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Real-time Business Process Intelligence. Comparison of different architectural approaches using the example of the order-to-cash process.

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Abstract. Business operations are becoming more and more integrated with the real-time intelligence. Core business activities are being carried out through OLTP systems that provide limited monitoring capabilities of the running process instances. The article shows how to turn the gap between the classic transactional system and the process-centric approach into an organization that provides more accurate and faster decisions on the strategic and operational management levels. This study aims at determination of what kind of information can be retrieved during the process execution and it tries to identify the need for the real-time process intelligence on the example of the order-to-cash process. Furthermore, we compare two architectural approaches of the real-time process intelligence monitoring system. The proposed frameworks retrieve process data from the ERP system in order to record crucial performance indicators on a real-time basis with the use of the in-memory technology.

Keywords: Real-time business process intelligence, intelligent business operations, process management, order-to-cash process, SAP HANA.

1 Introduction

The pace of business continues to accelerate in a way that decisions based on real-time information have become a competitive advantage and up-to-date information is really required by many business practices, ranging from just-in-time inventory to operational business intelligence [1]. Nevertheless, Business Process Management systems have become very popular in the last decade, most of the core business activities are still being performed through transactions in the OLTP systems that provide limited monitoring capabilities of the running process instances [2], [3]. Several years ago most companies were focused on the standardized reporting, historic trend analysis and forecasting, now the point of interest is being shifted to the analytics that may be applied within business processes [4].

However, there are two general challenges in the implementation of real-time analytics into business processes that are discussed by many academic researchers and business users.

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The first challenge is that there is still no de-facto technology standard that can be used as a benchmark for business process intelligence (for example as data warehouse for the business intelligence). Most researches consider application of the process intelligence approaches to the Business Process Management Systems (BPMSs), thus identification of such an architecture and technologies is still a challenge that requires more attention.

Secondly, many researches discuss the need for real-time insights into the processes, often providing some examples of how a certain functional area or a company succeed with the implementation of the real-time analytics, but the conceptual understanding of what real-time process information is needed by business is still missing.

Researching the general challenges of business process intelligence the paper seeks to find the answers to the following research:

(RQ1) What process-related information and process performance indicators can be and should be monitored in real-time (through the example of the order-to-cash process)? What order-to-cash process-related information is currently gathered?

(RQ2) How can this process-related information (RQ1) be technically realized via Process Intelligence approaches through the example of the SAP software? (Two approaches are taken into consideration: SAP Process observer architecture and In-memory computing technology – SAP HANA Operational process intelligence).

The paper is structured as follows. The next part specifies the research method that is employed in this study. Afterwards the current state of the real-time process intelligence is dwelled upon. The results of the study follow in the part three. Real-time information needs for the order-to-cash process are discussed with process owners and consultants from different industries; and order-to-cash process related information needed to be addressed in real-time is defined. Except for the interviews the practical part of the paper includes implementation of the requirements named above via two business process intelligence approaches: direct transaction monitoring on the top the ERP system and in-memory technologies of SAP product pallet. The last part of the result section includes description of the real-time process intelligence platform architecture and advantages and disadvantages of both approaches. Lastly, the paper provides the discussion, some further research areas and the conclusion.

2 Research Method

In order to investigate chosen topic literature review was conducted. On the one hand the as-is situation of the process intelligence approaches was analyzed, on the other hand – the order-to-cash process and its KPIs. The output of the research should define what process-related information needs to be monitored in real-time to provide process visibility and decision support on strategic and operational levels. Literature search is divided into two different spheres – business process intelligence and order-to-cash process KPIs. Watson et al. [5] suggest that search should be started in the leading academic journals. However, the topic under consideration is rather new and practice-oriented, thus the literature search was conducted in terms of scientific da-

tabases as well as reports and success stories of the leading consulting, advisory and research companies in the sphere of information technologies (Gartner Group, Accenture).

The next step of the present research is interviews with experts, consultants and process owners. The aim of these interviews is to find out practical relevance of the determined process-related information and to refine it on basis of practical experience. Afterwards the defined information requirements for the real-time monitoring are implemented through the two process intelligence approaches. The SAP products are chosen to build the demo solution. SAP Operational Process Intelligence (OpInt), SAP HANA Platform and SAP Process Observer are under observation. The design phase involves the development of a process KPI model in the ERP system, design of the Graphical User Interface (GUI) and order-to-cash process monitoring on top of a HANA-based SAP ERP System.

