AN OBJECTIVE-BASED APPROACH FOR DEFINING AND SELECTING THE MOST RELEVANT KPIS FOR MEASURING BUSINESS PROCESS PERFORMANCE

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ABSTRACT

The purpose of our work is to improve the performance of business processes. Our contribution consists of proposing an approach to defining key performance indicators for a set of well-defined objectives. To test our approach, we defined a set of objectives and KPIs, and then we elaborated a survey to match the objectives to different specific KPIs. This survey is applied to the case study of a COVID-19 care process and is dedicated to the members of Farhat Hached's crisis unit. In addition, we have developed a web application dedicated to the crisis unit. This application allows to: (1) add the objectives and to manage the KPIs, (2) assign the objectives to the KPIs, (3) display a comparative table of the values of the KPIs, (4) present a histogram for each KPI. Moreover, through this prototype we can (5) know the percentage of the achievement of the objectives.
Furthermore, we used the DMN, based on the Signavio tool. Indeed, the use of DMN in our work consists first in matching the objectives to the KPIs, then placing the decision rules based on the threshold values of the KPIs, entering the observed values, and finally obtaining the result about the achievement of the objectives.

KEYWORDS

Business Process Performance, KPI, BPM approach, SMART Criteria.

1. INTRODUCTION

According to (Gries and Restrepo 2011), KPIs are quantifiable measures that help an organization to measure the success of critical factors. For a company or a process, activities are conducted for achieving a set of objectives. Thus, KPIs and objectives are closely related terms, since performance measures allow to measure the achievement of objectives.

Following our study of previous works of the literature, we observed that the decisions are taken for the improvement of BP lack essential analyzes because of several reasons. First, a very large number of KPIs is defined for a business process. Second, the relation between KPIs and objectives remains unknown. Third, logs contain information that is misused to improve business processes.

We will therefore seek to answer the questions listed below, (1) How can we define KPIs and objectives? (2) How can we determine the relation between KPIs and objectives or select the most appropriate KPIs according to a well-defined set of objectives? (3) How can we know if the objectives are achieved or not?

Our work answers these questions by proposing a new approach to support the definition of key performance indicators. More precisely, our contribution consists of (1) defining a set of KPIs and objectives, (2) associating the KPIs with the objectives, (3) evaluating the degree of achievement of the objectives of the business processes through the comparison of the threshold values with the observed values and (4) improving the performance of the business processes based on the KPIs. To do this, we take the case of COVID-19 care process.

This paper is divided into 6 main sections planned as follows: section 2 presents the main concepts used in this study. Section 3 presents a literature review of existing methods for KPIs and shows clearly the need for a method that covers both KPIs and goals. In section 4, we expose the proposed approach. Then, section 5 shows the main obtained results. Finally, section 6 concludes the paper and gives directions for future works.

2. THEORITICAL FOUNDATIONS

In this section, we present the two most important concepts on which our work is based, which are business processes and key performance indicators.

2.1 Business Process

In (Hammer and Champy, 1993) a business process is defined as a set of activities that form one or more types of input that produce an output that has value to the customer. However, they do not mention any relation between these activities. While in (Davenport, 1993) this relation is taken into consideration where a business process is defined as a set of activities that are logically linked to achieving a business result defined by the customer or by the market. Based on these two definitions, in (Weske, 2007) a business process is defined as a set of activities that are performed in harmonization in an organizational and technical environment, and that achieve a business objective. In addition, each business process is implemented by a single organization, it can interact with other business processes executed by other organizations.

2.2 Key Performance Indicators

According to (Gries and Restrepo 2011), KPIs are quantifiable measures that help an organization to measure the success of critical factors, these measures must be agreed upon in advance and depend on the objectives of the organization. This is the most general definition, so it can be applied to all KPIs in all use cases.

According to (Parmenter 2015), KPIs represent a set of metrics that focus on critical aspects of organizational performance for the success of the organization.

