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Research paper

Structural Framework for Measuring the Performance of Information Systems – Case Study

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Abstract

Measuring the performance of Information System (IS) is considered as one of the main pillars of the IS governance in the company. Key performance indicators (KPI) are the most used tools for measuring IS performance. In this work, we propose a structural framework based on the extended ISO 194400 Meta-model that can provide a multiview meta-knowledge library, to enrich all the company dashboards for decision-making. In practice, we propose a case study in a Moroccan telecom company for deploying the proposed structural approach. We use especially Galois lattices in order to evaluate the synchronization level between some processes and key performance indicators as a contribution to measuring the performance of Information Systems.

Keywords: *Structural Framework; Key Performance Indicators; Galois lattices; ISO/DIS 19440.*

1. Introduction

Information Systems Governance is an integral part of corporate governance. It aims to define the objectives assigned to the information system, to plan, define and implement processes related to the management of the IS life cycle. Today, the Information System Governance as defined by ISACA (Information System Audit and Control Association) is based on a pentagon focused on 5 pillars namely: Strategic Alignment; Value Delivery; Risk Management; Performance Measurement and Resource Management. Measuring the IS performance aims to evaluate the IS according to some criteria (costs, strategic resources, IS value, etc.) with measurement tools [1]. In this article, we propose a structural framework based on formal extension of the ISO/DIS 19440 Enterprise Meta-model [2]. This extension integrates the necessary structures for developing systemic tools, for a better vision of IS performance.
This article is structured as follows: We present, in Section 2, the state of the art of the IS performance measurement. In section 3, we remember the extended enterprise meta-modeling approach for measuring the IS performance. Then, we propose, in section 4, a structural framework to technically operationalize this approach. In section 5, we deploy the proposed approach in a real context of a leading Telecom company in Morocco. We particularly study the structural matrix "Process, KPI" in a particular area of the company in order to integrate it into a specific platform for viewing the generated lattice. This architecture enriched by a specific analysis methodology helps evaluate how studied IT processes contribute toKPIsimprovement. The conclusion of this work defines the strengths and weakness of this technique and the future prospects for further development.

2. State of the Art

2.1. The objective and subjective measurements ofIS performance

According to R. Reix, the performance measurement of Information Systems is based on a synergy of objective and subjective measures reflecting information systems user perceptions [3].

2.1.1. The objective measurements

This concerns essentially the Information Systems efficiency (ratio of the results to the resources used). However, it is often reduced to cost tracking [4].

2.1.2. The subjective measurements

The subjective measurement reflects the perceptions of the Information System user and thus make it possible to consider the IS effectiveness according to some indicators as user satisfaction and usability. Also, all studies found that regardless of the type of adopted measure, the performance measurement of Information System is done in relation to System quality; Information quality ; System use and Service quality [5]. However, Grembergen has shown that the Balanced Scorecard BSC can ideally be applied to Information System to measure its performance [6].

2.1. The Balanced Scorecard

Between 1992 and 1996, Kaplan and Norton introduced the "balanced scorecard" into the company. The founding concept of this approach was that the evaluation of a company cannot be

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reduced to a simple financial estimate but must be supplemented by the results of measurement indicators relating to customer satisfaction, efficiency of internal processes and Capacity for innovation. The two authors proposed a three-level structure (missions, objectives and evaluation) for each of the four perspectives: finance, customer relations, processes and innovation [7]. The implementation of a balanced scorecard involves the following steps:

Step 1: Identification of strategies for achieving financial objectives (causal relationships between organizational / innovation axes, internal processes, customers, finance);

Step 2: Selection of the best performance indicators and "Target" objectives to drive the strategy;

Step 3: Implementation of the BSC.