The profiles of the interviewed companies and contacted persons are represented below (Table 1).

Table 1. Profiles of the interviewees

Interview	Industry	# of employees	Interviewee position
A	Business Consulting	n.a.	Senior Business Consultant
B	Business Consulting	n.a.	Business Consultant
C	Business Consulting	n.a.	Senior Business Consultant
D	Research, development, manufacturing of the pharmaceutical products	47.000	Team Lead of the Procurement Construction and HVAC
E	Producer of luxury cut lead glass	25.000	1st Interviewee: IT Manager Center of Excellence, department Business Intelligence 2nd Interviewee: IT responsible for purchasing 3rd Interviewee: IT responsible for sales and distribution
F	Producer of optical instruments	24.000	Controlling BioScience Manager
G	Producer of the electrification systems	650	Head of the Process management and SAP systems

The employees from different management levels and functional areas are interviewed: workers of the logistic department, managers of the departments involved in

the order-to-cash process, IT department that supports order-to-cash process management, the leader of the procurement.

The questionnaire pursues several objectives defined on basis of the three parts.

The first part includes general questions about the organization where the interviewee works. This information is essential to compile a profile of the potential companies that have a need in real-time process intelligence. The questions of this part include information about business model, size, products, clients and organization of the business process management department.

The second part is concentrated on the analysis of the order-to-cash process in the company, whether the whole process or its parts are modelled and how, what the ways to find the process improvement potential are, whether the whole process is being monitored or not. After the analysis of this part, the order-to-cash process model and corresponding key performance indicators extracted from the literature review are refined and generalized on basis of the experience of different industries.

The third part is concentrated on the real-time aspects of the process monitoring. In this part we are trying to find out what managers understand under the term "real-time" applicably to their everyday activities. The aim of this part is to find out whether the process owners see the need and value in the process monitoring in real-time.

3 Research Background. Business Process Intelligence: state of the art

The importance of the process visibility at all levels in the company is proved by many authors [1], [6], [7], [8]. The ability to respond quickly to business events in real-time is a crucial factor that allows companies to effectively manage competitiveness and profitability in today's business environment. To improve process intelligence new tools that could provide such functions as analysis, monitoring and optimization of the business process are demanded. This collection of tools is referred [9] to as a set for Business Process Intelligence. Current ERP systems provide a limited set of schedules operational reports for recent business events and there is no support for ad-hoc queries. ERP systems are not designed to provide real-time reports to massive users and cannot facilitate the decision support function. Most of the existing business workflow and business process management systems can be helpful for the purposes of process monitoring and can visualize this process during runtime. At the same time calculation of the Key Performance Indicators (KPIs), monitoring the duration time and alerts based on KPIs is not possible directly on the data from the classical ERP system.

Data warehouses [5] focus on providing strategic decision support, and as a result, along with the development of real-time technologies, decision support has expanded to the tactical level to support operational decisions. Significant amount of data and information remain either unused or mostly detached from their interpretation context because data analysis and information retrieval capabilities are commonly isolated from the process execution and occur rather concurrently [3]. In regard to the traditional business intelligence approaches, it is worth mentioning that the time stamp of

the information in the warehouses is very different depending on the type of data and on the latest update.

Introduction of the process intelligence approaches and techniques changes the improvement cycle of business process in a way that the outcome of the process on a certain step of the execution will be monitored in the real-time and improvement will be implemented right in time rather than the outcome of the process execution will be monitored upon the whole.

Significant research has been done on different aspects of BI technologies during the last decade. Previous works address a wide scope of different BI aspects, some authors discuss how BI systems can pull the data in ERP and perform different analysis [10], how to combine data warehousing and workflow systems [11], while others talk about operational Business Intelligence concept [12], [13] case-handling BI [12], event-driven BI [14]. Real-time BI is associated with the data warehousing technologies by many authors. Farooq [15] discusses the architecture that provides data that enables real-time or near real-time data warehousing for business intelligence. However, hardly any researches provide proof for the need of the real-time data and consider process-centric approach.

