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Preliminary communication

Automation of Process Performance Management in a Company

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Abstract: The paper describes the automation of process performance management in a particular company, using specially developed client application. Performance management process is based on an analysis of data from the process. The main problem, of analysis in real cases, is the low availability of data from the process and the impossibility of obtaining the analysis results in real time. A detailed specification of business requirements related to performance management in the organization is presented as well as the way of application of WCF (Windows Communication Foundation) services, the concept of business intelligence, methodology for data warehousing DW (Data Warehousing), and application of Silverlight technology for solving this problem. In particular, it shows the implementation of Silverlight client application for processes performance management within the company.

Keywords: company; control; key performance indicators; process quality

1 INTRODUCTION

The main bases of successful business of a company are comprised of the following elements:

a) clearly determined basic organizational matters - the vision, mission, goals, policies and plans,
b) defined set of processes goals that are related to: needs of customers, survival and development of company, the shareholders' interest, employees satisfaction and social responsibility of company in the surrounding,
c) adequate human and infrastructural resources for the processes realization,
d) defined way of the processes realization, including the sequence of activities, responsibilities of employees and documents containing the necessary data and
e) an established management system that is based on the feedback that involves the analysis of data from the processes - processes performance measurement as a basis for making management decisions.

The focus of this work is a detailed analysis of the last of the above elements (marked "e").

According to the requirements of ISO 9001:2015 standard (International Organization for Standardization, 2015 [19]) the company must apply suitable methods for monitoring and processes performance measurement. These methods must demonstrate the ability of processes to achieve planned results. All processes in the company are subject to measurement and monitoring. General supervision of the processes performance is achieved through periodic control of business plan realization that specifies core activities and objectives for all processes. Methods of measurement and control of processes characteristics during the course of their implementation shall be regulated by appropriate procedures. Monitorig of the characteristics of the overall company business is conducted in the work processes of the management of company. Monitoring includes periodical control of the realization of operations plan which specifies the basic technical and economic outcomes and goals for annual period, as well as specific analysis of the characteristics - the performance of all processes.

Processes performance analysis is carried out to provide information about the achieved level of quality of the process in a systemic approach, and as the basis for management by objectives and improvements.

In the process of analysis, the quality of data and information from the processes is essential, as well as their timeliness and availability, to all participants in the analysis - the processe's managers and the company's top management. In that sense, there is also expressed need that the information system of the company, in addition to the key role related to business process automation, should be expanded in such a way to include elements that provide such analysis. This paper provides a practical approach to this expansion of IT support to company business.

2 LITEATURE REVIEW

Control of achievement of strategic goals is done by measuring and comparing them with data on business results from a company database, establishing a process measurement program in the company (List et al. 2005 [1]).

Previous research (from [2] to [11]) related to performance measurement models is primarily based on partial, individual performance measurement models, whose concept did not give insight into the basic factors of the business results achieved, and no insight into aspects of the business to improve and in the future affect the key performance of the company.

In the early 1990's a new organization performance measuring system was developed under the name Balanced Scorecard (BSC). This was just a reporting tool in the beginning, but included the critical aspects of business. Today, BSC is a system, or a methodology that transforms the mission, vision and strategy of the organization into a comprehensive cluster of selected measures that secure a framework for strategy implementation. It is used for the transformation of organizational strategic goals to performance indicators.

For the company to accumulate the knowledge necessary to achieve its goals, measurement of Key Performance Indicators (KPIs) is obligatory. Measuring and reporting in the Balance Scorecard concept are done through Key Performance Indicators in light of certain perspectives that include different key processes in

business. These are, originally (Kaplan and Norton, 1999 [2]) financial perspective, buyers perspective, internal processes perspective and learning and development perspective. Due to different views on the measuring problem and success rating additional different measuring methods were developed such as the Balanced Scorecard (BSC), System of 20 keys, Six-Sigma models, TQM, etc. Lately, the Balanced Scorecard has become the most used model due to its rationality and reliability. It tracks an optimal number of key characteristics, whose selection comes from the vision and strategy of the company. The research (Kaplan and Norton, 2001 [3]) has shown that the BSC, in comparison to other models, is mostly directed to the results and nearest to the consumer. It is easily connected to other tools for success measuring that are used in the company.

