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KPI Design as a Simulation Project

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Abstract

Design of key performance indicators (KPIs) is a repeated and challenging problem for organizations. KPIs are measured at the operational level, but are used to manage organizations at the strategic level. Strategic goals often change, and professionals with different backgrounds must understand and implement new KPIs that correspond to them. Nowadays, KPIs are designed and directly implemented on running organizations, which is disturbing to operational personnel. To avoid the disruption of business processes, we propose to design and test KPIs through simulation. After satisfactory experiments, a KPI can be implemented on the modelled organization. We have developed a conceptual reference model to organize KPI design simulation projects, showing what should be produced in a project. Our model has been built by the application of requirements engineering methods to the review of the literature of performance indicators. The model has been tested on several case studies. In this paper, we show two studies that demonstrate how unspecified concepts from our conceptual reference model damage reliability and improvement orientation of the designed indicators.

Keywords: Key Performance Indicator, KPI Design Simulation, Conceptual Reference Model, Properties of KPIs, Validation

1. Introduction

Organizations commonly extend information systems with performance indicators and key performance indicators. New strategic goals often emerge, and corresponding performance indicators are introduced. Typical case studies (e.g. Gries & Restrepo, 2011) show that KPIs are chosen for a business process based on experience. In fact, experimenting with new KPIs disturbs personnel. It is not always known in advance if the chosen KPIs are sensitive to changes in the business process, or if they are reliable and will help an organization in achieving new strategic goals. Only the analysis after taking measurements over time can show whether the KPIs work toward the strategic goals of the organization.

The best practices to support the choice of KPIs are summed up as lists of KPIs in different domains (KPI institute, 2017; KPI institute, 2016). There are also conceptual specification models of KPIs (Popova & Sharpanskykh, 2010; Strecker et al., 2012). These describe KPIs according to their attributes and border values of indicators, whose values are often unknown, and whose specifications are meant to be used after implementation.

KPIs also have non-functional requirements, traditionally called properties, collected in the literature on management and information sciences from interviews of KPI users (Neely, 1997; Kueng, 2000). Some properties relate to the dynamics of an organization toward its goals; these can be evaluated only on a running business process or on its model (Roubtsova & Michell, 2013)). KPI properties often demand calculations and comparisons of KPI values during several business process runs during a period.

Experimenting with KPIs and evaluating their properties can disturb the measured working business. Hence, it is advantageous to experiment with KPI design on models and consider it as a simulation project. Only after satisfactory experiments will a KPI be implemented on a modelled organization.

We define a KPI design project as a simulation project and propose a conceptual reference model for such a KPI design simulation project (CRM-KPI-DSP). Compared to existing conceptual models of KPIs, our model combines the concepts of KPIs with those needed to simulate KPI design and define their non-functional requirements. This covers concepts of different layers of an organization: strategic, operational, and measurement. It covers concepts of different levels of precision: goal and business process models, traces of model execution, formulas, and values.

CRM-KPI-DSP has been built by applying requirements engineering methods to analyze the literature of performance indicators in management and information sciences. It has been tested on several case studies.

In this paper, we present the CRM-KPI-DSP and demonstrate the use of its concepts in simulation case studies.

Section 2 presents a model of a KPI Design Simulation Project. Section 3 proposes a Conceptual Model for a KPI Design Simulation Project. Sections 4 and 5 describes the results of case studies that have followed a KPI Design Simulation Project. Section 6 provides discussion of the use of CRM-KPI-DSP. Section 7 presents conclusions and outlines future applications of CRM-KPI-DSP.

2. KPI design as a simulation project

Robinson et al. (2015) state that a simulation project has the following stages: (1) problem description; (2) project goals; (3) conceptual model to clarify problem description; (4) credible simulation model (program) representing relevant elements of modelled world; and (5) suitable experiments for project goal resolution. Two goals can be realized in any simulation project. One is to obtain a credible simulation model, truly representing the relevant elements of the modelled system. The second goal is to resolve the problem via experiments that should be done on the credible simulation model.

We specialise a simulation project from Robinson et al. (2015) as a KPI Design Simulation Project (KPI-DSP) by specialising the stages. Figure 1 presents the stages of a KPI-DSP.

1. The problem description of a KPI-DSP is the absence of a direct way to design KPIs with desirable properties (non-functional requirements), because the properties relate a strategic goal and a given business process. The KPIs are defined by strategic managers, but implemented by operational workers. The desirable properties of KPIs depend on the business process and are restricted by external processes and constraints.
2. The project goal is to propose KPIs corresponding to business and strategic goals, and to validate a set of KPI properties on a business process model of the given business process.
3. The conceptual model of a business process selects and relates the concepts and relations of the process needed for KPI design.
4. A credible simulation model is an executable model of business process (case study). The credibility is tested by populating the simulation model with instances of business objects (resource units) and by executing the model, often together with operational workers.
5. The experimentation for resolution of goals of a KPI-DSP covers experiments for KPI calculation and validation of KPI properties (non-functional requirements) using results of a credible simulation model.

