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A Performance Assessment System incorporating indirect indicators and semantics

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ABSTRACT

Measuring performance is key to reengineering and optimization of business processes. Although many of them cannot easily be measured due to their quantitative or non-deterministic nature, most performance measurement systems rely on the usage of numeric parameters (Key Performance Indicators, KPIs). So, performance problems stay invisible that could be assessed by other indirect indicators like goals, complexity, maturity, relations or dependencies. In this paper, a Four-Box-Model is presented that also includes internal process views, descriptive approaches and semantics in addition to KPIs. It offers a broad range of possibilities to better identify performance problems and hence, to increase process performance.

Keywords

KPI, Non-numeric, Indirect, Indicator, Metrics, Goals, Semantics, Ontologies, Process Performance Management, Performance Measurement System, Performance Assessment System

INTRODUCTION

If you can't *measure* it, you can't *manage* it? Of course measuring is necessary in principle (Franco-Santos and Bourne, 2005), because it pushes both internal operations and external competitiveness (Sheu and Wacker, 2001). But what if many performance problems that are hard to catch by measurement but contain other relevant or unique implications stay fuzzy, *invisible* and lost for review, control and improvements? If business performance is likely to increase by the number of improvements (which can better be applied to business processes with *visible* performance problems), there is a certain danger of not revealing problems in processes with diffuse, unseizable or invisible performance. This leads ultimately to an inability to implement improvements and therefore, to *lose* money by wasting business performance.

The goal of this paper is to enhance the *visibility* of business performance problems through the implementation of appropriate indicators for process performance in order to *reveal* improvement and optimization possibilities.

Business performance measurement is not as successful as it may seem though many recommendations, methods, performance measurement systems (PMS) or software solutuions (compiled e.g. by Genrich et al. (2007) or van der Aalst (2007)), exist. The majority of approaches to assess process performance rely on *KPIs*, few use other indirect indicators and semantic technologies are rather unusual in performance measurement. This restriction leaves it very difficult to identify invisible process problems that would be better assessable by other indirect indicators like success factors, soft goals, complexity, maturity as well as relations or dependencies, a typical application for ontologies.

The contribution presented in this work is a *Four-Box-model* as Performance Assessment System (PAS) for business process performance assessment that does not only use KPIs, but also incorporates other non-numeric and indirect indicators in order to complement and overcome constraints of numeric measurement in any given business domain, explicitly including semantic technologies. It is able to address performance problems hardly tangible by KPIs or invisible to them alone.

Proceeding with the description of the state of the art and the formulation of the resulting research gap, the research design and investigation course part are rendered. Finally, the conclusion and outlook part frame this paper.

STATE OF THE ART

In this state of the art section, currently used approaches to the problem and recent research are discussed. Out of these examinations, the research gap is postulated.

For an enterprise, the usual starting point to process performance measurement is to *evaluate* performance, usually through numeric KPIs in a PMS.

Performance Measurement Systems

Lots of business processes can be easily evaluated by numeric parameters since they are rather systematized, pre-structured or automated, and use measures related directly (units, yield, price) or indirectly to income (machine hours, throughput or downtime). To use a more broad approach many PMS add *value* to the measures by the implementation of additional measures apart from the classical financial background, additional or enhanced viewpoints, other qualitative and quantitative objectives as well as strategies to archive them, e.g. the Balanced Scorecard (BSC) by Kaplan and Norton (1996) or the Performance Prism by Neely et al. (2002). But one of the most important obstacles to successful implementation of PMS stays to be the unwillingness and difficulty to quantify and measure performance in process areas that are more *qualitative* in nature, intangible or hard-measurable (e.g. Ittner and Larcker, 2003; Lönnqvist, 2004; Rehage, 2009) because this means extra cost for finding, defining, applying and maintaining measures (Bierbusse and Siersfeld, 1997; Kueng and Krahn, 1999; Lönnqvist, 2004). The common elusion is either to artificially design stopgap KPIs by reducing complex problems to single parameters (Ittner and Larcker, 2003) or to circumscribe the problem by a whole range of measures (Brown, 1996; Bierbusse and Siersfeld, 1997; Bourne et. al, 2003).

But certain performance problems still remain fuzzy despite circumscribing or special tailoring of measures since they are hardly or not visible *at all* to numeric parameters and so, might be underrepresented or even left out to measurement. Though, the majority of approx. 90% of PMS still and *exclusively* uses numeric KPIs as Indicator of choice (Pidun, 2011). This fact raises the question for the existence of *alternative* indicators.