Grigori [9] addresses the existing challenges of the Business Process Intelligence solution development introducing the architecture and technologies that offer capabilities of analysis, prediction, monitoring, control and optimization for the business processes. Along with the Business Process Intelligence concept, there is process-centric business intelligence defined [3] as "all BI capabilities that are dedicated to analysis as well as to systematic purposeful transformation of business relevant data into analytic information and that have been, at the same time, embedded into an operational process". The level of its maturity and practical implementation of the process-oriented business intelligence is rather low at the moment, though.

ERP systems [16] have certain limitations in terms of the business processes they can model. However, analysis of the possibilities of the real-time process monitoring of the ERP systems that provide infrastructure for the integration of all business operations consolidating the information flow across different departments is missing.

Overall, this topic may appear to be controversial. On the one hand, a significant research has been done about the process monitoring on top of the workflow management systems and about application of the traditional business intelligence within the process-centric approach. On the other hand, there are few, if any researches concerning real-time business process intelligence approaches on top of the ERP system or using in-memory technologies, which certainly underlines the importance of the present research.

4 Results

4.1 Order-to-cash process: as-is situation

Real-time business process intelligence is required in the organization where a fast reaction is a key factor in achieving the operational efficiency. There is still no

benchmark that can define the term "real-time". Some [25] understand this term as an activity that happens instantaneously, while for airline executives, for instance, [5] real-time is anything that happens within 14 minutes. According to the interviews, the meaning of the real-time data for the order fulfillment process varies from half an hour to one day. The term "right time" in this context emphasizes not the latency of data, but the business value of information.

As stated by many practitioners and academic researchers [7], [17], [18] and [19], in order to improve the supply chain and order management performance, information should be delivered in real-time. The order-to-cash process is a common process in almost every organization. The process starts with the creation of the sales order and finishes with the confirmation of the incoming payments from the customer. This whole cycle is normally involved in every organization that uses an ERP system.

Among all the companies considered few, if any have a Business Process Management department. Two companies out of four have Business Excellence departments, but those departments are limited to some extent to quality management and controlling or to monitoring and process support via IT systems.

Improvement potential of the order-to-cash process in most cases (as stated by 5 out of 7 speakers) is usually determined on basis of the internal interviews in teams on the usual terms (varying from once in two weeks to once in three months). Other two respondents rely on the reports from the BW and ERP systems that are tracked once in a month. Improvement potential still relies a lot on the subjective knowledge of the responsible people. Several of the respondents stated that they get most of the information about the bottlenecks of the process from the one-to-one "stand-up" meetings with employees. Other techniques apart from interviews include the analysis of the cash flow and some reports by the functional areas in the data warehouse, or combination with third-party systems data.

All the interviewees are working with SAP system. It is stated that all the steps of the order-to-cash process are brought into effect in different modules of the SAP OLTP systems. This is one of the reasons that the process is not visible across the company. Three out of four company representatives show the process model consisting of four to five basic steps, but such a model serves the function of comprehension of one's own activity. Therefore, just two of the respondents know where to find the information on the running process instances. Although some of the delivery, billing, order dates (creation, change) are available, there is no tool for the proper analysis of this data, which turns out to be another reason for this on-the-ground problem.

Additionally, six out of seven respondents confirmed that the main aim for them is to deliver the product to the customer in time, however, they do not put much emphasize on the order-to-cash cycle time. The reason for this is that finance department always stays behind all other departments that take part in the order-to-cash process, and no practices of the common KPIs are introduced.

As of now, the current situation in the companies shows that most of the companies do not distinguish between process real-time reporting and operational reporting. Some of the respondents claim that operational data needs to be delivered in real-time, but in most cases, this data is limited to the provision of the overview on the instance level only for a certain sets of departments. Interestingly, just one of the in-

terviewees has an overview of the whole end-to-end process from the order to the invoice creation. Indeed, just two interviewees confirm that there is a single person in the company who is responsible for the whole process, but this position is yet more related to quality management or IT control.

4.2 KPIs of the Order-to-cash process

As stated by [21] there are four types of process measures: time, cost, quality and flexibility. The question is what KPIs are significant in the order-to-cash process and required to be addressed in real-time.

While some companies consider such a quality measure as a number of orders delivered in time and in full as one KPI, other use a number of orders delivered in time and a number of orders delivered in full. While some respondents state that the most important thing is to deliver the order to the customer in time, others put emphasize on the availability of the products in stock. These measures can be considered as quality measures of the process.