3. Conceptual model for a KPI design simulation project

Any KPI-DSP is a result of communication of the roles of the modeller, manager, and operational worker. To support their communication, we have built a Conceptual Reference Model for a KPI design simulation project (CRM-KPI-DSP) combining all the concepts used in a KPI-DSP, as it is shown in Figure 1.

The CRM-KPI-DSP is depicted in Figure 2. The grey boxes and their relations in Figure 2 define a KPI internally. The external definitions of a KPI specify it via non-functional requirements, which are known as KPI properties. The definitions of KPI properties in the literature stem from interviews of KPI users (management) (Neely, 1997; Kueng, 2000; Kumar et al., 2013).

Hence, they often use different terminology. The properties obtained from these interviews have been reduced by Kueng (2000) quantifiability, sensitivity, linearity, reliability, efficiency, and improvement orientation. These properties have been related with the internal definition of a KPI by Roubtsova & Michell (2013).

In this paper we show that these properties can be defined using the concepts and relations of CRM-KPI-DSP (Fig. 2).

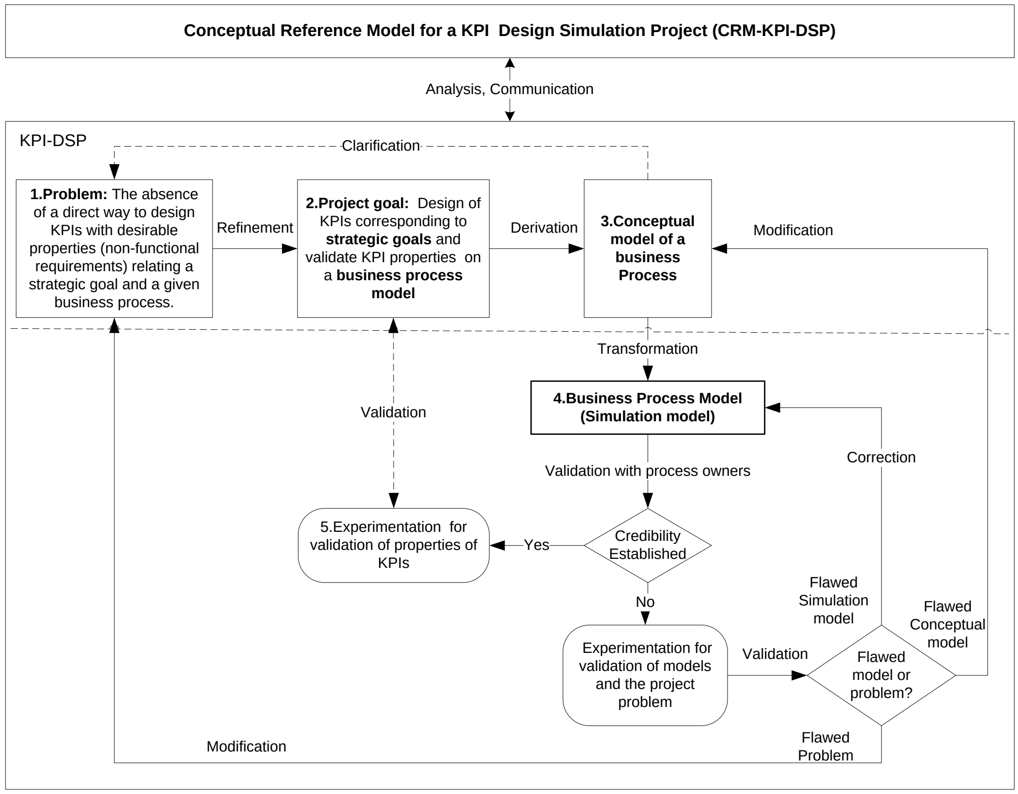

Figure 1. KPI Design Simulation Project

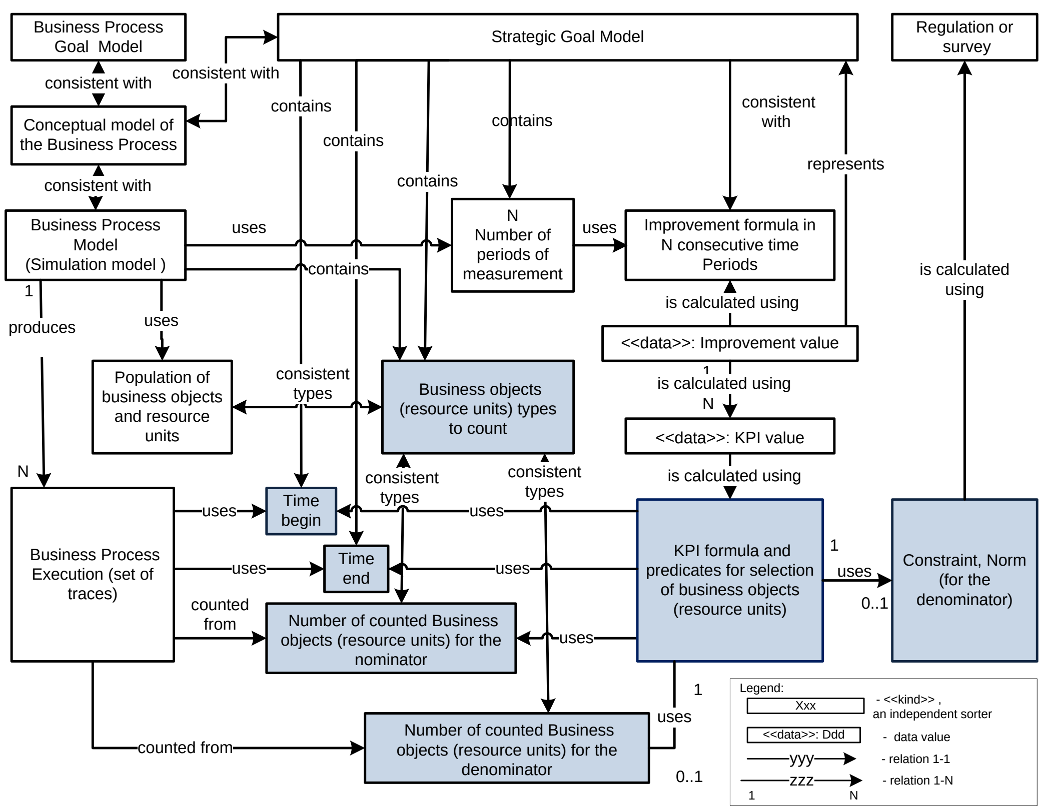

Figure 2. Conceptual Reference Model for a KPI Design Simulation Project (CRM-KPI-DSP)

Quantifiability of a KPI is the counting of something. CRM-KPI-DSP has types of business objects (resource units) to count. If a strategic goal model specifies a quantitative goal, e.g., customer payment attitude, the goal should be refined to countable (and/or comparable) concepts. For example, customer payment attitude can be refined to a number of days between sending an invoice and receiving payment, counted for a number of customers during a chosen time period. The counted business objects in this case are days. So, quantifiability is guaranteed by the KPI formula design in correspondence with CRM-KPI-DSP. A simulation experiment is not required to guarantee quantifiability, but an experiment can demonstrate what is counted.