Various researchers are trying to determine a set of quantitative measures which would be used for advanced control of software product development processes, which includes the initiation and control of implementation of improvement programs. Wang et al. 2006 [4] proposed a set of measures developed on a case study from industry. Abran et al. 2004 [5] give an example of modern methods for measuring the performance of the company with a proposal for the effective processes management to achieve business excellence. Management based on quantitative data is one of the conditions of a higher level of maturity in the organization and the management model based on the International Standards Organization, stresses the importance of quantitative measurement and management processes. A piece of evidence for the importance of quantitative measurements, for example, in developing software programs is the fact that Software Engineering Body of Knowledge, SWEBOK (as one of the standard references for software engineering), plans to introduce a special area of knowledge dedicated only to measurements. New starting point in developing models for measuring key performance indicators of the company is a concept given by Kaplan and Norton, 2011 [6], which stems from the vision and strategy of the company, and which is essentially a balanced model of corporate governance, target performance and their criteria, based on financial and nonfinancial "perspectives". Model for measuring key performance indicators in a particular company (Djuric et al. 2010 [7], Djuric et al. 2013 [18]) was developed as a part of a quality management system. Garengo, 2009 [8] contributes to the understanding of performance measurement systems (PMSs) in small and medium companies (SMEs). The paper proposes a framework for the classification of PMSs and shows how it can be used to study the PMSs, and it is adopted by a group of leading Italian SMEs. Skibniewski et al. 2009 [9] deal with key issues in the enterprise resource planning (ERP), and systemic application used in the construction industry. Gongbo et al. 2011 [10] and Radujković et al. 2010 [11] identified KPIs to measure performance management in construction industry.

3 THE ANALYSIS OF PROCESS PERFORMANCE

3.1 Procedure to Analyze Process Performance

Process performance is a set of data which in accordance with the scope, subject and time of observation, fully describes the state of the process - its effects and which provides objective information in the form of descriptive or numerical reporting parameters.

Key performance indicators (KPI) are quantified performance measures of the organization - its goals. The process of processes performance analysis, in general, consists of actions shown in Fig. 1.

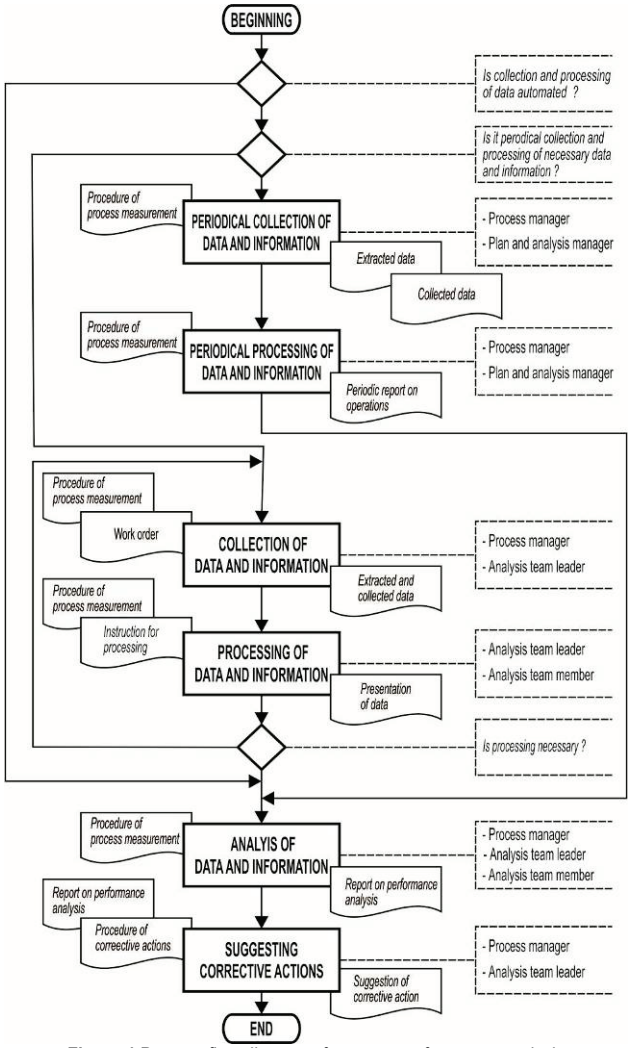

Figure 1 Process flow diagram of process performance analysis

Process flow diagram of process performance analysis, shown in Fig. 1, is described in detail in Djuric et al. 2013 [18].

3.2 A Review of Business Requirements

The subject of case study in this paper is a large company with over 1.000 employees, whose core business is the exploitation of mineral resources (bauxite, silica sand, zeolite and others). Besides the core business, the company is engaged in engineering, construction, transport of goods, passenger transport, wood processing, tourism, trade etc. The detailed structure of company processes is given in section 4.1 of this paper, in Fig. 5.