Nevertheless, to apply the balanced scorecard concept to the IS function, the four dimensions cited above have been redefined by the ITGI (Information Technology Governance Institute). According to this organization, the balanced scorecard of information systems (IS BSC) can be developed by considering the following questions:

- The added value for the company: How is the information system seen by the business departments of the company?
- User satisfaction: How is the IS seen by its users?
- Operational excellence: how effective are the IS function processes?
- Future Directions: How well is the IS positioned to identify future requirements?

Otherwise, Grembergen has demonstrated that the Balanced Scorecard could ideally be applied to the measurement of IS performance. However, the empirical works that operationalize these concepts and refine the measurements are still lacking.

3. SystemicEnterprise Metamodeling approach

3.1. Systemic Enterprise Meta-modeling

In this section, we remember the systemic meta-modeling based on structural paradigm and proposed in our latest research in this field. This approach is focused on a formal extension of the ISO/DSI 19440 Enterprise Meta-model. This meta-modeling highlight the alignment between the functional, informational, organizational and resource views in a systemic context and supports some constructs allowing a structural analysis for better synchronization of Information System and Strategy. Indeed, the structure of the basic Meta-model allows the expression of the alignment in the above-mentioned forms. This approach has been discussed, argued and deployed through a few case studies [8]. It is a holistic meta-modeling integrating a systemic analysis likely to establish a multiview synchronization between all components of the company (Process, Activity, Indicator, Resource, Information, Decision etc.).

In this work, the proposed meta-modeling provides a formal framework giving the company global representativeness with a holistic view for systemic analysis that goes beyond the explicit definitions of functional, organizational, informational and resource entities to also mingle the relationships and associations linking these entities in order to better situate this notion of multiview coupling and evaluate the performance of several elements of the IS (Figure 1).