Implementation of indirect indicators

Recent research of Raschke and Ingraham (2010) indicates strong evidence that for example a high business process *maturity* in key processes of the production environment also positively affects overall business performance and hence lead times, inventory and holding costs, which ultimately reduce cost of goods sold and increase the *gross margin*. In general, indirect indicators are considered to be very important because they act as intermediate performance measures (Dehning et al., (2002), Melville et al., (2004)). So, additional improvements that could be read out by additional indirect indicators besides maturity are likely to contribute to process success and outcome in their way *as well* and hence, to contribute to business performance.

An example for an indirect indicator is a *goal*. If its result, e.g. a documentation file, lies within a certain specification or reference corridor, a goal *documentation delivered* can considered to be fully or partly fulfilled, as Letier et al. (2004) define goals as variables related to performance indicators that are also able to disclose a partial degree of satisfaction. Descriptive goals in this context are desired results of an action and as such, can be considered as indicators of success or failure and have to be regarded in the background of performance assessment as well.

In contrast to that, only very *few* approaches exist that explicitly consider the use of goals or other indirect and non-numeric indicators for process assessment. Distinct models are e.g. the Process Performance Measurement System (Kueng and Krahn, 1999) or the EFQM model (Moll, 2009), in which qualitative aspects of performance are used as well through the definition of descriptive *goals* and the use of secondary scores or indicators that state to what *extent* the goals are fulfilled. So, *describing* performance instead of quantizing it is a promising way to overcome the restrictions of numeric parameters. This aspect is being explored in the following sections.

Adding descriptive methods

In a previous study on the analysis of business processes, the existence of additional indirect indicators was shown (Pidun et al., 2010). In it, a *performance system* space is spanned in the two dimensions *embodiment* and *scope* of the indicators. The indicators assess either the process performance by the assignment of a certain *numeric* value or by *verbal* description and judgment. Within the other dimension, assessment is done by indicating *efficiency* through evaluation of process success and *effectiveness* through process outcome. So four systems, called parameters (or factors) for efficiency (or effectiveness) are formed. In this context, numeric KPIs that usually evaluate process *success* can be considered as being just *one* of possible indicators.

Scope	Process success / Efficiency		Process outcome / Effectiveness	
Indicator embodiment	Numeric parameters	Verbal factor	Numeric parameters	Verbal factor

Table 1. Overview of Performance Systems framed by Indicators

We also proposed *internal*, effectiveness-related indicators, both numeric and descriptive. The latter can be formed by reasoned results over process ontologies as a verbal statement of process outcome, since ontologies are descriptive, formal specifications of a concept (Gruber, 1993) and can be used to *describe* how a process is working.

Popova et al. (2009) propose a similar integrative approach with generic Process Indicators (PI) like measurability, roles, capabilities or goals, but without discussing the possibilities of ontologies as indicators or semantics as integrative approach. Semantic technologies are a key concept in modern information science. Combination of and referral to verbal elements contained in semantic objects while reasoning (most prominent *ontologies*) allow gaining additional broader context information or alternative descriptions and interpretations of a circumstance. So, they could be very helpful to add *verbal-descriptive* possibilities to performance indicators to assess the hard-measurable.

Semantics as value-adding concept

Semantics are useful in many parts of the enterprise, e.g. customer data integration and project management, but also in business process management or quality with the purpose to better structure, coordinate and integrate applications and data (Merdan et al., 2010), but not very common in the direct context of process performance.

There are already some ontologies in particular designed for the description of business processes, e.g. Samiresh et al. (2006) or Dimitrov et al. (2007). Though, the application of ontologies in business life is still *experimental* and only very few interested parties may want to build a process ontology for their own needs. To our perception, the use as indicator also still is rather *unknown*. Another application of semantics refer to exercises of annotating additional information to process notations, e.g. Other applications of process notation models enriched with ontologies are e.g. Born et al. (2008) for BPMN or Stein (2009) especially for ARIS. So in principle, also annotating *indicators* for process performance by the use of ontologies should be possible and value-adding as well, but such an application hasn't been found yet.

Research gap

The main problem of bad *visibility* especially of performance problems that are hardly or not measurable to numeric indicators used in common PMS at this point seems to remain *unsolved*. The majority of approaches to assess process performance rely on KPIs, few use other indirect indicators or try to combine viewpoints and indicators to reveal potential that is invisible to KPIs. Moreover, no solution exists that incorporates semantic technologies despite their implementation bears added value for the assessment of process problems through *description* instead of *quantization*. Hence, still potential business performance is lost by not addressing invisible process problems.