However, the relation between changes of the KPI value and improved performance should be tested through simulation and shown to managers and workers. These experiments may reveal issues with KPIs and business model credibility.

Efficiency is the absence of complex data transformations in the code implementing the KPI formula. This can be estimated through simulation.

Reliability is attained by avoiding assumptions in KPI calculations. There are examples of unreliable KPIs in the literature (Kueng, P. (2000), Roubtsova, E., & Michell, V. (2013)). The conceptual reference model shows the attributes of the KPI formula that require definition, as well as the artifacts from which their values should be derived.

The *Time begin* and *Time end*, the *Business objects (resource units) types to count* are taken from the refined *Strategic Goal Model*.

The instances of *Number of counted business objects (for the nominator)* and *Number of counted business objects (for the denominator)* of the *KPI formula* are counted in the *Business Process Execution* (set of traces) recorded for the *Time begin* and *Time end*.

In some KPIs, the denominator is derived from other sources shown in the CRM-KPI-DSP (Figure 2) as *Regulation or Survey*. Concept *Constraint, Norm* is used to present the results of surveys or norms defined by regulations. For example, the population of a country or number of houses in a region can be taken from surveys. For reliability, it is necessary to show the source and method of acquisition of the value of *Constraint, Norm*.

If the sources of all of the elements of the KPI formula are known, it is not necessary to validate reliability through simulation. However, simulation can demonstrate unreliable KPIs to business process owners. Section 4 provides a case studies with unreliable KPIs.