According to (del Río-Ortega 2012), KPIs are defined for the organization as a means to measure the level of achievement of its strategic and operational objectives.

2.3 Business Process Management

According to (van der Aalst and al. 2003), Business Process Management (BPM) can be defined as a support of business processes using methods, techniques and software to design, control and analyze operational processes that involve humans, organizations, applications, documents and other sources of information.

As mentioned in (Weske 2007), the basis of business process management is the explicit representation of business processes, since it allows discovering the weaknesses of the organization of activities in order to analyze and improve them.

2.4 Decision Model and Notation

According to (Hasić and Serral 2019), Decision Model and Notation (DMN) is a recently introduced decision-modeling standard that has generated great interest in the literature. The DMN consists of two levels, which must be used, in parallel. First, the decision requirement level represented by the Decision Requirement Diagram (DRD), which describes the requirements of the decisions and the dependencies between the elements that exist in the decision model. Second, the decision logic level, which presents means for specifying the underlying decision logic.

The DMN standard uses rectangles to represent decisions and sub-decisions, and ovals to represent input data, while the decision logic level is represented as decision tables.

3. RELATED WORK

In this section, we present the various related works that are most relevant to our contribution, with particular emphasis on KPIs, objectives, and business processes.

The work of (Kbira and al. 2017), presented a procedure which consists in identifying candidate KPIs from existing sources, then defining new candidate KPIs, next, selecting the most appropriate KPIs according to the KPIs criteria. Finally, they compose a final set of selected KPIs. However, before these four steps, we must first start by establishing the objectives of the KPIs. The work of (Ponsard and Darimant 2019) provide a guide in two steps, the first approach, is an analysis of implicit goals, and the second approach, is an analysis of explicit goals. The authors used KAOS as support for modeling objectives. The work of (Baisli and al. 1994), create the GQM approach with an example of its application to an organization that can measure in an accurate and targeted manner. The work of (Ammar Elhadjamor and Ayachi Ghanouchi 2017), proposed an approach using the Analytic Hierarchical Process (AHP) method to solve multi-criteria decision-making to prioritize key performance measures of health care organizations using Expert Choice (EC) software. The work of (Cherni and al. 2019), proposed a KPI4PPI approach for process improvement by first defining and configuring target values of KPIs, then using process mining techniques to discover and analyze deviations from those values, and for each deviation, they propose improvement solutions based on BP redesign models. The work of (Simeunovic and al. 2020), proposed a new model of process performance measurement (PPM), named GPI model. The objective of this model is to help companies measure the performance of their processes, by selecting PPIs based on their strategic objectives. GPI is tested through case studies, and the results verified that the model could achieve this goal. The work of (Lamghari and al. 2018), presented a business process improvement methodology, which includes a new vision of the BPM lifecycle, including the design phase, modeling, execution, then monitoring, and ending with the optimization phase. Hence, on each phase, they define a set of improvement indicators for redefining business processes with better optimization results. The work of (Pusnik and al. 2019), mainly focus on the possibilities of optimizing the business process by analyzing and evaluating the activities of the process such as measuring the quality of existing software, introducing new information system support and risk management solutions, as well as identifying potential for optimization. The work of (Del Río-Ortega and al. 2013), proposed a PPINOT metamodel, which is a metamodel of PPIs, which is very flexible. It provides automatic semantic mapping that enables automated reasoning.

For comparing this existing works, we rely on the following criteria Proposes a life cycle of KPIs / PPIs, Integrates the life cycle of KPIs into the life cycle of BPM, Determines the correspondence between objectives and KPIs, Uses the construction of a DMN, Proposes / uses a method that determines KPIs / PPIs and / or objectives, Offers a framework and Calculation of the of KPIs / PPIs values. First, we find that none of the works fully meets all the criteria and there are three approaches that offer a KPI / PPI lifecycle. Then there are three works that integrate the proposed lifecycle into the BPM lifecycle and seven works that determine the relationship between KPIs / PPIs and goals. On the other hand, we find that all the works proposed or used a method that determine KPIs and / or objectives. However, we find only one approach that offers a Framework. We notice that only works of (Ponsard and Darimant 2019) and (Simeunovic and al. 2020) did not calculate the values of the indicators. Moreover, the strongest point of the approach we are targeting to build will be the construction of a DMN. We will ensure that our approach takes into account all the criteria mentioned in the table.

