



# Process-centric business intelligence

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## Abstract

**Purpose** – The purpose of this paper is to deliver an insight into the interaction effects of process-oriented management and business intelligence (BI).

**Design/methodology/approach** – The paper takes up publications from the fields of BI and business process management and analyzes the state-of-the-art of process-centric business intelligence (PCBI). To highlight the potentials and limitations of the concept, two exemplary use cases are presented and discussed in depth. Furthermore, a vision for the technical implementation is sketched.

**Findings** – PCBI is found to play an important role in an organization's strive for competitiveness. The concept's potential benefits are significant. However, the overall levels of adoption and maturity of the concept within real-world organizations appear to be rather low at the moment.

**Research limitations/implications** – The paper discusses solely two exemplary use cases – the most that could be done within the scope of a journal publication. Therefore, the explanatory power and the representativeness of the results need to be scrutinized in detail.

**Practical implications** – The paper highlights the practical significance of PCBI. It therefore represents a useful source of information for both practitioners and academics who are interested in improving the efficiency and effectiveness of an organization's information supply in support of its processes.

**Originality/value** – The paper motivates, describes, and analyzes the concept of PCBI. Furthermore, it provides examples of the concept's adoption and benefits from a practitioner's point of view.

**Keywords** Intelligence, Information management, Decision support systems, Process management

**Paper type** Research paper

## 1. Introduction and motivation

It cannot be disputed that information has become a major competitive factor in today's business world. Providing the right persons with the right information at the right time is of critical importance for an organization to both attain and retain its competitive advantage: "With the help of information system technology, a company can become competitive in all phases of its customer relationships" (Ives and Learmonth, 1984).

Information and communication technology aimed at supplying an organization's management with relevant information in order to stay ahead of its competitors has undergone fundamental changes since the 1960s. Different terms such as "decision support systems", "management information systems", and "management support systems" have been introduced (Gluchowski and Kemper, 2006). Finally, in the mid-1990s, yet another new term – "business intelligence" (BI) – was created in response to dramatic changes in the IT market, the growing IT support for business



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process execution, and the extensive, world-wide diffusion of internet technology (Gluchowski and Kemper, 2006; Anandarajan *et al.*, 2003). Since then, various stakeholders such as consultancies, software vendors, practitioners, and the scientific community have used the term rather vaguely to describe processes and systems dedicated to the systematic and purposeful analysis of an organization and its competitive environment (Bucher and Dinter, 2008).

However, a major shortcoming of the aforementioned approaches is that they do not allow us to associate data with processes (Gile *et al.*, 2004). Data analysis and information retrieval capabilities are commonly isolated from process execution and occur rather concurrently. As a consequence, a significant amount of data and information remain either unused or at most detached from their interpretation context.

Furthermore, traditional BI is primarily aimed at supplying employees at the management level of an organization with relevant information in order to support tactical and strategic decision making. In this context, it is a matter of fact that managerial tasks are less frequently organized by means of well-defined processes as this is the case for operational day-to-day tasks.

To overcome the aforementioned shortfalls of traditional BI approaches, concepts such as operational BI (Marjanovic, 2007; Chemburkar and Keny, 2006) and real-time BI (Azvine *et al.*, 2006; Watson, 2005) have been introduced. Although focus shifts from the exclusive support of managerial tasks to that of both managerial and operational activities, most of these suggestions still fall short of taking the process perspective into account (Bucher and Dinter, 2008).

The essential shift towards process orientation has been discussed by many authors in recent years. Traditionally, process orientation is aimed at replacing function-oriented separation of work by processes that span both functional and organizational boundaries (Bucher and Dinter, 2008). As early as in 1993, Hammer and Champy placed emphasis on the empowerment of frontline workers by granting them increased decision authority. However, in order to carry out tasks related to this increased decision-making authority, frontline workers need a “technology” – i.e. they need to have access to relevant data/information and corresponding data analysis tools (Hammer and Champy, 1993). Other authors such as Davenport and Glaser(2002), Ericson (2007), Inmon (2000), Imhoff (2005), Azvine *et al.* (2006), Gile *et al.* (2004), Gile *et al.* (2006), Herschel and Burton (2006), Marjanovic (2007) and White (2007) have argued similarly.

The current discussion on the service-oriented architecture (SOA) paradigm represents yet another driving factor towards process-centricity of data and information (Section 5). The SOA paradigm calls for an encapsulation of functionalities into loosely coupled components. Therefore, changes in an organization’s business operations can be met by merely recomposing components instead of by having to change the implemented functionalities (Schelp and Winter, 2007). Accordingly, the SOA paradigm requires an organization to identify, define, and model its processes such that process execution can be supported by means of loosely coupled services.

The paper in hand is aimed at assessing and describing the state-of-the-art of process-centric business intelligence (PCBI), primarily by means of case study research. We have conducted interviews with major organizations from both Switzerland and Germany, which operate in various industrial sectors. In the context of

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this paper, we will present two use cases of PCBI. The discussion of these use cases will be in two parts: Section 3 presents a classification matrix and discusses the processes themselves as well as their surrounding conditions, whereas Section 4 is dedicated to the discussion of the beneficial effects of PCBI. Beforehand, relevant terms and definitions are introduced in Section 2. Subsequently, a vision for the technical implementation of PCBI is outlined in Section 5. Section 6 concludes the paper and provides an outlook on further research to be based on our initial case study results.

## 2. Terms and definitions

The term “business intelligence” was originally coined by analysts and consultants of Gartner, Inc. (Anandarajan *et al.*, 2003). Since then, various stakeholders such as consultancies, software vendors, practitioners, and last but not least the scientific community have used the term rather vaguely to describe processes and systems dedicated to the systematic and purposeful analysis of an organization and its competitive environment.