The company's goal is to improve its information system for more efficient and effective planning, organizing, implementation and control of business processes by developing a specific client application Portal for business processes performance management.

Monitoring of the processes performance will be used as an incentive for continuous processes improvement. In this paper, supply and sales processes were selected for monitoring because these are the primary processes of company. System should generate the performance of business processes - defined key performance indicators (KPI) used by organization's management for measuring improvements in achieving startegic goals. KPI should correspond to the nature and size of the organization and its products/services, processes and activities.

One or more KPI can be defined for one process, in order to ensure information that is measurable, accurate, reliable and useful. They are used for the implementation of corrective actions when performance is not consistent with the objectives, or to improve the efficiency and effectiveness of the process. The following key performance indicators were defined, for selected processes of supply and sales in the company:

The supply process:

- *IQSU* - Index of quality of supply,
- *IRO* - Index of submission of requests for offer,
- *ISO* - Index of submission of supplier's offer,
- *ISD* - Index of supply delays;

The sales process:

- ISC - Index of success of contacts with customers,
- ISOB - Index of submission of offers to the buyer,
- IDD - Index of delays in delivery,
- IQSA - Index of quality of sales.

The system should provide an overview of the process KPIs in a defined period of time (month, quarter, year). Access to informations should be limited in accordance with the authorization of a system user. It is necessary to use data from an existing integrated information system (ERP). The system should be implemented as a SOA solution with the use of *Silverlight* technology. A web portal should be created for the interaction between user and system.

4 THE ARCHITECTURE SOLUTION

4.1 The Solution Basis

Based on the business requirements, the scope of the system and its relationship with the environment is defined. Conceptual architecture given in Fig. 2 is a service-oriented vision of the system, at the highest level, which is the basis for construction of services for the process performances analysis and future applications.

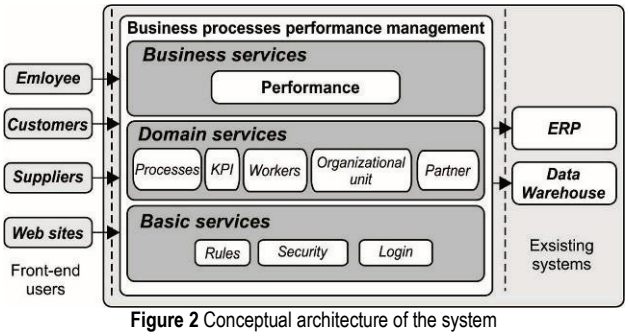

Figure 2 Conceptual architecture of the system

At the entrance of the system are potential users: employees, customers, suppliers, etc. In the central part is the initial set of services that should enable business processes performance management and which are divided into three groups: business services, domain services and basic services.

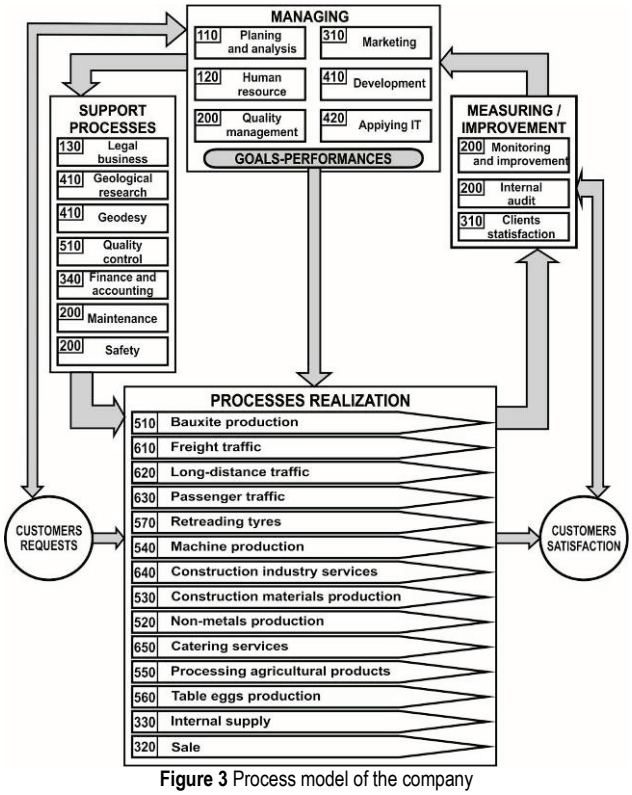

Figure 3 Process model of the company

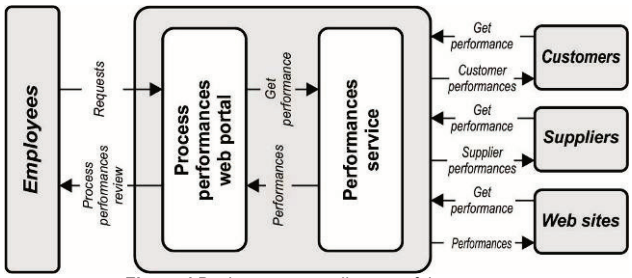

Figure 4 Business context diagram of the system

The first step in building business architecture is to define the value chain of the company, based on the company's process model (Fig. 3).