4. PROPOSED APPROACH

Through this work, we put in place an approach for defining and selecting the most relevant key performance indicators (KPIs) for a given set of objectives. To do this, first, we present our approach by introducing the different phases as well as the suggested modifications in the life cycle of BPM. The starting point of our approach is the life cycle of BPM to which we bring new sub-phases. We have adopted the BPM lifecycle described by (Weske 2007), and we add sub-phases as shown in Figure 1. The detail of these phases will be presented in the following subsections.

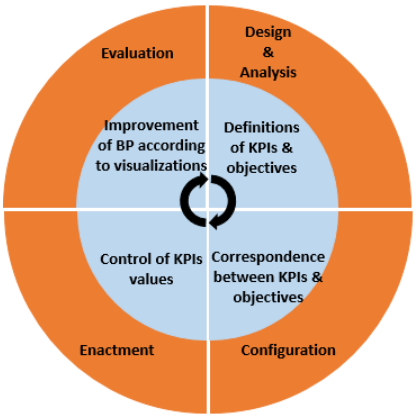


Figure 1: KPIs management lifecycle integrated into the BPM lifecycle

4.1 Design & Analysis phase

According to (Weske 2007), the life cycle of business processes begins with the design and analysis phase. In this phase, business experts define a new business process or redefine an existing process, which is represented by a business process model.

In our approach, we propose to exploit during this phase, the Goal Question Metric (GQM) method as well as the SMART criteria. Indeed, the combination of these two methods allows us to define clear objectives as well as significant KPIs. For this, we applied the five SMART criteria (Specific, Measurable, Attainable, Realizable, and Time-bound) on the questions described in the GQM method so that the KPIs and objectives are SMART.

We start by identifying general objectives, which are: (1) ensuring the quality of the processes, this objective refers to the extent to which the process takes into account the procedures defined by the organization. (2) Ensuring quality of results, i.e. ensure all the characteristics of the product offered by the process after its execution. In addition, (3) reduce the risks; it refers to all the strategies that aim to limit the risks and damages associated with a specific area.

Then, the next step is to formulate SMART questions according to the objectives defined above and to facilitate the definition of indicators. Table 2 presents the different questions proposed as well as the corresponding KPI (s):

Table 1: SMART questions and their KPIs

Question	KPI
Is the wasted time less than the waiting time threshold at time t?	Waiting time between an event and an activity
	Waiting time in a process/process fragment
Does the duration of the activities exceed the value of the ideal duration during a specific period?	Duration of an activity
	Duration of a process fragment/process
Is the number of repetitions of activities acceptable relative to the threshold for a given date?	Number of repetitions of an activity/process fragment
Does the number of activities reach the maximum number on a specific date?	Number of activities/process fragments (in progress, completed, repeated)
Is the number of instances acceptable at time t?	Number of instances (According to progress, per unit of time, per category)
Is the number of actors participating in the process satisfactory compared to the ideal value for a given date?	Number of actors involved in a fragment of a process/process or per service
Is the place where the process is carried out adaptable for a specific period?	Number of services/locals
Are the resources used throughout the process satisfactory compared to the ideal number?	Number of information that can be produced/retrieved/used
	Number of material resources

4.2 Configuration phase

According to (Weske 2007), in the configuration phase, the process modeled in the previous phase must be implemented. For this, the system must be configured, once the system is configured, the business process implementation should be tested. Subsequently, the system can be deployed in its target environment.