Consequently, BI is primarily aimed at supplying top management with relevant information in order to support strategic decision making. This fact has been particularly emphasized by Chamoni and Gluchowski who conceive BI as a collective term for characterizing systems capable of supporting an organization’s top management in its planning, controlling, and coordinating activities based on internal data from accounting and finance as well as on external market data (Gluchowski, 2001; Chamoni and Gluchowski, 2004).

These definitions of BI bear two important implications:

- (1) Oftentimes, approaches to BI are marked off by means of supported functions, systems, or system types (Kemper *et al.*, 2004). For example, Mertens (2002) differentiates between seven distinct approaches to or variants of BI that represent functions (such as “continuation of data handling and information processing”, “filter against information overload”, and “storage of information and knowledge”) or systems (“management information systems”, “early-warning system/alerting”, and “data warehouse” (DWH)) for the most part.
- (2) BI is primarily aimed at supplying an organization’s management circle (i.e. all levels of management as well as supporting staff functions) with decision-relevant analytic information in support of their management activities (Kemper *et al.*, 2004). Operational tasks (i.e. the execution of business processes and support processes) are scarcely supported by BI processes or systems.

In many cases, the analytic information that is needed to support management decisions is extracted from a common database, a so-called “data warehouse” (DWH). According to Inmon, a DWH is a “subject orientated, integrated, non-volatile, and time variant collection of data in support of management decisions” (Inmon, 1996).

As a consequence, many, if not all, of today’s BI implementations are primarily data centered, i.e. are focused on analyzing data from an organization’s DWH with the ultimate goal of generating reports and supplying management information systems with aggregate relevant information in order to support management processes.

As already sketched in Section 1, a variety of reasons militate in favor of a closer connection of BI on the one hand and process-oriented management on the other.

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The process-oriented management concept is generally referred to as “business process management” (BPM). BPM is understood as a systematic, customer-focused management approach to continually analyze, improve, and control the fundamental operational activities of an organization with the help of cross-functional teamwork and employee empowerment (Bucher and Winter, 2006; Zairi, 1997; Lee and Dale, 1998). By concentrating on the flow of activities, on how work is actually done, the organization is viewed as a series of functional processes linked across the organization (DeToro and McCabe, 1997; Bucher and Winter, 2006). Reasons that argue in favor of the integration of BI and operational process execution are as follows:

- Many operational processes generate transactional data that are integrated and analyzed in a DWH as well as by the use of BI processes and systems.
- Over and above, a lot of operational processes require suchlike analyses (“analytical information”) as input for process execution. Operational processes often include steps that are highly or entirely devoted to BI tasks. Hence, a model of such a process needs to contain BI services that are interwoven with transactional steps before and after. Consequently, whenever an instance of such a process model is executed, BI services are running directly in the context of operational activities. As far as possible, the analytical information should be available in real-time or near-real-time, i.e. no undesirable latency should arise from the execution of the BI services (Section 5).
- BI is concerned with the integration and consolidation of raw data into key performance indicators (KPIs). KPIs represent an essential basis for business decisions that are to be made in the context of process execution. Therefore, operational processes provide the context for data analysis, information interpretation, and taking appropriate action.
- Furthermore, once (operational) decisions have been made based on KPIs, useful context information (e.g. specific values of KPIs, corresponding decisions, consequences of and/or reactions to decisions, etc.) can be added to a dedicated “experience” data store. Thus, the data store is, bit by bit, filled with rules for making decisions. The accumulation of know-how can trigger a learning loop that eventually results in refinements of KPI definitions and/or in recommendations that particular action is to be taken (or not to be taken) if KPIs assume some given threshold values. A similar closed-loop approach has been discussed in the context of corporate performance management (CPM) by Melchert *et al.* (2004).

Thus, we define “process-centric business intelligence” as all BI capabilities that are dedicated to the analysis as well as to the systematic purposeful transformation of business-relevant data into analytic information and that have been, at the same time, embedded into an operational process. This implies that the pre-defined activity sequence of a process enhanced with PCBI refers the person in charge of process execution directly to appropriate pre-processed analytic information and/or data analysis techniques whenever process-inherent decisions should be made based on facts rather than intuition. The operational process provides the context for data analysis, the interpretation of the analyses’ results, and the taking of relevant action. By means of PCBI, data and information are not separated from their point of origin

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but remain connected to the operational processes that once have generated them. Without loss of the context, data remain especially useful and meaningful for decision-making. PCBI is therefore used to support operational decision-making in the context of process execution. To meet this end, data and information must be provided in real-time or, if not applicable, at least near-real-time.

However, it is very important to note that PCBI cannot be equated with other approaches that focus on using BI for process monitoring and controlling. In the BPM body of literature, many authors differentiate between process execution on the one hand and process monitoring and controlling on the other (Neumann *et al.*, 2005; Bucher and Winter, 2006). PCBI provides support for process execution by embedding BI capabilities and/or pre-processed analytic information into the process context at process runtime. By contrast, approaches such as “business activity monitoring” (BAM), “corporate performance management” (CPM), “real-time analytics”, and “process performance measurement” (Kueng and Krahn, 1999; Gluchowski and Kemper, 2006; Adams, 2002) are aimed at the identification and adjustment of process exceptions and errors – preferably at an early stage. All of the aforementioned concepts share a common ground in the issue of integrating BI and process orientation. It is possible to argue that the last-mentioned approaches (e.g. BAM and CPM) have paved the way for the emergence of PCBI. PCBI transcends these approaches since it advocates the integration of BI services into process models, i.e. the embedding of analytic information into processes in a narrow sense.

### 3. PCBI use cases

#### 3.1 Classification matrix for PCBI use cases

There is a broad agreement in the scientific community as well as in the entrepreneurial world that process-oriented management is one of the key factors for improving an organization’s effectiveness (Bucher and Winter, 2006).