Improvement orientation of KPIs explicitly states the relation between the *KPI formula* and *Improvement formula*. The *Improvement formula* is missing in existing conceptual models. However, management literature notes that performance indicators should emphasize improvement rather than conformity to instructions. Therefore, "measuring billing errors, numbers of safety violations, data entry errors and the like, do not create an atmosphere where feedback sessions are viewed in a positive, constructive light" (Kueng, P. (2000)). A refined *Strategic Goal Model* should not include the KPI value as a target. (Goodhart, C. A. (1984)) states that when a measure becomes a target, it ceases to be a good measure. Improvement should be a target, and this requires an *Improvement formula*.

We mediate the relation between the *Strategic Goal Model* and *KPI formula* with the *Improvement value*, which is calculated using an *Improvement formula* by comparing N values of KPIs for successive time periods. An improvement is revealed by differences of KPI values for two or more successive time periods. This should be validated by simulations whose results can be shown to managers and operational workers. We have demonstrated that the properties of KPIs are defined using the concepts of CRM-KPI-DSP. Most properties must be validated through simulations.

4. KPI-DSP Order-to-Pay

The first case study, Order-to-Pay (also known as purchase-to-pay or procure-to-pay), presents examples of often used time-related KPIs. All businesses receive orders from customers and send invoices for payment.

4.1. Goal Model Order-to-Pay

The goal of the business process is ***In time processing of Order-to-Pay***. Handling an order has three milestones: the customer can send, confirm, and close an order (Figure 3). The service provider receives the order, specifies it, and sends back the specifications. The customer can register and pay invoices corresponding to confirmed orders.

- Only invoices for confirmed orders can be registered. Several invoices can be registered for one order, but their total should not exceed the amount of the order.
- Only registered invoices can be paid.
- Invoices for an order are registered if their total does not exceed the amount of the order.
- When the total of paid invoices equals the amount of the related order, the order is fully paid.

The key concepts of this business process are **order** and **invoice**. The life cycles of these concepts and attributes are modelled in a business process model.

The measurement goal of the company is to **measure in-time processed orders and compare them with all closed orders**. Further, we use the concepts from CRM-KPI-DSP. The measurement is designed for real time, so **Time begin** for measurement is defined by the earliest order and **Time end** by the latest order. In this case, the concept **business object types to count** from our conceptual reference model means that all of the **closed orders** and **in-time processed orders** are counted. To assess the time of order handling requires one to calculate the time of handling for each order, called the **order lead time**, measured in days.

The strategic manager has specified a **norm lead time** in days and proposed to compare it to the **order lead time** of each order.

A KPI has been designed as **percentage of in-time processed orders**, which is a formula or algorithm that:

1. selects the set of instances of closed orders from **Time begin** to **Time end** and counts them as **Number-Of-Closed-Orders;**
2. selects the set of instances of orders closed in time less than or equal to the norm lead time from **Time begin** to **Time end** and counts the **Number-Of-Closed-Orders-Within-Time-Norm;**
3. calculates the **Percentage of in-time processed orders** as a fraction of **Number-Of-Closed-Orders-Within-Time-Norm** within the **Number-Of-Closed-Orders.**

Such properties of the KPI as quantifiability, linearity, limits of sensitivity, and efficiency. The quantified entities are Closed-Orders and Closed-Orders-Within-Time-Norm. The limit of sensitivity of the KPI is less than one in-time processed order per 100 orders.

The second performance indicator **average lead time of the closed orders (rounded to days)**, can be compared to the **norm lead time.** The reliability and improvement orientation of KPIs must be validated in simulations of a business process model.

4.2. Business Process Model

We use executable protocol modelling. The graphical presentation of the protocol model is shown in Figure 3. The executable protocol model is textual, can be downloaded and executed from (Protocol Modelling, 2020). The model includes data attributes of protocol machines and call-backs for data updating.

The states of protocol machines are shown as ellipses. For example, the protocol machine of any object **order** that can be in states **sent**, **confirmed** and **closed**. The states correspond to the milestones specified for an order in the business process goal model.

A directed arc connecting two states represents a transition. The arcs are labelled with events. An OBJECT contains ATTRIBUTES, local storage of ATTRIBUTES, STATES, and TRANSITIONS. The reader may compare the textual definition of the protocol machine order with its graphical presentation.

