more executed activities (fragment).
- Total duration for 2 (or more) activities with waiting time: This metric counts the sum of the average execution times between two or more activities while taking into account the waiting time between them.
- Number of resources: The resources can be either human or material resources. This metric counts the resources used by one activity. For a fragment, it allows to count the average number of resources used by this fragment.

### **3.4 Consultation of recommendations (2)**

These guidelines can directly affect the third phase of the BPM lifecycle, but in some cases, they also require a return to the "Re-Design" phase to make modifications in the BPMN model. After applying the modifications and obtaining a process with good maintainability, the monitoring phase is performed.

### **3.5 Identification of new modifications**

This phase is initiated by the arrival of a new modification request from outside the organization. This request can be either a demand for change coming from a customer or an innovation in the environment for example a new technology that appears. Similarly, this stage can be initiated by a modification recommended through the monitoring phase.

### **3.6 Modification impact analysis**

The analysis of impact determines the positive and negative effects of the modification request. Based on the analysis of the impacts of the proposed changes, an expert defines the costs of the modification request. Then s/he decides whether this request is accepted or refused.

## **4 Developed plugin and experimentation**

To verify our solution, we chose Visual Paradigm as a tool for modeling business processes expressed in BPMN notation. To be more precise, we adapted a plug-in to enable us to implement our solution. This plugin is open source, developed by Sadowska [15] using Java, and adapted by Kbaier and Ghannouchi [16] to evaluate the quality of the BPMN models. We extended this plugin to evaluate the maintainability of a given BPMN model. Fig. 2 summarizes how our plugin extension works. As a case study, we selected the medical field and evaluated the emergency care process introduced in [17]. The emergency care process includes six main activities: Registration, Sorting, Delayed emergency in case of not urgent patient, Consultation inbox, Shock treatment and the lying waiting. In this activity, there are two situations: transferring the patient to another department (hospitalization / special consultation) to ensure the continuity of care or the patient needs long-term treatment (during shock treatment activities).

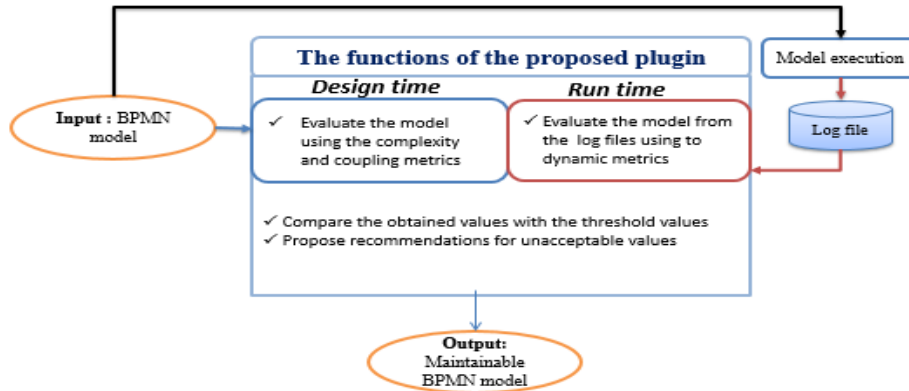


Fig. 2. The proposed plugin

First after the design of the BPMN model, the modeler can evaluate the static maintainability metrics. For example, there are two metrics, CFC and CLA, with unacceptable values colored in red and there are a set of recommendations (Fig. 3): “Minimize gateways such-as OR-split-joins to reduce the complexity of control flow”, and “Be away from OR routing every time it is possible”. Next, based on these recommendations, we have tried to improve the emergency care model. Indeed, we have applied the first recommendation of the CFC metric. To reduce the number of gateways, we have removed a XOR gateway while keeping the same model logic of the emergency care process. After these modifications, we obtained an improved model of the emergency care process with a good level of maintainability (Fig. 4).

| Symbol | Metric's name                       | Values   | Class   | Recommendations   |
|--------|-------------------------------------|----------|---------|---|
| CP     | Coupling metric                     | 0.055556 | Class A | Accepted Value  |
| CFC    | Control-flow Complexity metric      | 13       | Class D | Recommendation 1: minimize gateways such as : OR-split-jo...          |
| CC     | Cross-connectivity metric           | 0.023085 | Class B | Accepted Value  |
| RFP    | Response For Process                | 0        | Class A | Accepted Value  |
| TNDO   | Total Number of Data Objects        | 0        | Class A | Accepted Value  |
| CLP    | Connectivity level between Pools    | 2.0      | Class B | Accepted Value  |
| CLA    | Connectivity level between Activ... | 0.3      | Class D | If it is possible, try to Use a number of activities almost equal ... |

Close

Undefined = Metric cannot be calculated  
 Classe A = Very good quality ,Classe B = Good quality ,Classe C =Medium quality ,Classe D =Bad quality