In the context of the “New St Gallen Management Model”, Rüegg-Stürm proposes to differentiate between three categories of value-adding processes that jointly constitute the process architecture of an organization: management processes, business processes, and support processes (Rüegg-Stürm, 2002):

- (1) Management processes comprise all fundamental management activities dealing with an organization’s development, design, steering, and control (Rüegg-Stürm, 2002).
- (2) Business processes represent the actual execution of all market-sided core operations of an organization which are aiming immediately at creating customer value (Rüegg-Stürm, 2002).
- (3) Support processes are targeted on infrastructure provision and production of internal services that are required for the efficient and effective implementation and execution of the organization’s business processes (Rüegg-Stürm, 2002).

Processes and their constitutive activities need to be thought through and planned carefully. They need to be defined, designed, and modeled before being implemented and executed (Bucher and Winter, 2006). According to Zairi, there are essentially four key features to a well-structured process (Zairi, 1997): it has predictable and definable inputs, a linear logical sequence or flow, a set of clearly definable tasks or activities, and a predictable and desired outcome or result.

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There is no doubt that not all chains of activities that exist in real-world organizations will meet all of those requirements for well-structured processes. Particular situations that have not been foreseen or could not reasonably be anticipated will almost inevitably emerge from regular operations. In those circumstances, less formal, non-predefined, unstructured processes need to be initiated and carried out in order to meet the particular requirements and to handle the unexpected issues at hand. Although this applies to management processes in particular, business processes and support processes are affected by the differentiation between structured and unstructured as well (Rüegg-Stürm, 2002).

It is quite obvious that only well-defined processes can be supported by embedding BI capabilities and/or pre-processed analytic information into the process context at process runtime – the central idea of PCBI. On the contrary, if an unstructured process is retrieved rather spontaneously, the embedding of analysis capabilities or pre-processed information into the workflow is limited to basic functionalities and information, respectively.

The mixture of structured and unstructured aspects of real-life processes is certainly one of the most important reasons for the rapidly growing interdependency between BI and portal technologies. As unstructured information is in many cases represented by emails, contracts, manuals, and other types of documents, a central access point is of key importance in order to get unstructured processes under control. The budgeting process might serve as example to highlight the importance of that point: budgets are created in iterative steps of the process and documented with the help of transactional information systems. If a budget is not approved, the reasons for the rejection are recorded in unstructured documents that are oftentimes not part of the transactional information system. Document management systems are therefore needed to establish the missing link between structured budget data and unstructured data (documents pertaining to the structured data). Portals can be used as central point of access to the unstructured data that are stored in document management systems.

The aforementioned differentiation between structured processes that can be supported by means of PCBI on the one hand and unstructured processes that cannot at all or that can at most to a certain extent be enriched with analytic capabilities and/or information on the other hand is, without any doubt, exaggerated. Most likely, intermediate stages such as unstructured but recurring processes whose information requirements can, at least to a certain degree, be foreseen will exist in practice. However, in order to reduce complexity and to work out the requirements of the PCBI concept clearly, we adhere to this simplifying differentiation.

If the execution of processes can be supported by means of analytic information, it is essential to differentiate between two classes of data sources and information sources, respectively:

- (1) A narrow view on data is taken if the execution of a process solely requires data from inside the process itself –, i.e. data that is “owned” by the process. This kind of data can be accessed directly within or via the application(s) and/or the service(s) supporting the process in question.
- (2) A broad view on data is taken if the execution of a process requires data from outside the process –, i.e. data that is “owned” by other processes and process instances, respectively. It is irrelevant whether the data comes from inside the

organization or from external sources. Likewise, it does not matter whether the data is operational data from operational applications or analytic information from a DWH system or any kind of BI application.

Figure 1 summarizes the distinction between structured and unstructured processes (horizontal axis above) as well as the differentiation between operational processes (i.e. support processes and business processes) and management processes (horizontal axis below). The separation between use cases that exclusively require data that is owned by the process itself on the one side and use cases relying on additional data sources that are owned by other processes on the other side is depicted on the vertical axis.

As stated before, structured processes can be supported by PCBI more easily than unstructured processes. Furthermore, operational processes (i.e. support processes and business processes) tend to be more structured than management processes. Thus, the structuring of the respective use case processes is decreasing when moving from the left hand side to the right hand side in the above classification matrix.

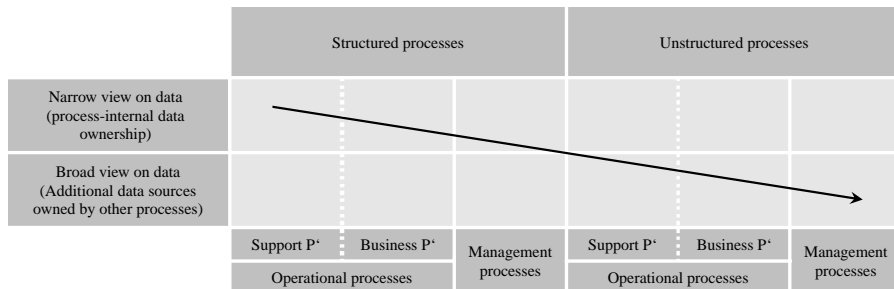
On the other hand, use cases that solely rely on data that is owned by the process itself require fewer degrees of freedom in process definition, modeling, and execution than those that rely on additional data sources owned by other processes as well.

Consequently, different challenges are connected with the implementation of the PCBI concept of different use cases categories. The arrow running from the upper left to the lower right in Figure 1 represents the direction in which the adaptation of PCBI requires more and more effort.

### 3.2 Exemplary use cases

In the following, we will briefly introduce two use cases of PCBI. Example A, the PCBI use case “fraud detection in banking”, is a structured support process that requires a broad view on data. Example B, the PCBI use case “impact analysis of incidents on production”, is a structured business process that requires a broad view on data as well.