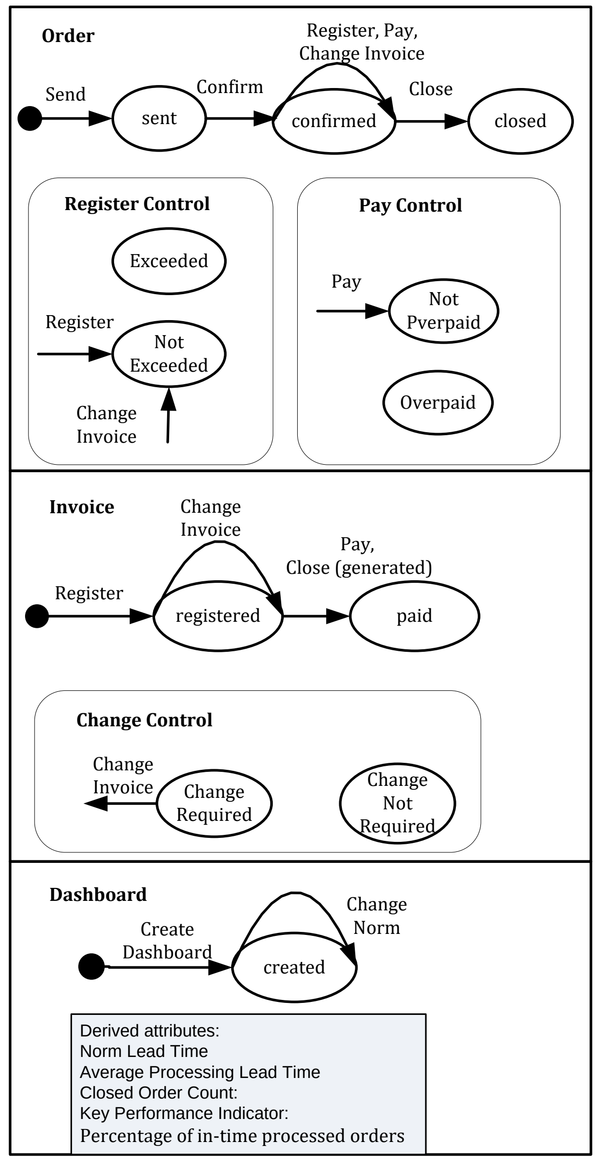

Figure 3. Protocol Model Order-to-Pay

```
OBJECT          Order
  NAME Order Number
    INCLUDES    RegisterControl, PayControl
    ATTRIBUTES        Order Number: String,
            Order Amount: Currency,
            (Date Sent: Date),
            (Date Closed: Date),
        (!Processing Lead Time: Integer),
            !Current State: String
    STATES  Sent,Confirmed,Closed
    TRANSITIONS @new*Send=Sent,
          Sent*Confirm=Confirmed,
          Confirmed*Register=Confirmed,
          Confirmed*ChangeInvoice=Confirmed,
```

Confirmed*Pay=Confirmed,
Confirmed*Close=Closed

An exclamation mark near an attribute indicates that its value is calculated in a small java callback Order.java of the protocol model as shown in (Protocol Modelling, 2020).

Each event instance in the protocol model has data attributes of predefined types. For example, event **Send** is related to an object Order, and has the **Date Sent**, **Order Number**, and **Order Amount** attributes.

EVENT Send
ATTRIBUTES Order: Order,
!Order Number: String,
!Order Amount: Currency,
Date Sent: Date

The textual model is executable in Modelscope tool (McNeile, 2005), so the current state and attributes of each OBJECT can be seen on the screen. Possible events are presented as a list for submission. The modeller inserts the data values of event attributes requested by Modelscope.

A protocol model can represent a business rule as a partial BEHAVIOUR included in an OBJECT. A transition of a BEHAVIOUR may have only an input or output state, hence the state of the protocol model is used to derive the pre- or post-state of the BEHAVIOUR.

For example, **BEHAVIOUR RegisterControl** uses the state of the protocol model with all instances **@any** to derive the extended state of the order **NotExceeded** or **Exceeded.**

BEHAVIOUR !RegisterControl
TYPE ALLOWED
ATTRIBUTES (!Registered Amount: Currency)
STATES NotExceeded, Exceeded
TRANSITIONS @any*Register=NotExceeded,
@any*ChangeInvoice=NotExceeded

An **order** may have states from the Cartesian product **{new, Sent, Confirmed, Closed} × {NotExceeded, Exceeded}**.

The designed KPI **percentage of in-time processed orders** has been added as an attribute to the protocol machine **Dashboard**. The **average processing lead time** and **closed order count** are added as additional indicators:

OBJECT Dashboard
NAME Dashboard Name
ATTRIBUTES Dashboard Name: String,
Norm Lead Time: Integer,
!Average Processing Lead Time: Integer,
!Closed Order Count: Integer,
!Key Performance Indicator: Integer
STATES Created
TRANSITIONS
@new*CreateDashboard=Created,
Created*ChangeNorm=Created

Protocol machines of OBJECTs and BEHAVIOURs of business concepts of the complete business process model are composed using the calculus of communicating sequential processes (CSP parallel composition) (Hoare, 1985) extended for models with data (McNeile & Simons, 2006).