Process costs are not measured in any of the companies; in practice, some companies just use time-based costs depending on the activity type (machine, human task). Most of the companies have focus on the cost flows, which states the importance of the time between the start and the end date in order to get the invested cash back.

All the respondents confirm that they measure or would like to measure time of the process execution. However, it is not possible to discriminate between waiting and processing time.

All the respondents determine flexibility of the order-to-cash process as difficult to measure, and no practices of flexibility measurement have ever been introduced into the companies.

4.3 Process bottlenecks

In order to determine the improvement potential of the process in real-time, the aim of the questionnaire is to consider current problems in the order-to-cash process from different perspectives. The order-to-cash process bottlenecks vary based on the type of production approach and industry.

Respondents mention the following among the process bottlenecks:

- improvement of the non-value added activities in the part of logistic;
- number of orders that are out of the desired range; analytics is often insufficient to provide the decision about hiring new resources on a current stage of the process;
- orders delivered not in time and not in full: there is a wide variety of reasons for that, which can include customer, delivery blocks, credit hold, certain logistic reasons, etc;
- product configuration: the client knows nothing about the technical configuration from the very beginning.

The analysis of the order-to-cash process depending on the industry is often done on a regular basis and, as a rule, the quality measure of the percent of orders delivered in time and in full is observed. On basis of the data provided, a certain amount of the worst orders is analyzed to confront the problem. Almost all the interviewees stated that such an analysis should be done more often, and more intelligence is required to recognize the problems automatically, otherwise the process of problem recognition is usually done via checking different transactions.

4.4 Real-time information of the order to cash process

This section addresses the first research question, and being based on the literature review and interviews with the business representatives, it suggests what information is needed for the real-time order-to-cash process intelligence.

The research established that there is no common understanding of the real-time process intelligence. Interestingly, the definition depends on the position of the speaker. For the employees from the certain functional areas it is enough to use the functionalities of the standard operational reporting, while for the process owners it is important to have the full functionality of the business process intelligence platform that will enable the holistic process overview.

All the findings of the interviews and the research summarized, the following need for the real-time process metrics is determined in relation to the devil's quadrangle [21] (Table 2):

Table 2. Need of the process KPIs in the real-time Process Intelligence

		As-is in companies (based on the interviews)	Need for real-time process intelligence
Time	processing time	√	√
	waiting time	x	√
Costs	fixed costs	√	x
	variable costs	√	x
Quality	internal	√	x
	external	√	x
Flexibility		x	x

The outcome shows that in real-time only processing and waiting time can provide the process owner with the information that will allow him to act in a timely fashion.

Based on the literature research and conducted interviews, process-related information that needs to be represented in the real-time process intelligence is incorporated in a diagram (Fig. 1).