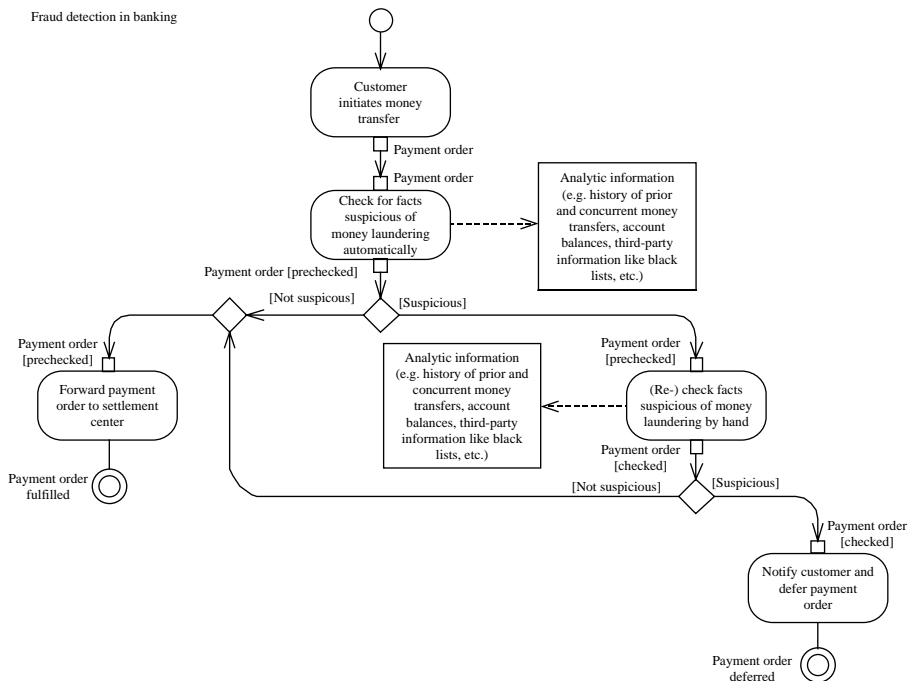
3.2.1 Example A. “*Fraud detection in banking*”. The PCBI use case “fraud detection in banking” is a support process that is targeted at supporting the efficient and effective execution of all business processes that initiate or comprise any kind of money transfer from one bank account to another. The PCBI use case represents a process dealing with risk coverage and compliance with legal issues (Rüegg-Stürm, 2002). Since data from sources both internal and external to the



**Figure 1.** Classification matrix for use cases of process-centric BI

support process are taken into consideration when checking for facts that render a transaction suspicious of money laundering activities, a broad view on data is taken. Figure 2 depicts the use case's activity diagram using UML notation. The process has one initial node capable of triggering the workflow. In order to reduce complexity, the activity diagram solely shows the case that the money transfer is initiated directly by a customer. However, without loss of generality, the money transfer could as well be activated by any other person or even by any business process (instance). Furthermore, the process possesses two activity finals. One activity final is used to designate the successful fulfillment of a customer's payment order (in case no suspicion of money laundering-related activities exists), whilst the other one is representing the deferment of a payment order due to suspicious facts.

In the exemplary use case at hand, the process is started off by a customer initiating a money transfer from one account to another. The payment order is automatically checked for facts suspicious of money laundering. This automated check is carried out by means of case-based reasoning (Aamodt and Plaza, 1994) or, less sophisticated but nevertheless just as well adequate, so-called business rules. Data and information that is accessed in order to detect suspicious transactions include, but are not limited to, the history of a customer's prior (i.e. executed within a particular timeframe) and concurrent money transfers from and/or to any account related to the client, the customer's prior and concurrent account balances, noticeable and/or periodic money transfers from and/or to the same account or account holder, third-party information like black lists, etc. As a result, the system will output a measure representing the



**Figure 2.**  
Activity diagram of the  
use case "fraud detection  
in banking"

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likelihood of the existence of money laundering activities in connection with a particular transaction.

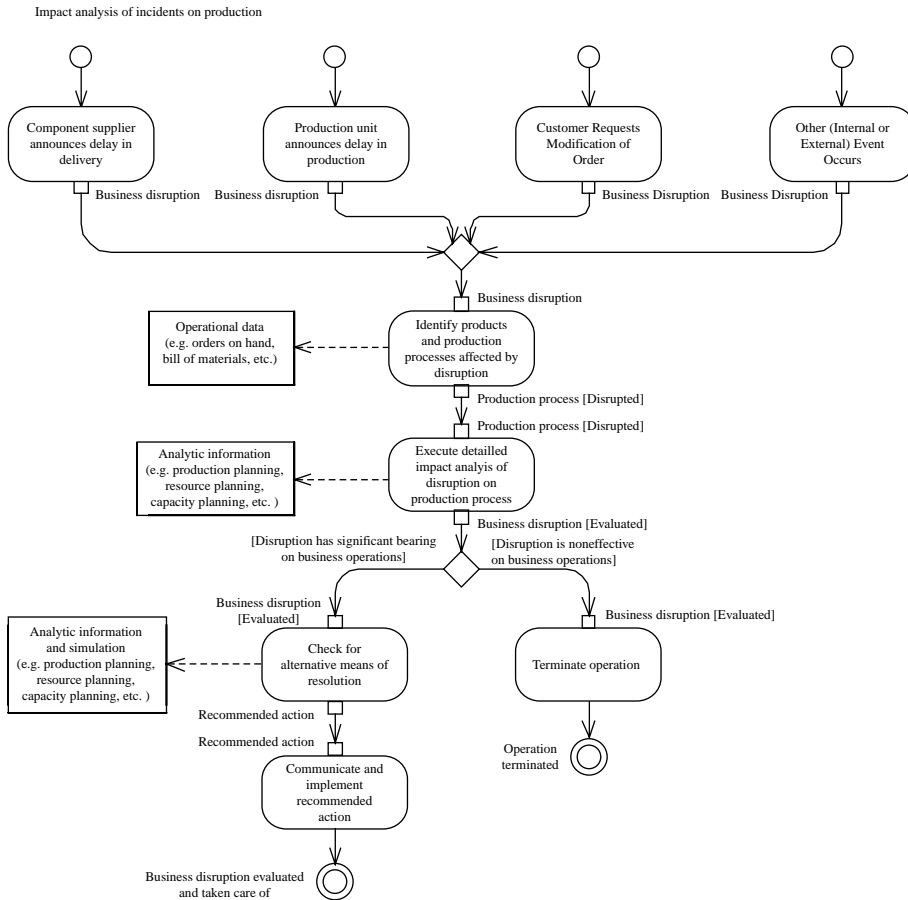
If this measure meets or even exceeds a particular threshold value (which is decided upon by the company's risk management and/or compliance professionals), the payment order is not cleared immediately but suspended and marked down for manual re-checking. On the contrary, if the measure falls below the threshold value, the transaction is cleared and forwarded to the settlement center for fulfillment.