4.3. Population of Business Process Objects. Business Process Executions (set of traces)

The population of objects **Order**, **Invoice**, and **Dashboard** has been chosen to produce sets of traces that demonstrate the life cycle of an order and the properties of KPIs.

The following example shows an order processing trace, a sequence of events with data that were submitted to and accepted by the model. An order can be processed with one invoice or several partial invoices. The trace below shows two invoices corresponding to one order. The model does not allow overpaid orders. The lead time is defined by the final payment of an order.

Event Send: Order = 001; Order Number = '001'; Order Amount = 10.00; Date Sent = 1 Apr 2019

Event Confirm: Order = 001

Event Register: Invoice = 001; Invoice Number = '001'; Invoice Amount = 5.00; Source = 001

Event Pay: Invoice = 001; Source = 001; Date Paid = 2 Apr 2019

Event Register: Invoice = 002; Invoice Number = '002'; Invoice Amount = 5.00; Source = 001

Event Pay: Invoice = 002; Source = 001; Date Paid = 4 Apr 2019

Event Close: Order = 001; Date Closed = 4 Apr 2019

Another example of a trace demonstrates unreliability of the KPI **Percentage of in-time processed orders**. The business model **Actor Business Manager** (defined as a set of selected behaviours and events) is able to submit event **ChangeNorm**:

ACTOR Business Manager
BEHAVIOURS Dashboard
EVENTS CreateDashboard, ChangeNorm
EVENT ChangeNorm
ATTRIBUTES Dashboard: Dashboard,
Norm Lead Time: Integer

With different Norm Lead Times, the same numbers of in-time processing orders produce different values of the KPI:

Event Send: Order = 001; Order Number = '001'; Order Amount = 10.00; Date Sent = 30 Mar 2019

Event Send: Order = 002; Order Number = '002'; Order Amount = 20.00; Date Sent = 31 Mar 2019

Event Send: Order = 003; Order Number = '003'; Order Amount = 30.00; Date Sent = 1 Apr 2019

Event Confirm: Order = 001

Event Confirm: Order = 002

Event Confirm: Order = 003

Event Register: Invoice = 001; Invoice Number = '001'; Invoice Amount = 10.00; Source = 001

Event Register: Invoice = 002; Invoice Number = '002'; Invoice Amount = 10.00; Source = 001

Event ChangeInvoice: Invoice = 002; Invoice Amount = 10.00; Source = 002

Event ChangeInvoice: Invoice = 002; Invoice Amount = 20.00; Source = 002

Event Register: Invoice = 003; Invoice Number = '003'; Invoice Amount = 30.00; Source = 003

Event Pay: Invoice = 001; Source = 001; Date Paid = 9 Apr 2019

Event Close: Order = 001; Date Closed = 9 Apr 2019

Event Pay: Invoice = 002; Source = 002; Date Paid = 4 Apr 2019

Event Close: Order = 002; Date Closed = 4 Apr 2019

Event Pay: Invoice = 003; Source = 003; Date Paid = 2 Apr 2019

Event Close: Order = 003; Date Closed = 2 Apr 2019

Event CreateDashboard: Dashboard = KPI In-time Processing; Dashboard Name = 'KPI In-time Processing '; Norm Lead Time = 2

Event ChangeNorm: Dashboard = KPI In-time Processing; Norm Lead Time = 3

The simulation shows that:

- Norm Lead Time: 2
  Key Performance Indicator: 33
- Norm Lead Time: 3
  Key Performance Indicator: 66

The Modelscope tool has been used to demonstrate this trace and the dashboard to the process-owner, using a generic user interface of Modelscope. The modeller plays roles of actors and submits possible events. This manipulation of the **Norm Lead Time** has been a convincing evidence of the unreliability of the **percentage of in-time processed orders**. The demonstration of unreliability has been used for communication with managers about the source of the **Norm Lead Time**.

The advice to the company is to estimate the **Norm Lead Time** by populating the model with orders from a log for one month or more. The average lead time can be taken as an estimation. However, it is even better to reformulate the strategic goal without the **Lead Time** and measure improvement. The notion of improvement should be defined. For example, improvement can consist of maintaining or reducing the average lead time of orders over consecutive time periods. Such an orientation of a KPI to improvement makes it resistant to manipulation.

The order-to-pay case study has followed our conceptual mode from Figure 2 and has shown its usefulness for KPI analysis and advice to the company. This case is typical. Orders of different types (e.g., travel expenses, materials, and services) can be recognised in any organisation. We hope that this case study will stimulate interest in improvement-oriented KPIs for such cases.

5. KPI-DSP Marketing of Children's Savings Accounts

Let us use our conceptual reference model to describe the KPI-DSP for a marketing campaign in a bank in the case of a children's savings account.