So there is a *need* for a PMS that faces four main challenges that should:

1. be a model that uses the taxonomy of four performance systems, combining both numeric and descriptive as well as process success and outcome analysis in order to better identify invisible or hard-measurable performance problems,
2. contain appropriate indicators that operationalize the model in order to better assess hidden performance,
3. explicitly include semantics in the design of the model in order to enable verbal description and possibility to combine or integrate the indicators
4. address multiple or all business domains.

RESEARCH DESIGN

Following research questions can be raised in order to approach the research gap:

1. What are suitable descriptions or paraphrases for the main problem? In what way can information be gathered best?
2. Are there already integrated or combined approaches to the main problem that contain viewpoints or principles similar or equal to the performance systems?
3. Does information on current approaches contain specific viewpoints that could be used to identify and delimit ranges of performance problems or corresponding measures that are able to assess specific ones?
4. Can viewpoints and measures be used to extract and group intrinsic and essential indicators that correspond to the performance systems?
5. What implementations of semantics exist in the evaluated approaches?
6. How can a combined or integrated model using these indicators be designed?

To achieve the goal to visualize *hidden* performance problems, we use four subsequent methods (literature review, comparative analysis, conceptual modeling and case study) and establish two major research approaches described as follows.

Extraction of indicators

To identify generic indicators that are contained in process assessment models, a *literature review* was performed. The results of the review were also used for the postulation of the state of the art. Around sixty sources out of online and printed journals, books and practitioner reports were reviewed using a systematic review scheme Denyer and Tranfield (2009). Used databases were e.g. Emerald, Springerlink, EBSCO Source Complete and Google Scholar, where possible including reverse lookup (papers cited in newer work) Lookup terms were expanded from search terms that are rather common in performance measurement systems' contexts to a wording used in business process management surroundings in order to stretch the extent of viewpoints from the concept of numeric performance measurement to the specification of the indicators out of the performance systems.

Through *comparative analysis*, key elements correlated to the performance systems as well as complementing concepts should be found in the literature.

Modelling of PMS and indicators

Additionally, we were collecting implications on the layout and workflow of organizations, the quality and domain of their processes as well as work in the literature review. Results and viewpoints were used for deployment of the model while *conceptual modeling* that followed the principles of the intrinsic *symmetry* of the performance systems, *abstraction* of the key elements to generic indicators and the *collection* of elements that relate to domain-independence.

The literature review and comparative analysis was also used to assess the possibility to evaluate *semantic* annotation methods of indicators to processes as well as the construction of software artifacts. Research itself was performed from January 2010 to February 2011 and is described in the following sections in detail.

INVESTIGATION COURSE

In the following description of the investigation course, the performed literature review, comparative analysis, conceptual modeling and a brief description of first validation approaches are documented. Findings summarize this section.

Literature Review

The literature review facilitated the distinction of various *key elements* related to the performance systems, and could identify some rather sophisticated combination or integrated *models*. Intentionally, these models also obviously demand the *extension* from numeric to more convenient indirect indicators like goals, quality or meta-indicators as remarked in the state of the art section. They were designed to either contain suitable indicators and guidelines for specific problems or to prove the possibility to add semantic functionality, but *no* model uses ontologies containing process information directly *as* an indicator. At least, several approaches are found that add *annotations* to multiple process notation models.

Comparative Analysis

The following table contains an overview of evaluated models with regards of their originating domains, viewpoints to process assessment and recommended indicators.

Originator	Domain	Viewpoints	Measures
Andersen (1995)	Productivity	Productivity, Effectiveness, Intangible dimensions	KPI
Brewer et al. (2000)	Logistics		Internal process measures, Intangible measures
Naumann et al. (2000)	Information Quality	User, Source, Process	
DeToni et al. (2001)	KPI	Cost/Productivity, Time, Quality, Flexibility	
Bruce et al. (2002)	Benchmarking		Stability, Skills, Staffing, Automation, Technology
Remus (2002)	Knowledge Management	Time, Cost, Quality, Knowledge intensive processes	Complexity, Variability, Granularity, Competence
Wettstein et al. (2002)	PMS Maturity	Measurement, Data collection, Storage of data, Communication of performance results, Use of performance results, Quality of performance measurement process	Maturity
List et al. (2004)	Performance Measurement		Instances, Cycle Time, Revisions, Complaints
Juan et al. (2005)	EPC Quality		Scenario Similarity Degree
Cardoso et al. (2006)	EPC Quality		Loops, Parallel paths, Joins, Splits
Aburub et al. (2007)	Goals		Goals, Measures
Vanderfeesten et al. (2007)	EPC Quality		Coupling, Cohesion, Complexity, Size
Cardoso et al. (2009)	Soft Goals	Accessibility, Confidentiality, Completeness, Accuracy, Traceability, Integrability, Trust and confidence, Emphaty	
Moxham (2009)	Non-Profit organisations	Political reasons, Organizational transparency, Community involvement	Public confidence, Staff quality
Popova et al. (2009)	Performance Indicator	Process, Performance, Organization, Agent	Discrete or continouous, Assessable with a scale, Qualitative soft or Quantitive measurable, Customer satisfaction, Company reputation, Employee motivation, Hard or soft goals, Process implicit indicators
Heinrich et al. (2010)	Business Process Quality		Suitability, Maturity, Operability, Effectiveness, Productivity, Compliance, Variants, Components, Media disruptions, Capacity, Capability