The manual re-checking of the payment orders that have been marked as suspicious during the first automated check is done by a service employee who has access to the same reports and analytic information that have been used for automated checking purposes. Furthermore, the service employee has the opportunity to access all accounts and to view all balances and related transactions (both flawless transactions as well as those transactions having been marked as suspicious of money laundering activities in the past) that have been initiated by the customer. Over and above, the clerk might even contact the customer and inquire more details about the transaction. As a matter of course, these activities need to be in compliance with relevant national and cross-national privacy regulations. For members of the European Union, the EU Directive 95/46/EC governs "the protection of individuals with regard to the processing of personal data and on the free movement of such data" (Gesellschaft für Datenschutz und Datensicherheit e.V., 1997). At the same time, national legislation controls the protection of data privacy as well, e.g. the national data privacy regulations enacted in Switzerland (Bundesversammlung der Schweizerischen Eidgenossenschaft, 2006) and in Germany (Spiros and Bizer, 2006).

Based on the service employee's appraisal, the arguable payment order is either cleared as being not suspicious anymore and at the same time forwarded to the settlement center, or it is irrevocably categorized as suspicious of money laundering activities. If the latter is the case, the payment order is deferred indefinitely, the customer is notified, and legal action is taken if needed.

*3.2.2 Example B. "Impact analysis of incidents on production".* The use case "impact analysis of incidents on production" represents a business process that is aimed at assessing the impact of various disruptions (e.g. delay in delivery on the side of a component supplier, delay in production of the product itself, request for modification of the product order from the customers' side, etc.) on the production process of chemical and pharmaceutical products. Since those production processes normally have multiple stages that are mutually intertwined, it is of particular importance for both internal and external stakeholders to identify products and production processes that are affected by a particular incident, to assess its impact, to check for means of resolution, and to communicate the effects. According to the classification of Porter (Porter, 2004), the process can be classified as appending to the category of operations. Since the whole value chain from inbound logistics (e.g. component supplier) up to outbound logistics and sales (e.g. customer request for modification) is under consideration, a broad view on data is taken.

The activity diagram of the use case "impact analysis of incidents on production" is depicted in Figure 3. The process has four initial nodes that can trigger the workflow independently. The occurrence of one single incident is sufficient to set off the process. If multiple incidents occur at the same time, the process is instantiated multiple times. On the other hand, the workflow has two activity finals. One is used to designate the



**Figure 3.** Activity diagram of the use case “impact analysis of incidents on production”

successful evaluation and handling of the particular business disruption that has triggered the process. The other one is representing the termination of all continuative process activities since the incident has been evaluated as being non-effective on the business operations.

The process starts off with the occurrence of any kind of business disruption – be it external to the organization (e.g. on the side of a component supplier, of the customer, etc.) or internal (i.e. breakdown of the production process itself due to reasons that are within the organization’s field of responsibility). Based on operational data such as the organization’s order book, the production planning, and the bill of materials for the products, the employee in charge of handling the disruption has to identify all products and respective production processes that are or potentially will be affected by the disruption. Subsequently, a detailed impact analysis of the incident on the disrupted production processes has to be executed. This work step is supported by operational and analytic information (e.g. information from the production planning, resource

planning, and capacity planning that is supplemented by simulation results that are based thereupon).

If the impact and consequences of an incident on production are found to be rather marginal in the sense of being non-effective on business operations, the process is terminated without further activity. However, if a disruption is supposed to have significant bearing on the production process, it has to be further evaluated. The person in charge has to check for means of resolving the business disruption that are “realistic” in a sense that they are acceptable for both the organizations’ customers and the organization itself. It is of utmost importance for the organization that the customers are served in the best possible way (e.g. by reducing the price in return for being allowed to extend delivery time, or by prioritizing customer orders according to the customers’ preferences). On the other hand, the organization must strive to operate as profitable as possible. The challenge of the person handling the use case process at hand is to reconcile those contrarian interests. Again, the employee’s decision is supported by analytical information and simulation techniques. Finally, the recommended action has to be communicated within the organization as well as to external stakeholders, i.e. to suppliers and customers affected by the incident, and to be implemented. At the end of the day, the business disruption has been evaluated and taken proper care of.

#### 4. Benefits of PCBI

##### 4.1 General benefits of PCBI

In order to develop a deeper understanding of potential benefits that can be realized through the implementation of PCBI, a short survey was conducted. Data were collected by means of a questionnaire distributed at a practitioner conference held in Switzerland in late 2006. The forum participants were specialists and executive staff, primarily working in IT or operating departments of various organizations from Austria, Germany, and Switzerland. All participants had substantial data warehousing and/or business intelligence background.

The participants were asked to indicate their degree of consent to a total of ten statements about potential advantages of PCBI (Table I) on a five-tiered Likert scale.