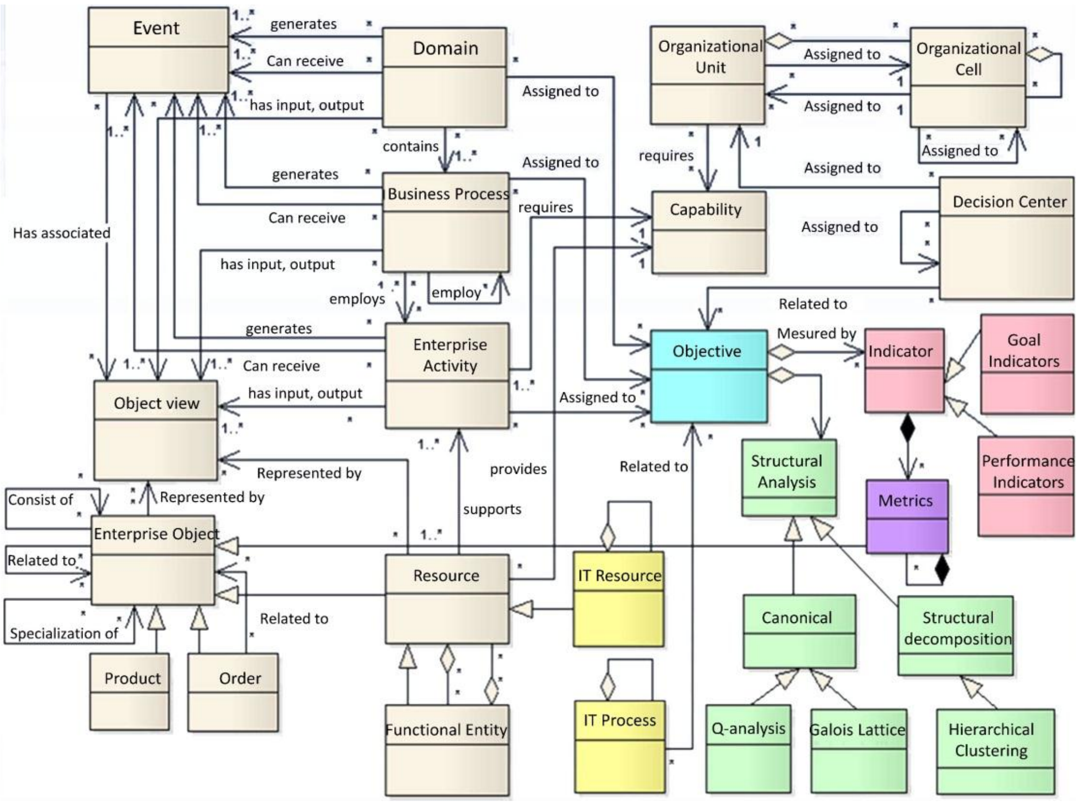

Fig. 1 : Systemic Enterprise meta-Modeling as contribution to IS Governance

3.2. Structural Analysis

The structural analysis (SA) proposed in the extended meta-modeling aims to evaluate the existing relationships between the different entities of the company and the analysis of their impacts on the overall performance [9]. We model these relationships using a simple (1/0) association to form structural appropriate matrices to each area of the company and for specific purposes.

For example, if a given process measured by some key performance indicators, this KPI will be associated particularly with this process and not necessarily with the others.

Other associations could be defined between process, activity, resources, objective, object, etc… In this simple way of modeling, the basic relationships can be established between several entities of the enterprise structure. This association makes it possible to model hierarchical and non-hierarchical relationships. As we will see in the case study, the interpretation of relations is always clear by the semantic meanings of the concerned entities. To model complex relationships within an organizational structure, simple associations can be extended to include inheritance, aggregation and common characteristics of multiplicity [10]. The entities and their associated relations in structural analysis can be implemented using the well-known relational model. In particular, the Entity-Relation model can be implemented in some tables of a relational database. By highlighting associations between specific entities, the analysis can define different views of a company and, therefore, have in-depth insights into performance from several perspectives. Structural analysis can be used to produce a functional, organizational, informational or resource perspective. This form of analysis is useful in a fairly broad range of business scenarios, from business design to real-time performance monitoring (Figure 2).

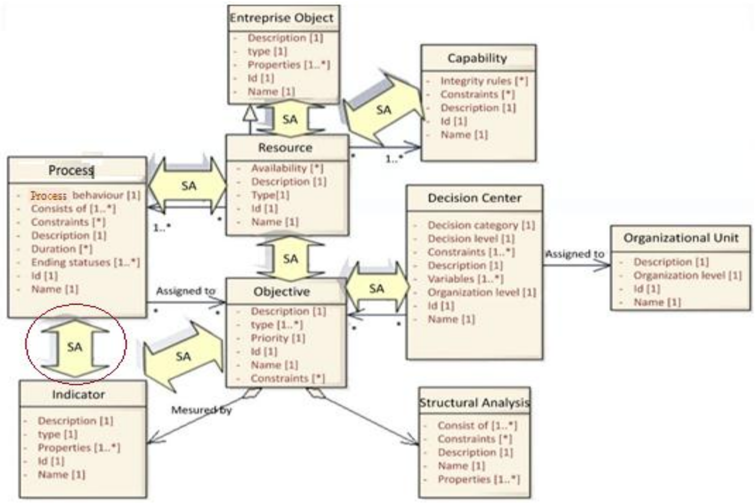

Fig. 2 : Multiview structural analysis

4. Structural Framework

In this section, we present architecture for the implementation of the Structural Analysis (SA) approach for the IS performance measurement. The aim of this architecture is to provide a generic tool to be modeled by a computer system in order to undertake a practical and realistic structural analysis of all components of the company. This architecture is realized in three essential steps: a configuration step, an analysis and evaluation step and a step dedicated to the exploitation of the results for structural analysis purposes (Figure 3). In the following, we describe each of these steps.