5.1. Strategic Goal Model

In this case, the strategic goal is to "**increase the number of customers by inviting minor customers**". The strategic goal is refined to the sub-goals "**register new minor customers**", "**measure effectiveness of marketing**". These goals separate the domains of the underlying business process and measurement.

The goal "**register new minor customers**" is refined with milestones. A bank employee mails an **invitation** to all adult customers to open a children's savings account. An **adult customer** may ignore the invitation, or submit an **application for a children's savings account**. Upon receipt of an application for a children's savings account, if the child is under the age of 11 years and does not yet have such an account, a back-office employee BO-employee registers the child as a **minor customer**, who will retain that status until reaching the age of 18.

The goal **measure effectiveness of marketing** is refined to performance indicators. Our CRM-KPI-DSP shows that the strategic goal is used to define the business object types to count in the performance indicators. The business object types to count are **invitations** and **applications**.

The process owner has suggested that the most valuable management information is the **conversion rate of invitations to applications**, i.e., the number of received **applications for a children's savings account** divided by the number of sent **invitation**, expressed as a percentage. The business objects are the received applications for a children's savings account and the sent invitations counted during a given time interval: fro **time begin** to **time end**. Managers also proposed the indicator **conversion rate of applications to minor customers**.

With these indications, suggested by the process owner, the strategic goal to increase the number of customers by inviting minor customers is measured by indicators of two business process stages. The modeller suggests one KPI, **conversion rate of invitations to minor customers**. The **time begin** is the start of a reporting year of a marketing campaign, i.e., sending invitations. The **time end** may be set as "time begin + one year".

As the definitions of indicators show, the quantifiability (summation of objects), linearity, and effectiveness of these KPIs are guaranteed. The sensitivity can be estimated if the number of invitations is known. The reliability and improvement orientation of KPIs requires further investigation through a simulation experiment on the business process model.

5.2. Business Process Model

The protocol model is graphically presented in Figure 4. The textual presentation of the protocol model with all of the data attributes of invitations and applications and call-backs for modelling of KPIs can be found on (Protocol Modelling (2020)).

Two major object types of the underlying model are **Adult Customer** and **Minor Customer**. They both include the BEHAVIOUR customer. Instances of both object types may be in the state **registered**. An adult customer can initiate the event **Submit Application**.

The marketing process is modelled with object types **Invitation ChildrenSavingsAccount** and **Application ChildrenSavingsAccount**. Each event **Send Invitation** creates a unique invitation object.

BEHAVIOUR Invitation Duplicate Check derives the existing invitations and permits the creation of a new unique one. For a unique invitation, a unique **Dashboard Effectiveness Invitations** can be created by **event CreateDB.**

The information about the **Invitation ChildrenSavingsAccount** and the **start of reporting year** of the created dashboard is copied to the dashboard by the generated event **CreateDB.** Dashboard contains indicators as attributes:

- conversion rate of invitations to applications;
- conversion rate of applications to minor customers;
- conversion rate of invitations to minor customers.

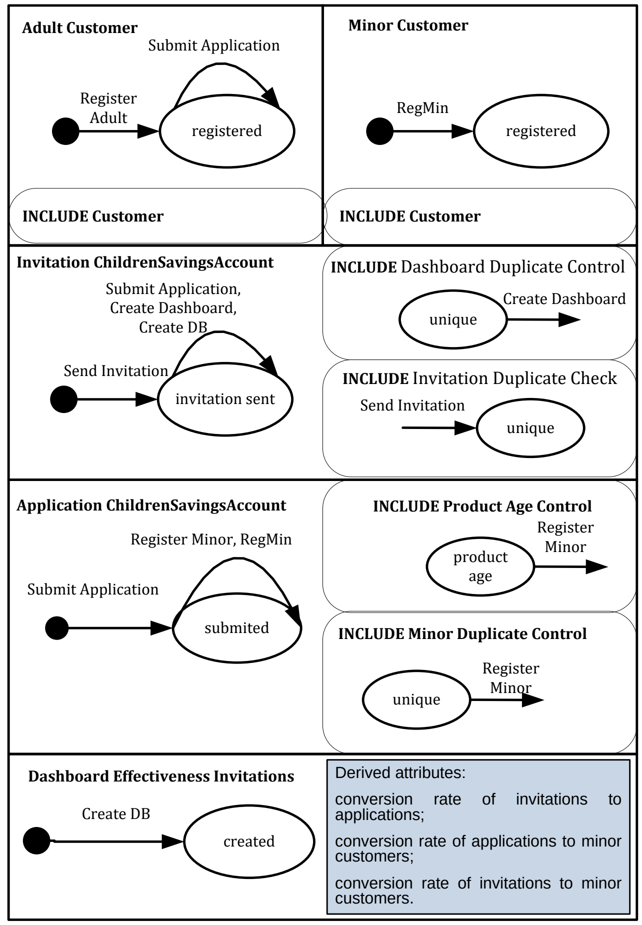

Figure 4. Protocol Model Marketing of Children's Savings Accounts

5.3. Population of business process objects. Business Process Executions (traces)

For testing, the model is populated with a toy number of bank customers.