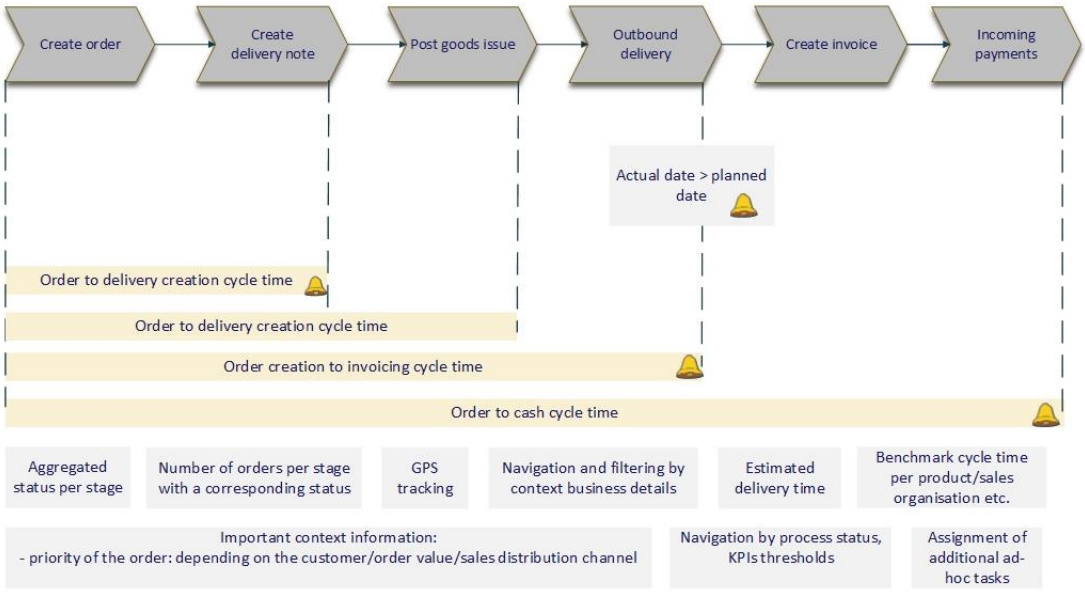

Fig. 1. Order-to-cash process information needed in real-time

Along with the visibility of each process activity, the following data is desired to be accessible in real-time:

- definition of process activities, phases and milestones, time measures;
- aggregated and instance level process indicators: to track separately process phases, milestones and instances;
- definition of the threshold values to enable alerting functionality;
- status of the phases and information with the number of instances pro stage with a certain status (for example, running, finished, exceptional);
- prediction regarding estimated delivery date;
- status of the current stage: whether the quality acceptance testing is carried out, middle payment terms are fulfilled, or the technical requirements for the new product are correctly interpreted, etc.;
- possibility of the third party information integration, as the example – GPS tracking of the delivery;
- direct assignment of ad-hoc tasks;
- subject- and context-oriented information that renders navigation and filtering across the model: sales organization, customers, products, suppliers, priority of the orders, etc.

4.5 Real-time process intelligence approaches description and comparison

To make the considered approaches clearer the general architecture of the Business Process Intelligence solution, based on the examples on the architectures from theory [9],

[14], [20], [21], [22], [23], [24] and implementation of the determined requirements for the real-time process intelligence of the order-to-cash process, is outlined. Basically, it consists of two layers: process execution and process intelligence. Process intelligence layer consists of three sub-layers: process warehouse, process intelligence definition and process intelligence user interface (Fig. 2).

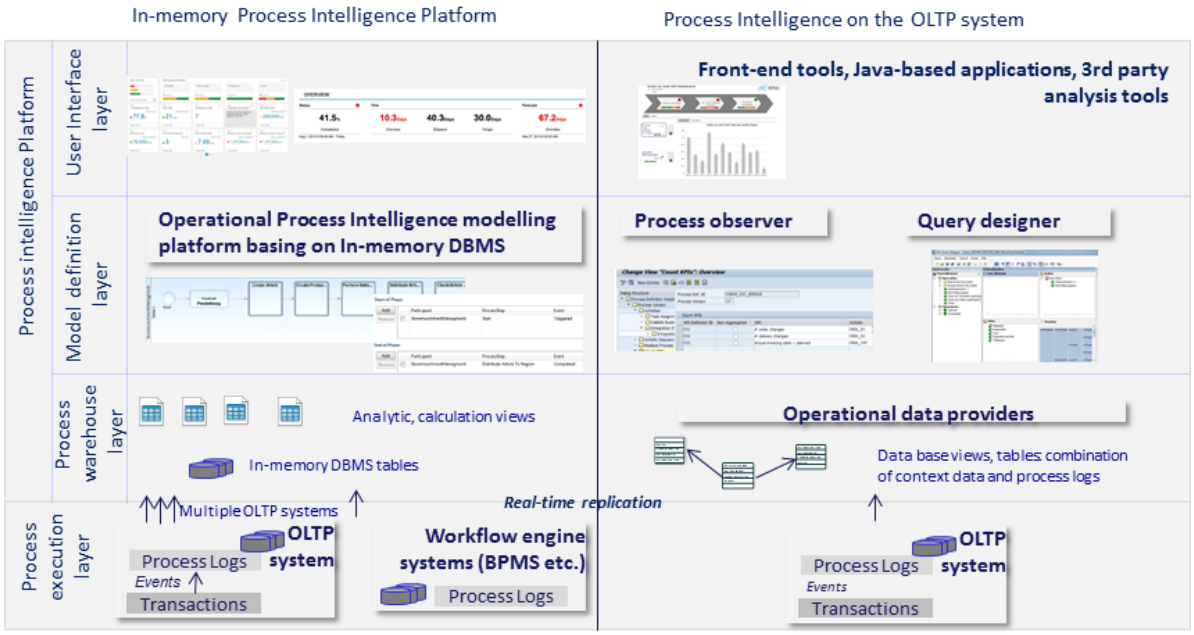

Fig. 2. Business Process Intelligence Platform architecture

Process Execution Layer:

On this level, events relevant to a certain business process are executed and process logs are created. This level offers limited monitoring possibilities. In case of the direct monitoring on the OLTP System with the use of Process Observer SAP EPR, CRM and non-SAP events can be tracked, while for the second option (Operational Intelligence on SAP HANA), additional processes can be combined also with SAP BPMSs and other non-SAP workflows.