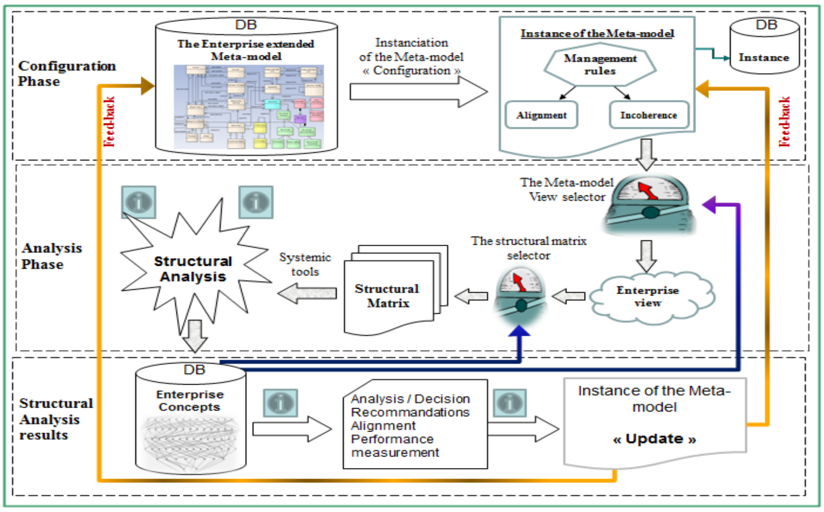

Fig.3 : Implementation architecture for the proposed structural analysis

4.1. Configuration step

The extended meta-modeling of ISO/DIS 19440 incorporating the proposed structural analysis allows for a more complete representation of the company in its systemic concept. This structure allows a holistic analysis based on the structural paradigm aimed at modeling any kind of company, institution or organization.
The first step that characterizes the implementation architecture of the structural analysis aims to constituting a database regrouping all the tables coming from the Meta-model (process, activity, objective, resource, indicator, etc.). According to the context chosen, the Meta-model instantiation provides a specific model that reflects the business in a particular area. This means a projection of the Meta-model on one or more views characterizing a predetermined aspect. Then, this instance is used for a configuration of the Meta-model to define explicitly management rules governing the level of performance of several components in the company (process, activity, resource, decision-making etc). This approach is a colossal project that requires both human and technical intervention. So, the identification of the parameters of congruence or inconsistency between all components of the company is essential for any structural analysis and performance evaluation. This allows a response to the fundamental question "Are the X and Y components synchronized, yes or no? ". We present, for example, some management rules characterizing the bilateral relations linking two or more constructs of thestudiedmodel:

- Completion of the Activity « A » requires, at most, 2 human resources;
- The achievement of the objective « O » should not use more than 3 processes;

- The budget allocated to resources for carrying out the process « Pi » is limited to 1M $;
- The customer satisfaction indicator should not be degraded due to a reduction in resources;
- A business process can deploy up to 3 resources
- the performance of a process can be evaluated by KPIs
- An objective can be measured by one or more KPI…

The result of the structural analysis of different matrices that can be generated refers to the explicit definition of the predefined management rules in order to identify possible incoherencies. Thus, we can establish a model configuration of the studied firm in order to begin the analysis step and to identify any inconsistencies requiring urgent actions.

4.2. Analysis step

This step is purely technical and tactical for the evaluation of the synchronization level of all Meta-model constituents. So, we can realize the projection of the Enterprise Meta-model on all views in order to reduce the complexity and overlap of the company's activities. Here, we use a computer tool that plays the role of a views selector able to identify appropriate components of the Meta-model in a given company context. This solution makes it possible to generate company views according to the target domain. Once we have chosen a particular view, we also use another structural matrix selector that generates a structural matrix from combinations of two components of the Meta-model (object, attribute). Each structural matrix is dedicated to an analysis based on systemic tools such as Galois lattices. The visualization of the binary relations linking these matrix components makes it possible to develop Galois lattices providing pertinent information based on the study of the generatedclosed. We use the same technique for all possible combinations of each view. All generated lattices are stored in a specific database for any purpose of analysis. This step is essentially based on a structural analysis to identify all the knowledge needed for better performance measurement and decision making support.