In our approach, in the previous phase, the questions asked are applied to all the objectives, this is due to the importance of the correspondence between the objectives and the KPIs, which must be made by experts in the field. Hence, during this 2nd phase, to match each objective with the appropriate KPI (s), we designed a questionnaire containing the general KPI(s) and objectives. This questionnaire is dedicated to those responsible for various processes such as the administrative process, the process of organizing an event with associations, the production process of services or products, etc.

Based on the responses collected by those responsible for the different processes, we obtained the most relevant KPIs for each objective mentioned in Table 3:

Table 2: Correspondence between general KPIs & objectives

Objective	KPI
Ensuring process quality	Waiting time between an event and an activity
	Duration of a fragment of a process/process
	Number of activities/process fragments (completed, repeated, in progress)
	Number of actors involved in a fragment of a process/process or per service
Ensuring quality of results	Waiting time between an event and an activity
	Duration of an activity
	Duration of a fragment of a process/process
	Number of activities/process fragments (completed, repeated, in progress)
	Number of instances (According to progress, per unit of time, per category)
	Number of actors involved in a fragment of a process/process or per service
	Number of services/locals
	Number of material resources
Reducing risks	Waiting time between an event and an activity
	Waiting time in a process/process fragment
	Duration of an activity
	Duration of a fragment of a process/process
	Number of activities/process fragments (completed, repeated, in progress)
	Number of instances (According to progress, per unit of time, per category)

4.3 Enactment phase

Once the system configuration phase is complete, business process instances can be executed, during this execution, valuable execution data is usually collected, in the form of event logs (Weske 2007).

In this step, based on the log files obtained from the execution of the business process, our contribution consists in monitoring the values of the KPIs, to know whether our objectives are achieved or not. To do this, we use the DMN, more precisely we place decision rules from which we can know the outcome of the objectives (in terms of whether or not these objectives have been achieved).

4.4 Evaluation phase

According to (Weske 2007), the evaluation phase uses the available information to evaluate and improve business process models and their implementations. Execution logs are evaluated using Business Activity Monitoring and Process Mining techniques that aim to identify the quality of the business process models.

Our contribution in this phase consists in evaluating the performance of the business process based on the result of the execution established in the previous phase. From where we bring corrective or improvement actions if there is a discrepancy between the ideal and real values of KPIs to improve the overall performance of the business process.

5. EXPERIMENTATION

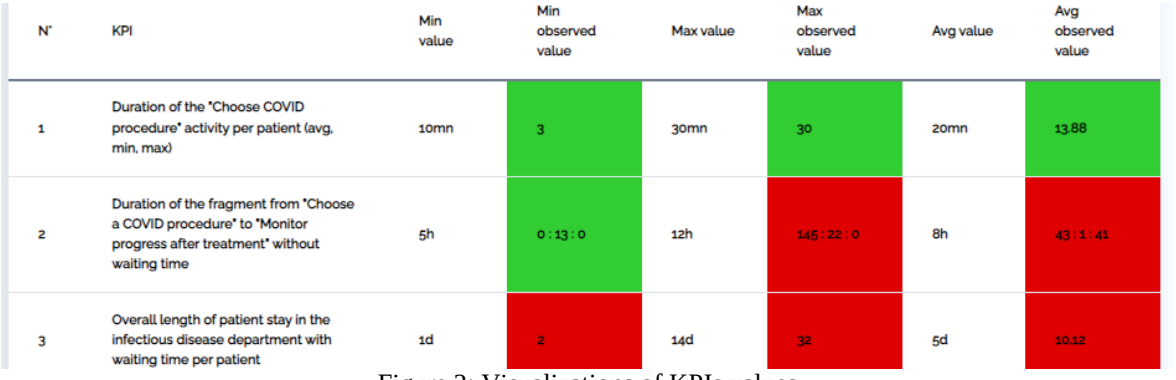
In this part, we have chosen to work on a case study related to COVID-19. More precisely, we will focus on the COVID-19 health care process.