Table 2. Viewpoints and measures of process assessment

In addition to the viewpoints and measures contained in the models above, the principal occurrence of *semantics* was noted and interpreted. Found solutions can be put into three categories according to the level of formalization, either semi-formal in accordance to the rules of the respective notation language or formal by using ontologies.

1. *Addition* of elements to a process notation model containing indicator information, e.g. Pavlovski et al. (2008),
2. *Semi-formal* annotation of indicator information *directly* to the elements of a process notation model e.g. Heinrich et al. (2010)
3. *Formal* annotation of information contained in a *process ontology* to the elements of a process notation model, e.g. Stein (2009)

Especially in the context of performance assessment, some more applications of *indicator* ontologies or process ontologies containing indicator *information* are imaginable, but weren't found. This lack also documents the *missing* involvement of semantics in performance assessment. Though, it would be favorable to add previously demanded *descriptive* and *integrative* features to notation models or PMS through semantic annotation or implementation of indicators in semantic constructs.

Conceptual modeling

The *viewpoints* and *measures* of process assessment that were identified in the literature review can be clustered to the dimensions *scope* (concerning efficiency or effectiveness) as well as *embodiment* (numeric and descriptive) according to the performance systems approach introduced in section two, and so, aggregated to form four appropriate generic *indicators*.

Contents	Performance System	Name	Short form
Numeric parameters that point to process success, e.g. measures or KPIs	Parameters for process efficiency	Key Performance Indicators	KPI
Hard or soft goals, success factors	Factors for process efficiency	Process Success Factors	PSF
Parameters pointing to quality, internal measures, skills	Parameters for process effectiveness	Process Metrics	PMX
Semantic technology	Factors for process effectiveness	Process Ontology	PO

Table 3. Generic indicators

In this context, we use the terms *efficiency* to describe to what extent the process is generating *success* and *effectiveness* to describe to what extent a certain process *outcome* is observable (also referred to as *quality*). Complementing characteristics are e.g. clusters like users/process, time/quality, accessibility/accuracy, transparence/involvement that point back to the demand of a certain *domain-independence* and need to abstract the model as far as possible in this direction.

On finally rearranging the *indicators* to the dimensions of scope and embodiment, the *Four-Box-Model* for process assessment can be described.

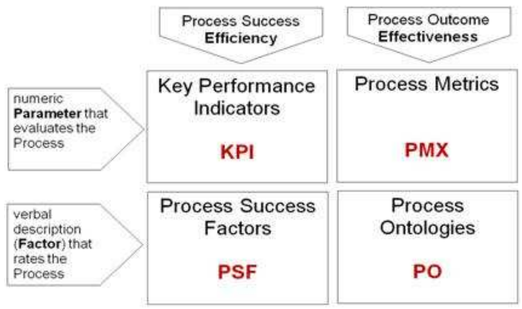

Figure 1. The Four-Box-Model

In the following section, the indicator properties and basic application principles are discussed in detail.

Key Performance Indicators

For a lot of performance problems in production or processes directly related to value, KPIs might be sufficient. As there are quite a lot of recommendations and solutions available on KPIs already, we will not collect or compare individual indicators here but point to existing catalogs like e.g. Baroudi (2010) or Parmenter (2010).

Process Success Factors.

Via an intermediate step of a mandatory declaration and *paraphrasing* of an abstract problem into a goal or so-called process success factor (PSF), the success of the process can be *rated* transparently.

They can be considered as conditions that are composed in free text and define a process *success* when fulfilled; the result of the process is basically rated, not *directly* evaluated with a parameter. The factors can take shape of either a *binary* yes-no decision or a discrete *cascade* of opinions about the process success. The opinion cascade can be a set of verbally escalating statements (like *hardly, partly, mostly, fully*) or quantized quasi-values that embody a success rate, e.g. from 0 to 100%, via a scoring scale of a parameter (e.g. 20 points maximum) or a *score* range (e.g. 1-5) similar to school grades. This *quantization* with a numeric quasi-value improves IS-supported processing, display and control similar to KPIs.