The second step in the business analysis is to build a conceptual architecture of the system that identifies the major participants in the company's value chain. Business context diagram of the system is shown in Fig. 4.

4.2 The Architecture of the Software Solution

One of the requirements is that the service *Performance* supports corporate *n-tier Web* portal. It is shown in Fig. 5 how the service *Performance* fits into the *n-tier* architecture.

The scope of the system for process performance management is determined by solid lines, and the boundaries between layers are represented by dashed lines. Presentation layer is implemented as *Silverlight Web* portal.

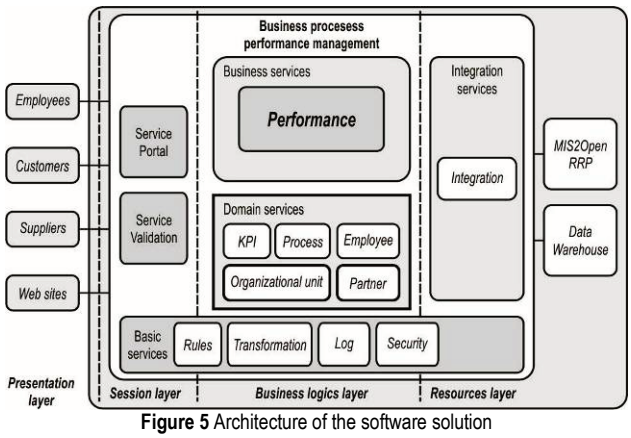

Figure 5 Architecture of the software solution

Software solution also defines the security aspects - authentication, authorization, confidentiality and integrity.

User *authentication* is done at the *Web* portal via *WS-Security SOAP* messages. When interacting with the service, customers and suppliers confirm their identity, which is secured using *SSL or VPN* connection. This approach meets the current authentication requirements and takes care of future requirements.

Authorization is provided by using mechanisms of roles and rules. The basic rule is that employee who uses the system has the ability to view data related to the organizational unit to which he belongs, and to subordinate organizational units. Customers and suppliers, through the potential future use of the system, will have the ability to view data related exclusively to the business transaction in which they participated.

Confidentiality is ensured with a minimum impact on performance. The eventual use of the system by customers and suppliers is secured by the data encryption. For these purposes *SSL and VPN* connection provides *"end-to-end"* data confidentiality.

Integrity, as such an important security aspect, is secured by using the *WS-Security SOAP* messages, or *SSL* or *VPN* connections.

4.3 Designing of DW *(Data Warehousing)*

A methodology that includes the following steps is used in designing *DW (Data Warehousing)* database:

4.3.1 Identification of User Requirements

The process of making *DW* database is limited to, on the one hand, the needs and expectations of information user, and on the other hand, to the availability of data from operational database and other sources.

In order to identify the users' needs, interviews of the users were conducted in the company to find responses to the following questions:

- based on which indicators users make decisions,
- what level of detail of these indicators is needed and how they are calculated,
- to which time intervals these indicators are related,
- what affects the size of these indicators and
- which business factors largely affect these measures?

Based on the results of interviews the following general elements are established:

- list of Key Performance Indicators (KPIs) for all processes in company,
- method for calculating the size of each KPI, with the necessary inputs and places of their generation,
- frequency of KPIs analyses and reporting, which is set for weekly, monthly and yearly period,
- criteria, in the form of limiting values for KPIs, which generate the need to take improvement actions.

Details on the structure of KPIs are displayed in Djuric et al, 2010 [7], Djuric et al, 2013 [18].

4.3.2 Logical Design

Logical design of *DW* database is conducted by Kimball/Ross mehtodology (The Data Warehouse Bus Archittecture - DWB) (Kimball and Ross, 2006 [12], Kimball and Caserta [13]) in the following steps:

- Determining the collection of related facts *(Data Mart)* and associated fact tables,
- Identification of the performance‘s dimensions,
- Preparation of the initial *DWB* architecture,
- Designing facts relation schemes and dimensions of process performance,
- Integration and
- Performance adjustment on the logical level.