4.3. Exploitation of results

The database with all of the lattices generated from the structural analysis is a robust warehouse to evaluate the synchronization between the various components of the company. Based on the management rules defined in the initial model, we can observe all the inconsistencies between different views of the Meta-model. The obtained results offer a good opportunity to understand the different facets of alignment and performance level. This technique ultimately leads to the creation of notes, suggestions and recommendations that can help top management and decisions-makers to review the company structure by means of multidimensional actions in order to improve the overall performance of the company.

5. Case study

This case study concerns the information systems department of a leading Moroccan Telecom company. This entity contains some divisions deploying IT processes responding to several strategic and business objectives of the firm (Production, support, validation, control, urbanization, operating, etc.). There are some processes, activities and resources used to achieve some objectives and measured by some key performance indicators (KPI) or metrics. As illustration, we apply the proposed structural analysis on the matrix (Process / KPI) in order to evaluate the performance of some processes according to their associated KPIs. By analogy, the same scenario could be projected on the other organizational components of the company, in order to have a global and holistic view of the information systems performance.

5.1. Choice of structural matrix to study

In this work, we are particularly interested to the (Process / Indicator) matrix: The elements of this matrix are essentially constituted of processes measured by some KPIs and generate intersections allowing better analysis of the performance measurement for the studied entity. The analysis concerns exclusively some IT processes grouped with their associated entities (Table 1):

Table 1 : List ofstudied processes with their associated entities

IdProcess	Process	Associated Entity
P1	Ensuring the monitoring and control of IS security	Control Division
P2	Ensure the deployment of IS applications	Production Division
P3	Ensure the exploitation of the IS	Operating Division
P4	Supervise and maintain the IS functionalities	Production Division
P5	Make workstations available	Support and validation Division
P6	Provide technical support	Support and validation Division

The achievement of all these processes is evaluated by some KPIs used in the performance dashboard of the IS department (Table 2).

Table 2 : List of Key Performance Indicators studied

Id KPI	KPI
KPI1	Compliance Rate of antivirus servers update;
KPI2	Compliance Rate of backup plans;
KPI3	Compliance Rate of resolving system and DB incidents;
KPI4	Info Centre refresh rate;
KPI5	Application Availability Rate;
KPI6	Incident resolution rate;
KPI7	Compliance rate of the IS production plan;
KPI8	Mediation response rate;
KPI9	Compliance Rate of the supply of computer equipment

The relationship between these particular processes and KPIs is mentioned in the following structural matrix. If the Process Pi improves the KPIj, it is denoted by 1. Otherwise, it's 0 (Table 3).

Table 3 : (Process / KPI) structural matrix

	KPI1	KPI2	KPI3	KPI4	KPI5	KPI6	KPI7	KPI8	KPI9
P1	1	1	1	1	0	1	1	1	1
P2	1	1	1	1	0	1	1	1	1
P3	1	1	1	1	0	1	1	1	1
P4	0	0	0	0	0	1	0	1	1
P5	0	0	0	0	1	1	0	1	1
P6	0	0	0	0	1	1	1	1	1

Of course, in other contexts, we can build several structural matrices by applying couplings like (Process / Resource), (Process / Objective), (Process / Process), (Resource / Objective), (Resource / KPI), (Activity / Resource), (Activity / KPI), (Activity / Objective), (Product / resource), (Product / activity), etc. These multiple scenarios address issues of alignment, performance, risk management and resource management for all Enterprise constructs as a structural model of IS governance.