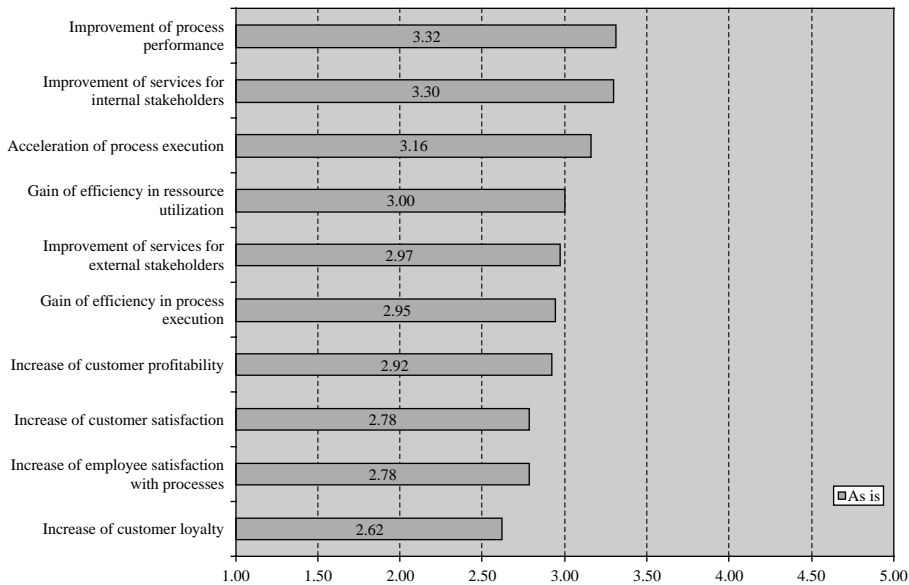
A total of 38 questionnaires were completed and returned. Figure 4 exhibits arithmetic means of as is-values for each of the proposed benefits of PCBI, arranged in descending order.

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*By integrating analytical information into the process context [...]*

- [...] process execution will accelerate
  - [...] process performance will improve qualitatively
  - [...] process execution will be more cost-efficient
  - [...] resources (e.g. human capital, machines, and materials) will be used more efficiently
  - [...] external stakeholders (e.g. customers, suppliers, government) will be served superiorly
  - [...] internal stakeholders (e.g. management, process customers) will be served superiorly
  - [...] employee satisfaction with the processes will increase
  - [...] customer satisfaction will increase
  - [...] customer loyalty will increase
  - [...] customer profitability will increase
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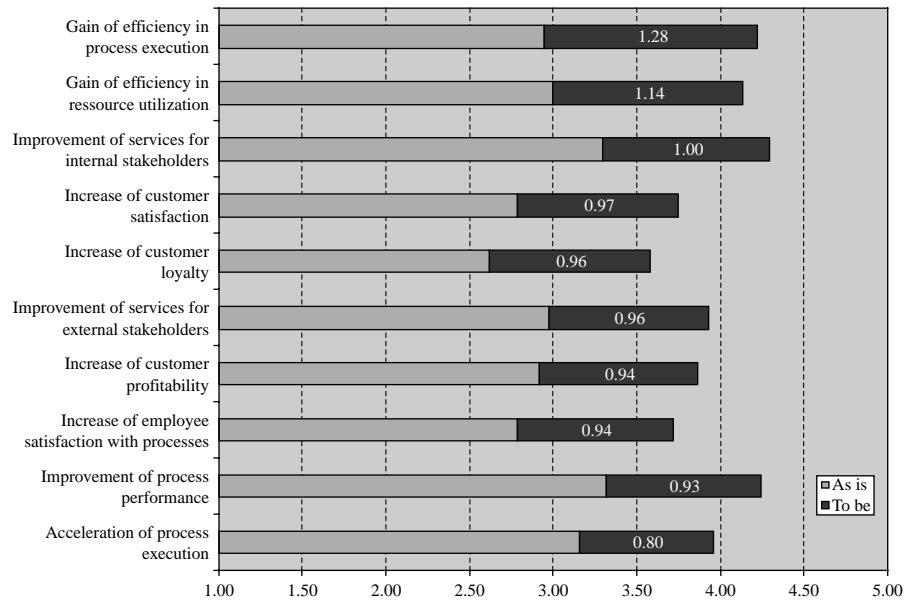
**Table I.**  
Statements used in the  
survey for assessing  
potential benefits of PCBI



**Figure 4.**  
Advantages of PCBI  
(arranged in descending  
order of as is-values)

According to the survey findings, advantages realized within an organization (i.e. improvement of process performance and quality, improvement of services provided to internal stakeholders, acceleration of process execution, and efficiency gains in resource utilization as well as in process execution) outrank those benefits that are external to an organization (i.e. improvement of services provided to external stakeholders, increase of customer profitability, of customer satisfaction, and of customer loyalty). Solely the increase of employee satisfaction with processes, a benefit clearly internal to an organization, is ranked similarly unimportant.

Figure 5 exhibits arithmetic means of the difference between as is- and to be-values (dark grey bars) for each of the proposed benefits of PCBI, likewise arranged in descending order of differences. The findings of this gap analysis correspond fairly well to the findings of the as is-analysis. Advantages that can be realized within an organization seem to be more prominent and important than advantages that are rather external to an organization. To that effect, organizations strive to implement PCBI in order to become more efficient in process execution and resource allocation as well as to improve the servicing of internal stakeholders. These are the areas that generate the highest return on investment in PCBI. Benefits that are realized in the competitive environment of an organization (e.g. among customers and suppliers) seem to be less promising at the moment. The increase of customer satisfaction, of customer loyalty, and of customer profitability as well as the improvement of services for external stakeholders is considered to develop more slowly. Interestingly, the bottom ranks in the gap analysis are taken by two advantages that have been ranked among the top three benefits in the as is-analysis, i.e. the improvement of process performance and the acceleration of process execution. According to the survey data, those benefits have already been realized to a great extent and, as a consequence, are not considered to evolve similarly in the future. The increase of employee satisfaction with processes



**Figure 5.**  
Advantages of PCBI  
(arranged in descending  
order of distances between  
as is- and to be-values)

due to PCBI seems to be virtually insignificant. The gap analysis shows that this particular benefit will stagnate on a low level.