4.3.3 Design of Data Mart and Corresponding Fact Table

Data Mart is a collection of related facts that are used together. Each *Data Mart* contains at least one fact table. For each fact table, the level of detailness of data on business factors is determined and is reflected on the lowest unit of the time dimension.

Data Mart Performances are presented in Tab. 1 and include, in the respective phase, only one fact table.

Table 1 Data Mart Performances facts

Data Mart	Table of facts	The level of data detailness
Performances	Key performance indicators	The process performance by months, organizational units and employees

4.3.4 Identification of Dimensions

Based on the level of data detailness from the fact tables and identified user requirements, the identification was conducted to identify dimensions of process performance. For each business indicator (the fact), one dimension is defined.

The identified dimensions in the company are shown in Tab. 2.

Table 2 Data Mart Performances dimensions

Data Mart	Table of facts	Granularity of data
Performances	Key performance indicators	Year, quarter, month, sector, organizational unit, employee, process, KPI

4.3.5 Designing Facts Relation Scheme

Development of dimensional model for *Data Mart Performances* is divided into two parts.

The first is designing fact relation schemes and the other is designing dimension relation schemes.

Designing of the facts features is conducted with the activities: identifying facts features, identifying the source (usually an operational database) and the definition of the algorithm for facts calculating.

For the *Data Mart Performances* the following measures shown in Tab. 3 are identified, including a description of semantics, data source and methods of calculation.

Table 3 Data Mart Performances calculation

Fact feature	Description	Method of calculation	Source of data
ser_num	Serial number	It automatically generates	-
year	Year for which analysis is performed	Retrieves from the given parameters	Object of class *Performance*
quarter	Quarter for which the performance analysis is performed	Retrieves from the given parameter	Object of class *Performance*
month	Month for which analysis is performed	Retrieves from the given parameters	Object of class *Performance*
sector	Sector for which analysis is performed	Retrieves from the operational database	Column *code_org_unit* from table *org_unit*
code_org_unit	Org. unit for which analysis is performed	Retrieves from the operational database	Column *code_org_unit* from table *org_unit*
id_num	Identification number of employee	Retrieves from the operational database	Column *id_num* from table employee
code_pro	Process for which the analysis is performed	Retrieves from the operational database	Column *code_pro* from table *process*
code_KPI	Key performance indicator	Retrieves from the operational database	Column code_*KPI* from table *KPI*
rating	KPI rating	Calculates from the KPI's participation in appropriate scope	Tables *evid_supply, evid_sales, plan_cont* and *ERP*
data	Data on KPI	$data = \frac{\sum data * num\_records}{\sum num\_records}$	Tables *evid_supply, evid_sales, plan_cont* and *ERP*
num_records	Number of records from which to calculate KPI	Summarizes the number of items for a particular KPI	Tables *evid_supply, evid_sales, plan_cont* and *ERP*
ser_num	Serial number	It automatically generates	-

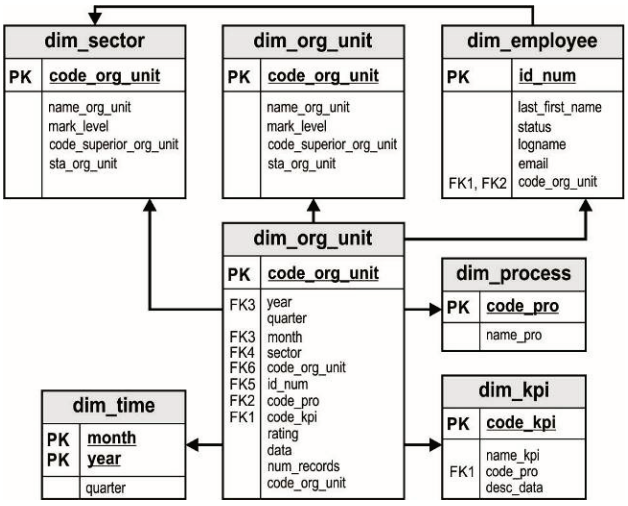

Figure 6 Fact table (Performance (fact_KPI))

4.3.6 Designing Dimensions Relation Scheme

In designing dimensions relation schemes the fact table (Fig. 6) is fully normalized, to store each unique combination of key of dimensions elements and with that combination calculates the corresponding values, without duplication.

Therefore, all facts are dependent only on the overall (foreign) key.

4.4 Development of *WCF* (Windows Communication Foundation) Service

Service storage, presented in Fig. 7, contains a broader set of identified services in comparison to the conceptual architecture. Service storage describes the main responsibilities of individual services, and it allows making decisions regarding the inclusion of new functions into the design and implementation of service in the future.