Fig. 3. Recommendations of static maintainability metrics

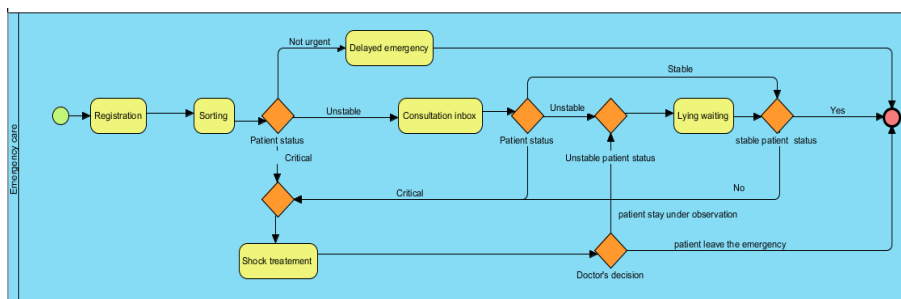


Fig. 4. The new model of the emergency care process

After that, we included a set of dynamic metrics where their evaluation is based on the execution of one hundred instances of the considered emergency care process. If there are unacceptable values (which exceed the threshold values), we have proposed a set of recommendations. For example, to decrease the execution time for the sorting activity, we have chosen to apply the recommendation "Add a new resource" (fig 5):

- Add a new nursing assistant who diagnoses the patient's condition in order to complete the sorting task and reduce the waiting time between the two activities (recording and sorting).
- Another proposal is to add a new agent for the "registration" activity to wait for the same objective and decrease the waiting time.

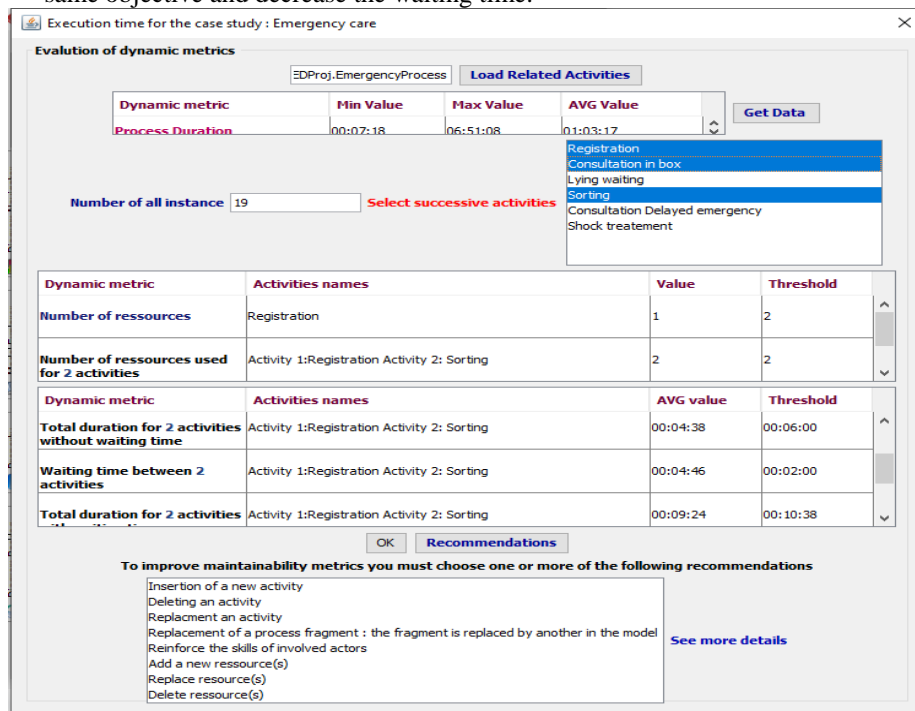


Fig. 5. Recommendations of dynamic metrics of maintainability of emergency care model

## 5 Discussion

After studying several research papers, in this section, we try to discuss the differences between our proposed approach and other related works summarized in section 2. More precisely, we have identified a set of metrics that allow the maintainability of the business process model under evaluation to foster its modification. In addition, we propose a set of recommendation. The advantage of these recommendations is that they ensure, on the one hand, the ease of application of the modifications and on the

other hand, they ensure the quality of the BPMN model. In addition, none of methods proposed in the literature takes into account the static and dynamic evaluation, at the same time, based on the criterion of maintainability of BPMN models. Moreover, we have enriched our work with new dynamic recommendations that are standard and adaptable for other processes.

Through the approach proposed in this paper, we benefit from (i) the identification of static and dynamic metrics with real values to be extracted from event logs generated by the enactment of Business Processes, (ii) the definition of a set of recommendations related to business process evaluation, (iii) the explicit integration of the maintenance into process engineering. To evaluate the proposed approach, we choose the "emergency care" process, in the medical field, because it is rather complex, and requires continuous improvement.

Now regarding the limitations of the proposed approach, we can mention that the proposed approach first requires having good expertise in order to be able to define the new changes. However, our target users may have limited knowledge and expertise. Second, after the decision-maker analyzes metrics values and the corresponding recommendations, s/he will have to identify possible improvements and s/he may still encounter difficulties.

## 6 Conclusion

In this paper, we focused on evaluating the maintainability of BPMN models based on a set of static and dynamic metrics. Therefore, we proposed a new approach, which combines the lifecycle of BPM and a part of the software maintenance lifecycle.

Second, we selected a set of metrics for measuring the maintainability of business process models, covering both (re)design and execution phases.

Then we developed a plugin, which calculates these metrics and we propose for each design and evaluation phase a set of recommendations to resolve the defects and obtain a maintainable model.

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