The findings suggest that the PCBI concept resides on a stage of maturity that has to be considered rather low. Proposed benefits of PCBI are appraised on an average level of “applies partially”, and the gap analysis shows that the level will evolve into “applies largely” for the majority of advantages within a time period of five years. However, as for the current status, organizations focus on benefits that are to be realized internally rather than on striving to attain competitive advantage with their external stakeholders. In this regard, organizations definitely have the opportunity to make up leeway in the future.

#### 4.2 Benefits of exemplary use cases

In the following section, the above mentioned benefits are discussed in the context of the exemplary PCBI use cases.

4.2.1 Example A. Benefits of the PCBI use case “fraud detection in banking”. Benefits that can be realized by means of PCBI in this use case are:

- *Acceleration of process execution:* as a matter of fact, the execution of the support process “fraud detection in banking” is highly time-critical. On the one hand, customers are not willing to accept noticeable delays in the fulfillment of payment orders due to fraud detection provisions. On the other hand, payment orders can hardly be canceled once they have been forwarded to the settlement center. Therefore, the checking for facts suspicious of money laundering has to be executed quickly by means of automated, rule-based decision making. A supplementary manual re-checking may be necessary solely in justified

particular cases. However, PCBI can support employees in this task by providing all relevant data and information in a timely manner.

- *Improvement of process performance*: the checking for facts suspicious of money laundering activities has to be executed not only within a short time period but also with high accuracy. A lot of data and information has to be taken into account when deciding upon the suspicion of money laundering in the context of a particular transaction. Therefore, service employees need to be provided with high-class quality reports and analytics that assist them in decision-making. By providing that kind of information by way of clear, easily understandable representations, PCBI can improve the performance of process execution.
- *Gain of efficiency in process execution*: by means of PCBI, the process execution can be both accelerated and improved in a qualitative way. Therefore, the financial service provider is able to handle payment orders fast and to maintain high security standards at the same time. As a consequence, the process execution becomes more efficient, and external as well as internal stakeholders can be served superiorly.
- *Improvement of services for external stakeholders*: both the financial service provider's customers and governmental organizations overseeing anti money laundering legislation are external stakeholders that can be provided with improved services by help of BI-supported processes. The customers' payment orders are processed fast and safe while at the same time the organization is able to comply verifiably with various regulations governing the operations of financial service providers.
- *Improvement of services for internal stakeholders*: "Fraud detection in banking" is targeted at supporting the efficient and effective execution of all business processes that initiate or comprise any kind of money transfer from one bank account to another. Put differently, the support process renders services to "customers" internal to the organization, i.e. to the business processes that retrieve the money laundering detection services of the PCBI use case process at hand. By accelerating process execution, by improving process performance, and thus by rendering process execution more efficient, PCBI can help to improve services for internal stakeholders significantly.

4.2.2 *Example B. Benefits of the PCBI use case "impact analysis of incidents on production"*. Benefits that can be realized by means of PCBI in this use case are:

- *Improvement of process performance*: the ultimate goal of the use case process is to assess the impact of interfering incidents on the production process of chemical and pharmaceutical products and to check for possible means of resolution. The better this process is supported by integrated, meaningful information, the better are the simulation results and thus the more appropriate are the action plans for taking care of the disruption that are recommended by the employees in charge of the impact analysis. PCBI can thus improve the performance of the process.
- *Gain of efficiency in resource utilization*: chemical and pharmaceutical products are produced by means of complex, multistage processes. If a disruption of

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production occurs, the process grinds to a halt, which possibly causes disturbances in subsequent processes in turn. Eventually, this will lead to downtimes that affect both the utilization of machines and manpower. PCBI can help to alleviate these effects of business disruptions by re-allocating resources as soon as an incident has occurred and its impact is assessed.

- *Improvement of services for internal stakeholders*: since production processes in the chemical and pharmaceutical industry are complex, efficient production planning is one of the key success factors. However, even the most accurate production plan can be troubled by events that could not have been foreseen. If such events occur, a quick, adequate, and well-founded impact analysis of the incident on production planning must be conducted and plans must be altered accordingly. PCBI can support this task by simulating alternative changes in the production plan and by identifying the best possible solution. Consequently, PCBI can improve services for internal stakeholders, and in this particular case even support a complex manufacturing process.
- *Increase of customer loyalty*: customer retention plays an important role in the chemical industry. Customers oftentimes intend to buy large amounts of chemical substances, and both customers and the original equipment manufacturer (OEM) are interested in entering into contracts that run over a long period of time. This is why customer relationship management is of extreme importance. If a disruption of the business occurs that potentially affects the customer, it is necessary to communicate possible consequences as quickly as possible and to look for a method of resolution that serves the customer well. PCBI can support effective customer relationship management and thus increase customer loyalty.

## 5. Technical implementation

In the following chapter, the concept of SOA is introduced due to the fact that a SOA-enabled BI infrastructure is regarded to deliver strong business and IT benefits (Besemer, 2007; Bitterer *et al.*, 2007; Hewlett-Packard Development Company, 2007). On the business side, such benefits are seen especially in the improved ability to respond faster to change (Besemer, 2007). On the contrary, the IT side regards SOA as a means to ease integration and to lower software lifecycle management costs (Besemer, 2007; Hewlett-Packard Development Company, 2007).

### 5.1 Fundamentals of service-oriented architecture

SOA is an architectural approach for aligning processes and software (IT business alignment) (OMG, 2007; Stutz and Aier, 2007). To begin, logical business functionalities are encapsulated in small and loosely coupled components (OMG, 2007; Stutz and Aier, 2007) – so-called enterprise services (Schelp and Winter, 2007). These services can be composed of more elementary enterprise services (Schelp and Winter, 2007).