5.2. Implementation

For the implementation side, we use a MySQL database with tables fed by data representing several classes defined in the extended Meta-model. A web interface allows selecting through DragAndDrop technique some objects and attributes to constitute specific structural matrices of the chosen context. Each matrix thus generated is integrated into an open source platform called

Galicia to visualize the appropriate lattice thus generated. Galicia [VGRR03] is intended as an integrated software platform that includes components for the key operations on lattices that might be required in practical applications or in more theoretically oriented studies [11]. Thus, the basic configuration of the platform performs major functions such as context input, lattice construction and visualization. The obtained lattices are stored in xml format in a database which will serve as a relevant analysis for all structural matrixes to interpret the correlations existing between the objects and their attributes and establish a report with suggestions and action plans to communicate to the decision-makers for a better performance evaluation (Figure 4).

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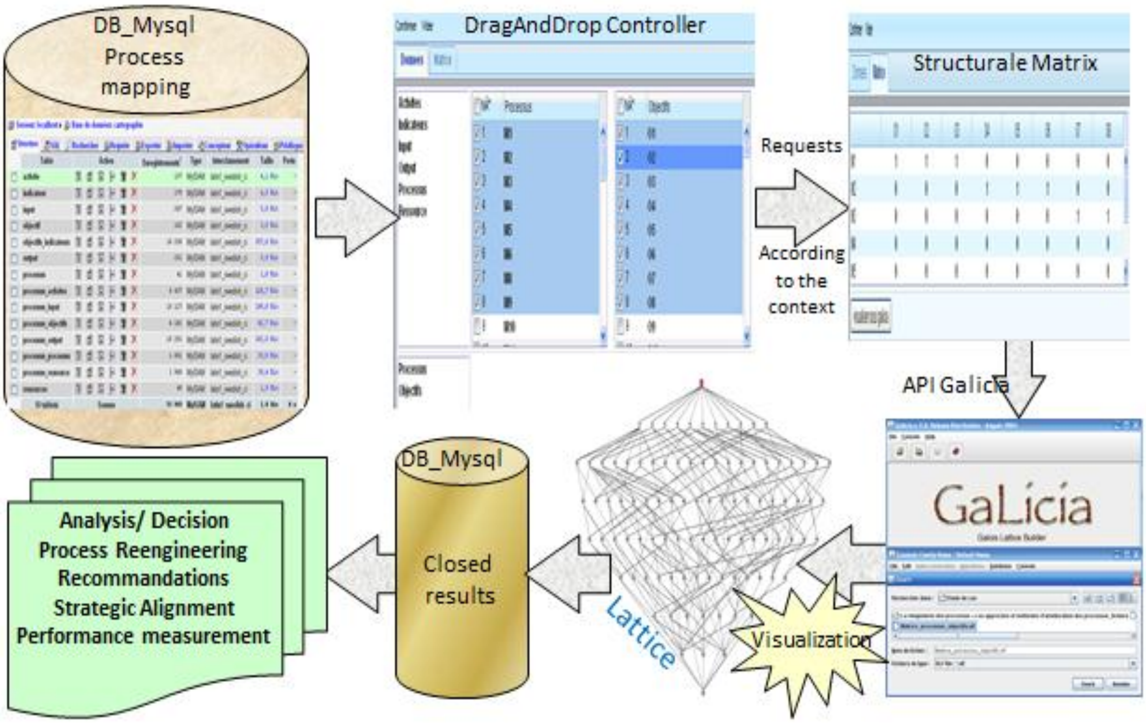

Fig. 4 : Prototype of the structural analysis implementation

5.3. Analysis

The visualization of the Galois lattice generated by Galicia platform gives a hierarchical representation allowing to answer questions like "what are the processes measured by this or that KPI?" and detailing the relations existing between the process objects and their predicates as well as their relationships (Figure 5). So, when one or more KPIs are deemed unsatisfactory, corrective actions are initiated. For some large firms, a first step is to identify potential problems that contribute to an insufficient KPI. The structural analysis provides an overview of the processes, resources, activities or products directly related to the suspect KPIs. For example, if the time to serve a user is too long, one or more processes might be responsible. By analogy, we can generalize to take up all the components responsible for the degradation of the KPIs, and take the necessary measures. This multiview analysis provides insight into the extent of a particular (Process/KPI) combination. An unsatisfactory KPI associated with many processes is naturally at the heart of a reflection for recovery and improvement.