To validate our approach, we have developed a prototype intended for the different 10 experts of the crisis unit. Therefore, we applied our proposed approach to this case study. Starting with the analysis and design phase, we take into consideration the objectives proposed by the crisis unit, and from our research, we have identified a list of objectives validated by Farhat Hached's team presented in table 4.

Table 3: List of objectives

N°	Objective
1	Monitor the state of health of staff and minimize contact with the patient throughout the care process
2	Ensure patient safety as well as data integrity
3	Help decide on the most appropriate treatment for each patient
4	Strengthen human and material resources
5	Strengthen human and material resources in the event of an increase in the number of patients to be treated
6	Reduce the number of actors involved in the care of a COVID patient
7	Minimize the time taken to take care of a COVID-19 patient

In addition, we have determined a list of specific KPIs from those identified in the first sub-phase of our approach. In the second sub-phase, we matched the specific objectives to the specific KPIs that were defined in the previous step. To do this and to have quality results validated by experts, we have developed a specific questionnaire dedicated to members of the crisis unit to carry out this assignment procedure. After the matching step came the process execution step. First, we calculated the values of the KPIs and compared them to the threshold values given and validated by the members of Farhat Hached. Figure 2 presents a screenshot with a comparison of the observed values of the KPIs (Min observed value, Max observed value and Avg observed value) to the threshold values (Min value, Max value and Avg value). Indeed, this visualization offered by our prototype makes it possible to detect whether the calculated value is higher or lower than the threshold value. For example for the first KPI "Duration of the activity 'Choose COVID procedure' per patient", we notice that the three values observed (3mn, 13.88mn, 30mn) are lower than the threshold values (10mn, 20mn, 30mn) respectively. This result is acceptable because we are always looking to reduce the time, which is applicable to our case of COVID patient care process.



N°	KPI	Min value	Min observed value	Max value	Max observed value	Avg value	Avg observed value
1	Duration of the "Choose COVID procedure" activity per patient (avg, min, max)	10mn	3	30mn	30	20mn	13.88
2	Duration of the fragment from "Choose a COVID procedure" to "Monitor progress after treatment" without waiting time	5h	0 : 13 : 0	12h	145 : 22 : 0	8h	43 : 1 : 41
3	Overall length of patient stay in the infectious disease department with waiting time per patient	1d	2	14d	32	5d	10.12

Figure 2: Visualizations of KPIs values

Second, we used the DMN, through which we put decision rules.

	Inputs								Outputs
U	Duration of the "Choo...		Duration of the fragme...		Overall length of patie...		Number of serious pat...		Evaluate the objective "Minimize the ti...
	Number		Number		Number		Number		{Reached,Partial Reached,Not Reached}
1	≤	30	≤	12	≤	14	≤	10	Reached
2	≤	30	>	12	≤	14	≤	10	Reached
6	≤	30	≤	12	>	14	>	10	Partial Reached
7	≤	30	>	12	≤	14	>	10	Partial Reached
15	>	30	>	12	>	14	≤	10	Not Reached
16	>	30	>	12	>	14	>	10	Not Reached

Figure 3: Decision rules of the seventh objective

Figure 3 shows the decision rules set which are based on the threshold values. These rules concern the seventh objective "Minimize the time taken to take charge of a patient" which is associated with the first, second, third and seventh KPIs. In fact, regarding this objective we have defined 16 rules, which give three types of results “Reached”, “Partially Reached” and “Not Reached”. To fully understand these rules, if all or most of the inputs satisfy the rule then the objective is reached, otherwise if half of the inputs satisfy the rule then the objective is partially reached, however the objective is not reached in the case where the majority or all of the inputs do not satisfy the rule. In our case, rule 1 indicates if (1) the duration of the "Choose COVID procedure" activity per patient (avg, min, max) <= 30 minutes and (2) the duration of the fragment from "Choose a COVID procedure" to "Monitor progress after treatment" without waiting time <= 12 hours and (3) the overall length of patient stay in the infectious disease department with waiting time per patient <= 14 days and (4) the number of serious patients treated at the same time in the infectious disease department <=10 patients, then our objective is reached.