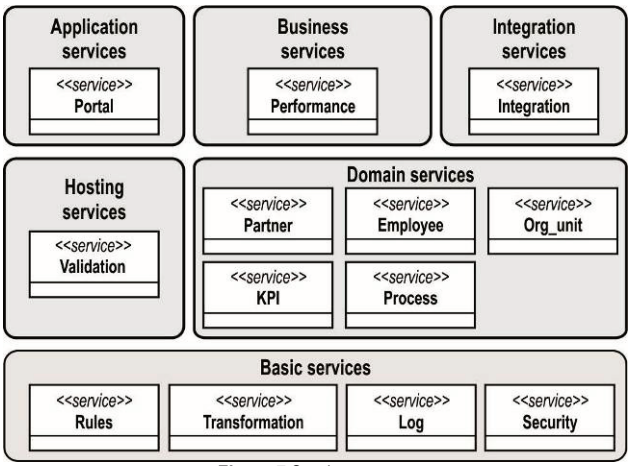

Figure 7 Service storage

The basic elements of WCF service from Fig. 7 are as follows:

- *Portal* - application service responsible for the separation of presentation, in this case the *Web* portal

from the service *Performance* and determination of the individual preferences of users and implementation of the logic on the individual user level. In this way it leaves the possibility to use all implemented services in the future customization of the presentation for other purposes;

- *Performance* - business service of the highest level, responsible to provide the relevant information about the performance of business processes, in accordance with defined parameters, at the request of service users;
- *Integration* - integration services responsible for accessing to all company applications and data, so that they can be used by other services;
- *Validation* - utility service responsible for validation of entered data and user requirements;
- *KPI, process, Org_unit, employee, partner* - the domain services which are responsible for providing relevant data corresponding to one or more domain entities;
- *Rules, Transformation, Logging, Security* - basic services responsible for: providing information about the current rules, transformation of data, controlling of user activity, and ensuring security.

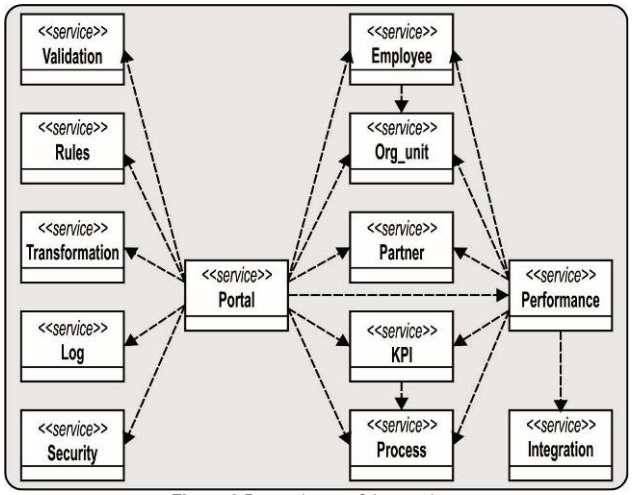

Figure 8 Dependence of the services

In service interface designing a great attention is paid to the degree of dependency between services. In regard to this, the simple service interaction is designed with minimal dependence, whereby certain groups of services, such as service entities and basic services, remained independent of other services, in order to have great potential for other uses (Fig. 8).

In the applied application *WCF* service is designed by separation of the application code and configuration file, as a way of more flexible approach in which three steps were used: defining the service contract, defining the *endpoint*, and service hosting (in order to receive messages), Löwy, 2007 [14].

Without influencing the generality of solutions, service *Performance* is applied to measure the KPI of two processes - *supply* and *sales.*

The service is developed in *Visual Studio 2010 SP1* developing environment as *the . NET WCF* service (*Performance.svc*) by using the *C#* language, with separation of the source code and configuration file (*Web.config*).

Detailed instructions for measuring KPIs of supply and sales processes, which are applied in the *private* methods individually for each defined KPI, given in Schmitz et al [15], Busi, 2005 [16] and Rodriguez et al [17].

Methods *InputUpdateFactKPI* and *PrepareFactKPI* perform automatic entry into the fact table *fact_KPI* for process performances that resulted from the operation *GetPerformance.*

Calling methods *GetPerformanseFromFactKPI* run queries that take adequate process performances from the fact table *fact_KPI* which are loaded in the application *Portal,* giving a review of KPI in a defined time period, including the possibility of overview of KPI for individual organizational units, employee and partner who were involved in the implementation of business processes.