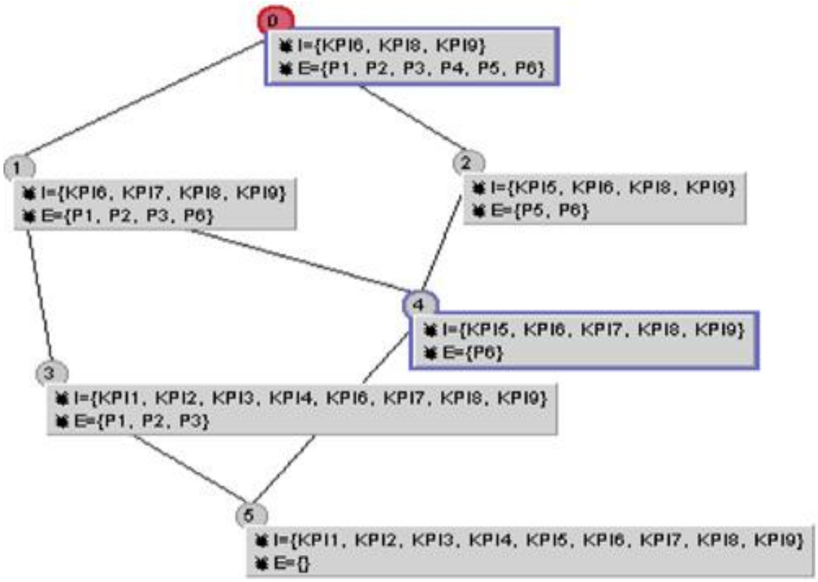

Fig. 5 : Galois lattice generated in the Galicia platform

5.3.1. Methodology of Analysis

In this section we describe a method contributing to the process reengineering. This approach consists to identifying non-value added processes to streamline the process model.

5.3.2. Analysis variables

P : Set of processes; K : Set of KPIs; f application embodying the impact force of a process on a target ; $f : P \times K \rightarrow R+$, g aggregate function, $g : R+ \times R+ \times \ldots \times R+ \rightarrow R+$.

For each process Pi we associate the h aggregate measure, impact on the overall KPIs;

$h(Pi) = (g((f(Pi, KPI1), \ldots, f(Pi, KPIj), \ldots, (f(Pi, KPIN))$.

The standard measure S is given by: $S(Pi) = h(Pi) / \Sigma(h(Pi))$.

A is the list of IT processes contributing to KPI improvement according to the Pareto rules [12].

B = P-A, processes contributing weakly to KPIs.

5.3.3. Analysis Process

The sequence of this analysis methodology is described as follows (Figure 6).