The open question is whether the measures are reliable and oriented toward improvement. Our conceptual reference model directs the analysis of reliability and improvement orientation of the designed indicators. One can define the improvement of marketing as the growth of conversion rates in successive marketing periods. However, the growth also depends on external factors. Where is the natural border of such growth?

The model of the marketing process discovers undefined relations of the business process and the useful external information. Indeed, the marketing process is intended to stimulate adult customers to open accounts for their children. The best possible result is that all adults open accounts for their children. The bank does not have the private data about children of their customers. However, the bank can estimate this. The demographic rate of minor citizens to adults in the country where the bank is located may serve as the border for the **conversion rate of invitations to minor customers**. To compare this with the demographic rate will increase the confidence in the reliability of the values of the KPIs of marketing.

Statistical data about the population in the bank's country can be found on the Internet. For example, say the population is 17,2 million, the number of potential minor customers under 18 is 3 million, and the population of adults is 14,2 million. These numbers indicate the maximum number of minor customers, based on a percentage of (3/14.2)*100= 21% of the population, that can be gained by marketing. This is an estimated maximum constraint on the value of **conversion rate of invitations to minor customers** of 21%. A conversion rate of invitations to minor customers that is less than this estimate indicates that the KPI is reliable. The discussion of the presented arguments with the managers of the bank extend the goal model to consult a demographic survey to estimate the percentage of minor citizens to adult citizens. An indicator **percentage of minor citizens to adult citizen**s can be added to the dashboard.

6. Discussion

The success stories of business intelligence encourage companies to pay heed to measurements. There are requests from companies in various fields to design measurable business processes with KPIs. The main condition of these requests is that business processes are not disturbed during these projects. The properties of proposed indicators should be shown in the business process model.

We have developed a methodology (Figure 1), which has been used in 7 projects (administration at hospitals, help desks, retailers. recruiting services). The CRM-KPI-DSP (Figure 2) is the result of analysis of those projects. The CRM-KPI-DSP presents the concepts of various related artifacts produced and used in a KPI-DSP. These concepts and their relations should be understood by modellers, managers, and workers involved in a KPI-DSP. The communication of three different roles in a KPI design simulation project is based on the CRM-KPI-DSP. The state of a KPI-DSP can be seen as a state of all of the artifacts.

The concepts of CRM-KPI-DSP are used to define non-functional requirements, reliability and improvement orientation. The absence of some artifacts corresponding to the concepts of the CRM-KPI-DSP directs the project to produce missing artifacts.

Two case studies presented in this paper show that the source of unreliable KPIs is the incompleteness of goal and process models of business processes and absence of some concepts mentioned by the CRM-KPI-DSP.

The first case study, order-to-pay, illustrates a KPI that does not achieve the properties of reliability and improvement orientation, because the improvement is not defined. Instead, a Norm lead time is submitted to the process without realistic estimation.

The second case study, marketing of children's bank account, illustrates how the reliability and improvement orientation of KPIs have been achieved by including a Demographic Survey into the process model.

7. Conclusions

The KPI design is one of the points of communication of different roles in organization: modellers, managers, and operational workers. They have to use the same vocabulary discussing KPIs.

We have proposed a conceptual reference model of a KPI design simulation project (CRM-KPI-DSP) that relates the concepts of the constructive definition of a KPI found in computer science and the properties (non-functional requirements for KPIs) found in the literature on management and information sciences. Combining all necessary concepts, our model serves as a basis for communication of different roles and directing their activities in design and use of KPIs.

The case studies presented in this paper have tested the usefulness CRM-KPI-DSP. The cases have identified the undefined elements of KPIs and doubts about reliability and improvement orientation of KPIs. The CRM-KPI-DSP shows what is missing and how KPIs can be improved.

KPIs can form some groups for such business notions as, for example, Service Level Agreement (Hofman,C., & Roubtsova,E. (2020)). The future research can be directed to assess the indicators of Service Level Agreements.

Modern business is oriented on the use of indicators, presenting dashboards everywhere. Design of reliable and improvement-oriented indicators gets important strategic value. Both the designers and the users should be able to assess reliability of indicators. The conceptual reference model of a KPI design simulation project (CRM-KPI-DSP) presented in this paper is designed to support such an assessment. We invite to use our model to assess properties of indicators in different domains.

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