Integration service is the service responsible for the access to existing company data, operating base of *ERP system* and designed *Data Warehouse* base *DW.*

4.5 Development of *Silverlight* Application *PORTAL*

Silverlight Web portal was developed in *Visual Studio 2010 SP1* environment, using *C#* programming language for programming *"code-behind"* classes and *Silverlight* technologies. The *Form-based* authentication is applied by using the *WAT (Web Site Administrative Tool)* to create user accounts.

Users *login* to the *portal* is implemented using the *Login* control.

Reference and finding *WCF MEX* service *endpoint* is solved by using the *Add Service Reference (ASR)* tool from the developing environment *Visual Studio 2010 SP1.*

Finally, *Silverlight Web* portal allows users different views of graphs and tables with KPI ratings of supply and sales processes. *B*y calling *Submit* the service *Performance* is called*,* which calculates and returns the process performance data to *Web* portal, in accordance with defined parameters, and results are presented in tables and graphs. Both displays are updated by selecting *Data* or *Ratings.* Review of informations is limited with the personalization of content, in accordance with positions and authorizations of system users.

Four reviews of the obtained processes performance are possible: review of KPI during the specified time period and by months, review of processes ratings during the specified time period and in parallel by months, including the possibility of obtaining these views for individual organizational units, employee or a partner, who were involved in implementation of business processes. Also, it is possible to view KPI's of only one process or the review of only one particular KPI of process.

Key performance indicators of supply and sales processes in observed company are shown in Figs. 9 ÷ 14.