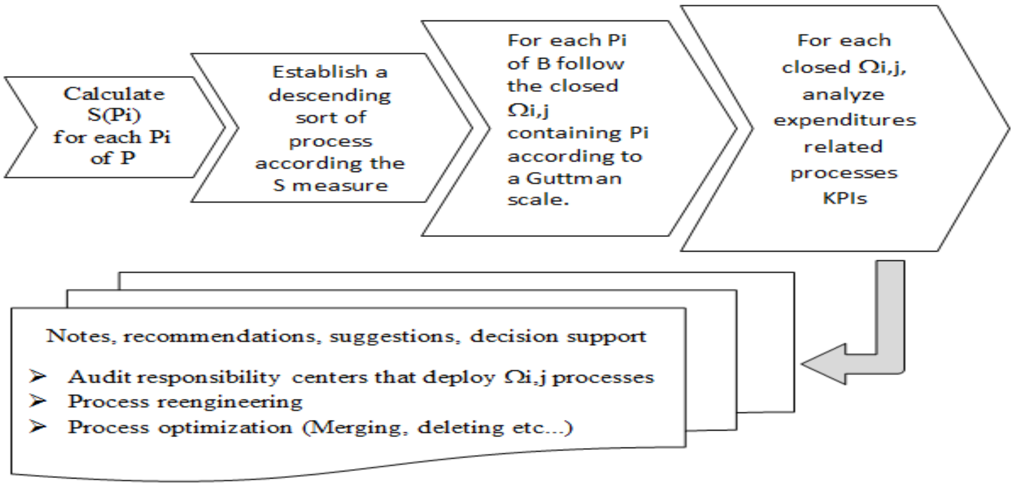

Fig. 6 : Analysis methodology

5.4. Result and discussion

We did the required calculation according to the analysis methodology and we obtained the set B which contains only the process P6 "Provide technical support" belonging to the "support and validation" division. This entity responsible of the P6 process will be particularly audited to identify the direct and indirect raisons causing a poor performance of this process. This can be related to several parameters like for example:

5.4.1. The effectiveness of user support and maintenance

The support performance (internal or external) is evaluated financially according to the cost of the user support. Quality of service is measured by the number of open tickets, the number and average length of calls, the number of calls on hold, the average duration of incident resolution, the total number of calls functions of the concerned staff. The monitoring of the maintenance which passes by the inventory of the contracts in progress, the rate of breakdown and the cost of the interventions by user or service, the number and the average duration of the interventions, the costs of interventions by type (remote maintenance, displacement on site, etc..).

5.4.2. The degree of user satisfaction

The degree of user satisfaction allows to take the temperature of the vision that the Information System user have of the work of the IS department (ISP). It is measured in particular through questionnaires or satisfaction surveys on the responsiveness of the ISP, its ability to support the business and manage projects, not to mention the issue of the holding of deadlines.

In the proposed case study, an investigation into the implementation of the process P6 revealed pertinent information related to the execution strategy for each of the activities of this process, which consumes significant financial resources, notably through a subcontracting policy, but which does not contribute to improve the satisfaction of internal customers "IS users". By analyzing these activities, the decision-maker can deduce the intolerable flaws that can be a source of such waste. Moreover, the realization of these activities can be decisive for identifying those that could be realized with internal resources but which were paradoxically entrusted to external service providers. Indeed, the decision-maker may even turn to the "support and validation" division in order to define the responsibilities of this abuse and initiate urgent restructuring and recovery plans. This technique converges towards a practical audit vision to detect operational and strategic incoherence that could hinder the overall achievement of the company. The final result of this act will serve as a basis for some recommendations for decision-makers to take all the necessary measures to adapt to the management rules defined previously in any instance of the meta-model, and to set the barriers and alignment thresholds or inconsistency between all enterprise components. Therefore, we propose to the decision makers these few recommendations:

- List the main sections of the functional and investment budget of the Support and Validation Division ;
- Define the procedure followed for establishing the process budget of this entity and more specifically the "Provide technical support" process ;
- Identify the percentage of the annual budget dedicated to the P6 process compared to the overall budget ;
- Review the subcontracting policy ;
- Promote internal skills ;
- Streamline spending;

The study is limited here to this simple analysis, which is the first step in a wider study that can identify all the possible inconsistencies that characterize the other constituents of the enterprise meta-model. Other forms of structural analysis will be at the heart of future case studies such as risk analysis, outsourcing analysis, reuse analysis, information analysis, etc.

6. Conclusion

In this paper we propose another view of performance evaluation based on a structural analysis integrated formally in the ISO 19440 Meta-model. This approach constitutes an instrumental causality of the process evaluation and requires an empirical validation to operationalize the concept. The structural analysis of the couplings linking the various components of the company is likely to provide the top management with pertinent information allowing a multiview evaluation of the IS performance. This technique could be used in conjunction with analytical tools or mathematical methodologies, including the Guttman Scalograms, for organizing, designing, process reengineering or decision-making.

Acknowledgements

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