Process Metrics

Many business processes, even most of the support processes cannot be assessed via the validation or rating of the process success, but by evaluating how a process is performing *at all*. Hence, they are *immanent* parameters that describe the processes' formal building blocks or *what it takes* to execute a certain task. The so defined indicator Process Metrics (PMX) can be applied both to single process parts or the entire business process. Examples of individual indicators out of this family could be abstracted and logically *derived* from the comparative analysis earlier in this paper.

Family	Process Diversity	Task Diversity	Task Difficulty	Quality
Name	Steps (S)	Responsibles (R)	Complexity (C)	Time (T)
	Elements (E)	Approvers (A)	Knowledge (K)	Maturity (M)
	Interruptions (I)	Departments (D)		

Table 4. Examples of Process Metrics

With e.g. i*nterruptions* as the amount of media breaks, c*omplexity* is the subjective degree of difficulty to execute a step and k*nowledge* is the subjective degree of the responsible's ability to execute a step.

Process Metrics can be direct countable or indirectly rated and hence quasi-valued, quantitative or qualitative. Completive combinations of parameters can be used to better assess outcome through the entire process landscape, e.g. the *ratio* of knowledge of a responsible compared to the complexity of the step, or a *product* of amounts of involved approvers by departments.

Process Ontology

Regrettably, direct insights on ontologies stay rather restricted to the persons *developing* this indicator since the use of semantics in management is not very common (Merdan et al., 2010). So unless semantic techniques are used to increase visibility of business related performance problems in a combined or integrated *performance assessment model*, especially in the context of implementations that are already state-of-the-art (like PMS or process *notation* models) the use and application of a semantic indicator *itself* might stay rather unusual. Hence, the *integration* of semantics is more promising than the application of ontologies *as-is*.

Case study

In a project that is outlined to assess the administration processes in a German public company during the year 2011, the PAS was primarily introduced in the workshops for process recording and optimization. Up to now, the participants of the workshops vastly verbally agreed to the subjective *usefulness* of the approach. Waste in the sense of *muda* in the *Lean* philosophy became visible. It was hidden in perceived untouchable quantitative processes that therefore were still untouched. As the project is not yet finished, we consider the *validation* process as still in progress and upgradable through a *test* in the direction of the Technology Acceptance Model (TAM). Though, the principal applicability of the Four-Box-Model in business process management can be considered to be given.

Findings

Using the research design and the framework of the procedural model in Section three, the *application* of the four performance systems' inherent principles to the viewpoints and measures contained in the literature can be performed. A combined Four-Box-Model for performance assessment of business processes can be *deployed* that contains a broad range of possibilities to *identify* performance problems and to *assess* performance beyond KPIs.

The model adds up comparability to the considered business processes due to the fact that the majority of indicators can also be *quantized* and hence displayed easily, as well as their ability to form combinations that are meaningful for the entire process *ecosystem*.

Though verbal *descriptions* may be hard to compare in their original form, *semantics* can be used to add a referring and comparing functionality from one meaning to another to render them *equivalent*. In the case of process ontologies, transparency will increase when the working principle of semantics is used to *integrate* various indicators rather than only to represent a single one. One possibility to do so is e.g. by combining semantics with a process notation model as a *carrier*.

CONCLUSION AND OUTLOOK

The Four-Box-Model as *Performance Assessment System for Business Processes* proposed in this contribution incorporates four different viewpoints to business performance problems and *broadens* assessment possibilities from KPIs to three additional indicators. It is able to identify process problems that are hard-measurable or invisible to KPIs by evaluation and rating as well as consideration of efficiency and effectiveness. Moreover, it is able to assess the concealed performance potential beyond the boundaries of KPIs. Though, results of the assessment can also be formulated in *figures*, thus is still leaving room for the implementation in popular dashboards.

Due to its initial design, it incorporates all business processes, not only production or value creating processes. Hence, it is able to add *visibility* to business process problems in *principle*, which leads to an enhanced possibility to implement *improvements*. Nevertheless, it is ready-to-use for business process assessment *immediately* and without the use of a certain framework, programming or modeling language.

A further contribution to the research community is the concept and discussion of combining or integrating various *different* concepts for assessing business processes. Especially the use of *semantic* technology to form an indicator or an integrated solution opens room for discussions on implications of the model design.

Direct annotation of the presented *indicators* to process notation models would already *add value* to them and enhance their usability and relevance in the future. In addition, the presented model model should also be *integrated* in a *semantic* framework which additionally raises the possibilities of process assessment. Hence, continuing research in the future will be on how to integrate the given indicators into an *ontology* and subsequent *annotation* to a process notation model.

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