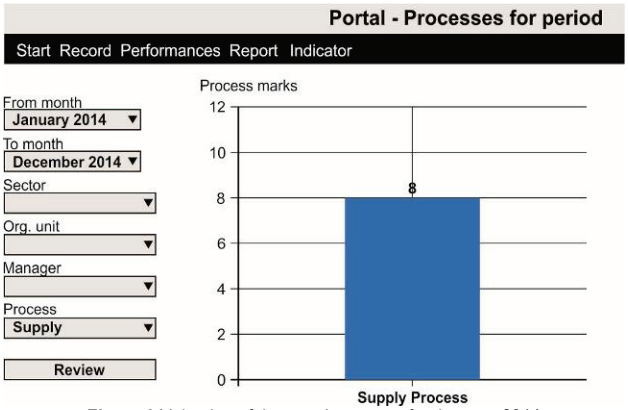

Figure 9 Valuation of the supply process for the year 2014

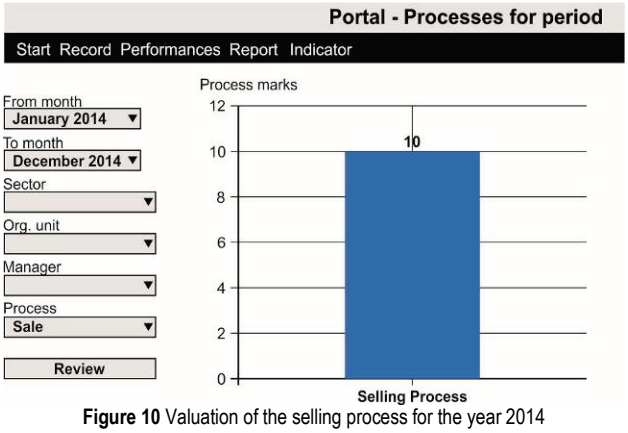

Figure 10 Valuation of the selling process for the year 2014

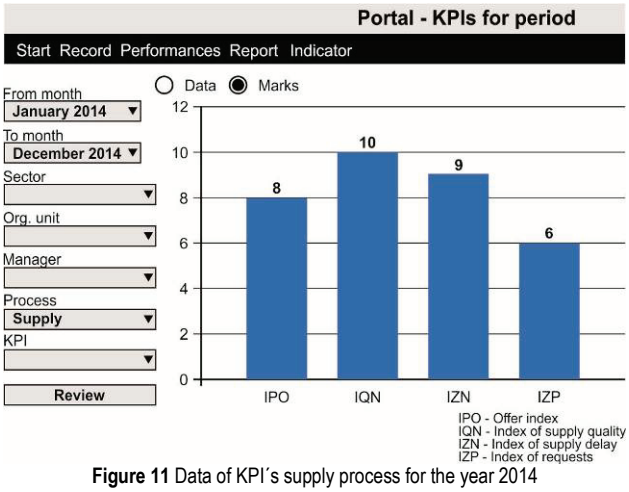

Figure 11 Data of KPI´s supply process for the year 2014

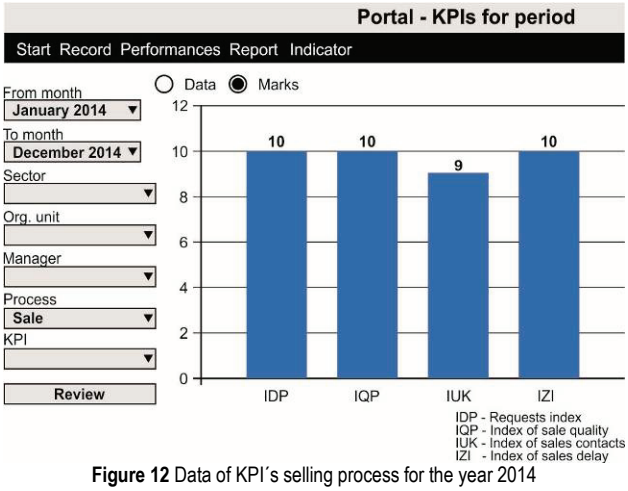

Figure 12 Data of KPI´s selling process for the year 2014

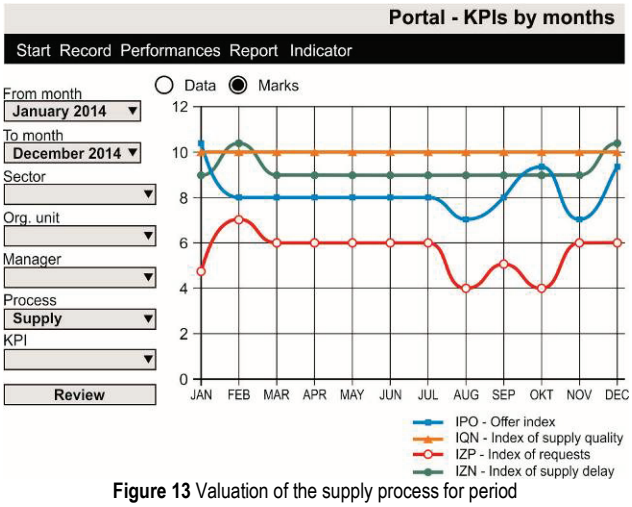

Figure 13 Valuation of the supply process for period January - December 2014

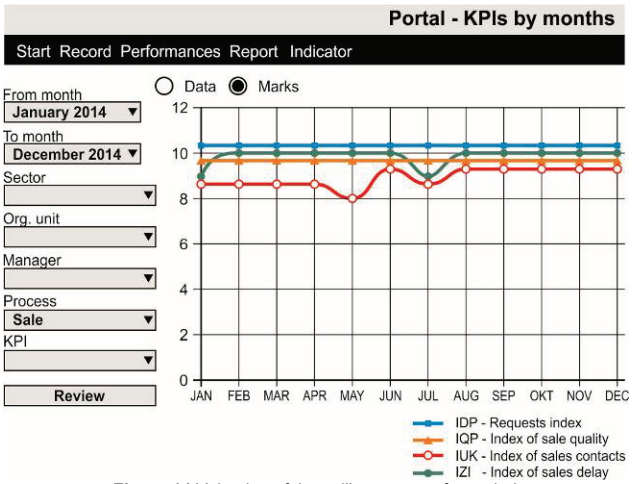

Figure 14 Valuation of the selling process for period January - December 2014

5 CONCLUSION

Automation of process performance management allows efficient process performance analysis in the company. Automating the collection and processing of necessary data and information in the company provides more accurate, more complete and more up to date information necessary for keeping records on the business processes, especially if these records are governed by appropriate procedures. Thus, performance measurement process focuses on a certain period of time and performs more effectively, it enables analyzing the results and efficient way to resolve inconsistencies with the goals of process improvement.

The analysis of process performance, i.e. key performance indicators (KPI) as described above, may allow timely determination whether the processes are implemented according to specified requirements and objectives of the company as well as processes capability to achieve planned results.

Performance measurement based on KPI is the basis for successful management of business systems. Without the proper metrics, such as KPI, it is not possible to properly assess the quality of processes and make decisions for business processes reengineering in order to improve their effectiveness and efficiency.

Applied solutions presented in this paper directly link IT resources with business goals of the organization, helping the organization to build connections with customers and suppliers, and internal links of organizational units, allowing more accurate and more complete business information, crucial for making quality decisions, and at the same time supporting key business processes through the increased availability of information which significantly influence increasing the total effectiveness of the company.

The case study presented in this paper is limited to the purchase and sales processes in the respective company, because the main goal of the paper was to demonstrate the way of functioning of the programming tools to automate performance management processes. In actual, practical cases, the processes of performance management are subject to all the processes of the company.

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