Process Intelligence Platform layer:

Process Warehouse Layer:

On this level, data management of the process logs and the business data required is conducted. Here the real-time replication of tables from the source systems is performed.

Model Definition Layer:

- definition of the business scenarios that includes definition of the process flow, milestones, and process activities is conducted on the level of process intelligence definition;
- free definition of KPIs: Process KPIs and business KPIs including target values. In the case of process intelligence the difference is that duration, count and classification KPIs are defined on the level of process execution;
- correlation of the process log data with business data;
- definition of filtering and navigation steps.

Process Intelligence UI Layer:

- operational monitoring of ongoing process instances;
- analysis of completed process instances in the aggregated form;
- filtering and business data search capabilities over the process instances (for example, search for a material, sales organization, etc.);
- presentation of KPIs;
- task management: creating tasks for process participants;
- checklists: creating adhoc tasks for process participants;
- visualization: phases, milestones, process steps;
- alerting customization for a certain KPI**.**

SAP Process Observer

Process Observer is a part of SAP Business Suite. Process observer model is not the same as the process model in the BPMSs. While BPMSs have a workflow engine and are dedicated to the modelled processes, in Process Observer business object repository events are used to track the execution of a process. This tool responds at runtime on the events that have been previously allocated to an activity of a workflow model. Alongside with the activities like “create an order”, “deliver an order” such a process model can also embrace activities like “change the order”, “change delivery”, “billing block”. As soon as a new start event executed, a new instance of the workflow is generated. The process log is being generated on basis of the running and executed instances. Analysis in the Process Observer is limited to the instance level; aggregated analysis is not possible.

SAP Operational Process Intelligence

SAP Operational Process Intelligence is an application based on the SAP HANA database. SAP HANA is a combination of hardware and software that has been designed as a database technology [4]. In SAP HANA a hybrid model is used, with both row- and column-oriented data storage available. On the hardware side, it comes to the use of the memory as a storage location for the data. SAP HANA has no reporting functionality. To create reports based on the data in SAP HANA, a BI application, front-end tools (such as SAP Business Objects BI) must be used additionally. Indeed, SAP HANA has no predefined data structures. The data structures must be modelled with SAP HANA Studio. There are two types of views exist - analytical views (analogy to OLAP cubes) and calculation views (for more complex functions and joins

over multiple fact tables). The data is loaded into SAP HANA from source systems. In the present study the SAP ERP system based on the in-memory database is used as a source system. This option allows combining OLTP and OLAP scenarios within a single system.

This approach provides the visibility of the order-to-cash processes alongside with different departments. It allows monitoring ongoing processes, provides operational decision support in real-time, makes required context information available for the user as well, and provides the analysis with aggregated views for both running and completed processes. Orderly integrated task management capabilities allow creation of ad-hoc tasks and execution of actions: notifications and take-off into transactional systems become possible. It allows many data exploration capabilities to get the insights into new business facts and future opportunities.

Design of the ERP systems offers a generic approach to the process automation in companies, benchmarking the processes for different industries. Therefore, new activities and process designs are very often evolved in practice, which requires the need to configure predefined models in the ERP system. Standardized processes cannot be used to create competitive advantages for a company and additional case handling is needed very often. When considering which approach to choose the company should first understand the business needs and strategic development, whether the occurrence of ad-hoc tasks is high or not. In case that process flexibility in this way is crucial for the business, the second approach can be taken into perspective.

The last but not least factor is the project budget specified for the business process intelligence initiatives. As of now, most companies use their ERP system based on the RDMS. The project of moving the ERP system to the in-memory DBMS along with high implementation costs will lead to a huge amount of work related to data transformation. However, the management of the in-memory DBMS will decrease the total cost of the ownership in comparison with traditional relational databases in the long run.