During this last step, and based on the following steps we obtained the result of the achievement of objectives through KPIs evaluation, this result of the objective 7 is shown in figure 4 below.

In this figure, we see that this objective is reached, in fact, the values of the KPIs “Duration of the "Choose COVID procedure" activity per patient (avg, min, max)” and “Overall length of patient stay in the infectious disease department with waiting time per patient” and “number of serious patients treated at the same time in the infectious disease department” are acceptable, while the value of the KPI “Duration of the fragment from "Choose a COVID procedure" to "Monitor progress after treatment" without waiting time” is not acceptable. Therefore, according to the rules defined previously the result gives us reached.

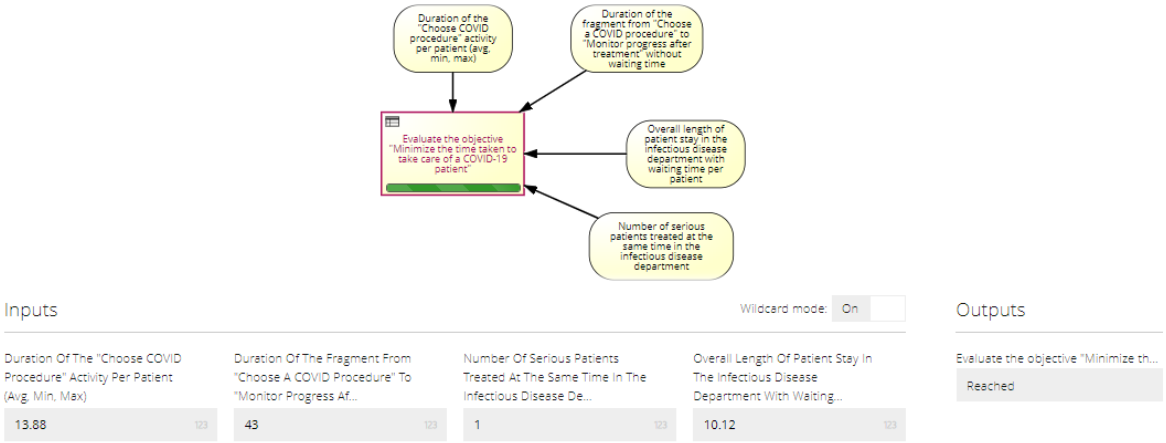


Figure 4: Decision rule results

Based on the results obtained through the questionnaire, the exploitation of the advantages of the GQM method and the SMART criteria as well as the use of a set of decision rules via the DMN, we can conclude that the addition of the proposed sub-phases offers a plus in the life cycle of BPM.

6. CONCLUSION

In this work, we proposed a new KPI management lifecycle integrated into the BPM lifecycle proposed by Weske. Secondly, we have defined a set of general objectives and KPIs. Then, we especially focused on the process of taking care of Covid-19 patients, in which we interviewed the members of the crisis unit. Finally, to experiment our solution, we proposed a prototype, which is a web application implemented by Laravel, intended for the members of the COVID crisis unit at Farhat Hached hospital in Sousse. To validate our prototype, we exploited data of COVID patients, and we evaluated the performance of their care process by analyzing the results of the KPI values displayed in a visualization table. This visualization allows displaying whether there is a difference between the values of the KPIs calculated and their threshold values, to improve the quality of the performance of the process in question. We also used the Signavio tool by introducing the objectives and their KPIs. Indeed, to help the user in the decision-making process, we put the decision rules based on the values of the KPIs to check if the objectives are reached, not reached, or partially reached. Finally, note that our work remains open to several improvements and perspectives such as exploring the correlations between KPIs by applying machine-learning techniques.

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