5 Discussion and further research areas

Providing the right persons with the right information at the right time is an important factor indeed for an organization that aims at attaining and retaining its competitive advantage. That is why real-time business process intelligence means not a fast system response, but concentrates on the data that should be available when making a decision during process execution.

Significantly, technology goes now far beyond the traditional needs of the order-to-cash process participants. Through the emerging of in-memory technologies and possibilities of the analysis of unstructured data sources, new scenarios of the order-to-cash process should be developed, namely improving the existing process models by integration of web and application logs, customer call transcriptions records, GPS coordinates, mobile device logs and data from social channels.

Important factor established is the lack of knowledge regarding how the process could be improved with the real-time information. A partial reason for this is a frag-

mented process view that gives to the representatives of a certain business function limited view on their task area without presentation of how certain task performance influences other areas in the process chain and value creation. As an option, the reengineering of certain processes is required. As it is mentioned by Eckerson [25], the companies need to restructure business processes in order to empower the real-time decision-making, not just data analysis. The bottleneck is often the business user; therefore, retraining is also necessary in order to teach users how to benefit from the real-time data, new policies are to encourage workers to exploit the real-time data.

One of the findings shows that the implementation of real-time business process intelligence initiatives also require different strategic activities or, for instance, BPM initiatives need, first of all, to change process organization, traditional practices and company culture. The introduction of the real-time business process intelligence initiatives also requires altering minds of the practitioners. Therefore, further investigations of the cultural factors influencing the format of real-time improvements as well as the assessment of the ROI of the implementation of the real-time BPI solution is necessary.

Process intelligence model presented in the current research can be extended via combination of the resource availability system managing the waiting time and process throughput according to the Little's law in real-time.

In respect of forthcoming trend of the evolving "big and unstructured data", further research efforts could also have in focus customer data vital to be integrated in the business process intelligence framework to accelerate real-time actions in the process.

6 Summary

The research establishes that today companies struggle with being inflexible to monitor solutions and to respond to process information on time. Most companies today have a vision of the end-to-end processes, but due to the fact that this process is not defined with the explicit workflow engine, analytics of the whole process is missing.

Process-centric management approach has gained a lot of popularity over the last years. In order to manage the company's processes and operations successfully and effectively it is of utmost importance to receive information in a timely manner. While for some industries it is enough to get an insight into daily operations within several days, other require scalable and full data with rich analysis capabilities within half an hour or even several seconds.

The research demonstrates that real-time insight into processes is far from standardized nowadays. The study contributes to the existing body of knowledge in the sphere of business process intelligence and real-time business intelligence by suggesting what information is relevant to the order-to-cash process in real-time to enable process improvements rightly during process execution. Moreover, the paper demonstrates the application scenarios of real-time business process intelligence on the example of the RDBMS and in-memory DBMS. The present study goes beyond the identification of application scenarios by comparing limitations and weaknesses of

both approaches. Real-time process analytics means information about certain process performance indicators that allow having a holistic view upon the whole process, rather than upon the certain services or applications, as it is widely accepted in traditional business intelligence approaches.

In regard to the question of the process performance indicators, companies usually reference to the supply chain management reference model [26] or aim at tracking such KPIs as orders delivered in-time and in-full on a monthly (in average the most often) basis. This research finds out that not all the KPIs of the end-to-end process are needed by the companies to be analyzed in the real-time. The reason is that cost and quality measures depend further on the accuracy of the time measures and are not required for the analysis during the execution of the instances. These dimensions are usually analyzed in the form of the reports based on the historical data of the executed processes on the ground of the time span ranging from 2 weeks to several months.

These findings help to clarify the potential of the in-memory technology in the context of intelligence operations that require integration of multiple data sources, wide range of analytical features and high response time.

In short, the study uncovers some essential principles of the architecture that combines BPM and BI approaches. In addition to that, paper also addresses several shortcomings in the area of business process intelligence. Practically speaking, these include but are not limited to the lack of a common understanding of what are the business needs for the real-time process-related information.

The paper presents the architecture of the business process intelligence solution based on SAP ERP and SAP HANA in-memory database. While implementation of the first architecture approach proves to be a simple and efficient option, it only allows the definition of some standard process measures and changing them involves much effort of the additional software developments. The company should choose the approach based on the complexity of the process. If integration of many sub-processes and systems is needed as well as if the amount of orders and generated data has a tendency to increase then the in-memory data base should be taken into consideration.

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