Next, the elementary enterprise services are technically implemented (Schelp and Winter, 2007; OMG, 2007; Stutz and Aier, 2007), either as traditionally implemented software or as software services (Schelp and Winter, 2007). Software services, in turn, are often implemented as Web services (Schelp, 2007; Schemm *et al.*, 2006), whereby

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other standards and technologies are possible as well (Schelp, 2007; Schemm *et al.*, 2006; Duan *et al.*, 2005). Following the World Wide Web Consortium:

A web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards (Booth *et al.*, 2004).

In order to determine Web services, a registry is necessary wherein the developed Web services are published. The Web standard UDDI can be used for this purpose. (Ferguson, 2005).

Finally, processes or parts of processes are either orchestrated from enterprise services or supported by traditionally designed applications (Schelp and Winter, 2007; Stutz and Aier, 2007).

### *5.2 Business intelligence services and their requirements*

According to the previous section, business intelligence services can be distinguished between BI enterprise services and BI software services. Furthermore, a differentiation of BI services is also possible in respect to their context of application. Front-end and back-end BI services can be identified in this dimension (Wu *et al.*, 2007; Besemer, 2007; Ferguson, 2005). Front-end BI services are services that are visible to the user whereas back-end BI services (data services) are only visible to IT (Ferguson, 2005).

Following Besemer, front-end BI services can be differentiated between:

- query and reporting services/dashboards and scorecard services;
- analytics and data mining services as well as; and
- alerting and notification services (Besemer, 2007).

Wu *et al.* (2007) and Ferguson (2005) argue similarly. The first group of front-end BI services can be used to run different queries as well as to produce certain reports such as dashboards or scorecards. The second group of these services can be applied for example to invoke a data-mining model or to access a cube (Ferguson, 2005). Eventually, an example for an alerting and notification service (group 3) is a service that notifies the end-user when a certain event has occurred, e.g. in case the stock of inventory fell below a certain threshold.

Regarding back-end BI services, Besemer distinguishes:

- source connectivity services/services addressing the movement between services;
- transformation and integration services as well as; and
- cleansing and quality services (Besemer, 2007).

Again, Wu *et al.* (2007) and Ferguson (2005) argue similarly. Examples for the first group of back-end BI services are data snapshot and data load services. In addition, a real-time subscriber service can be named which allows real-time synchronization in order to achieve collaboration and closed-loop processing (Wu *et al.*, 2007). Services in the second group are, e.g. responsible for the transformation and aggregation of data.

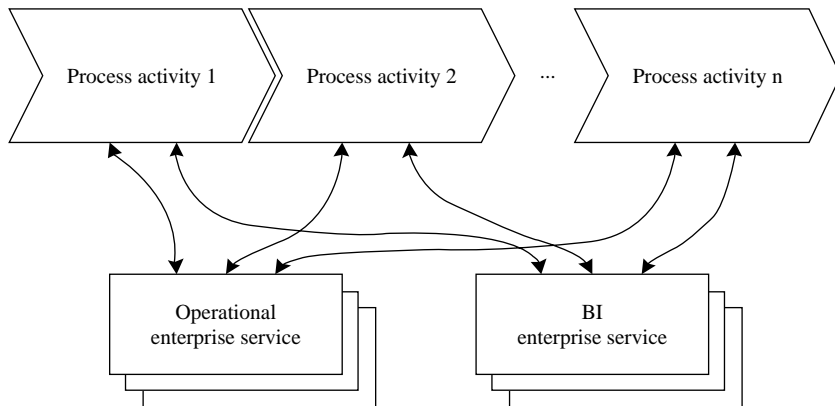
Finally, the third group comprises services which can be used for data cleansing or for the management of metadata (Wu *et al.*, 2007).

Several requirements must be considered when developing front-end and back-end BI software services. Because functional requirements are very specific about a certain BI software service, we introduce only non-functional requirements that apply for all BI software services (Hulford, 2006; Schulte and Abrams, 2006): BI software services should be developed in such a way that they offer implemented functionality to a service consumer via a standardized interface. To assure an efficient communication irrespective of the machine or the operating system, BI software services should be platform independent and be programming-language neutral. Furthermore, BI software services are to be stable, scalable, and reliable as well as location independent. In addition to these requirements, BI software services should not have any latency so they are available at process run time. Furthermore, they should use existing resources efficiently.

### 5.3 Integration of BI services and process management

As it has been said before, both operational enterprise services (OES) and business intelligence enterprise services (BIES) represent building blocks that encapsulate logical business functionality (Section 5.1). These building blocks are orchestrated into processes, process activities, or parts thereof (Figure 6) using a dedicated integration infrastructure that is oftentimes referred to as service bus (vom Brocke, 2006). Each process activity can be supported by one or multiple OES and/or by one or multiple BIES – depending on the granularity of the process activities and of the enterprise services as well as on the functional requirements of the process activities. Similarly, each OES and each BIES can support none, one, or multiple process activities.

The combination of OES and BIES in the same process creates a so-called “composite process” that spans both operational and analytic systems (Ferguson, 2005). The operational activities of a composite process (supported by OES) can therefore be enriched with analytic information that is provided and embedded into the context of process execution at process runtime by means of BIES. Figure 7 illustrates an exemplary composite process.



**Figure 6.**  
Orchestration of  
operational and business  
intelligence enterprise  
services

As a prerequisite for the implementation of composite processes, process management as a whole – consisting of the four steps process definition, design, modeling, and streamlining, process implementation and execution, process monitoring and controlling, and process optimization and refinement (Bucher and Winter, 2006) – must take into account both the coexistence and the interdependencies between operational process activities and BI activities that are carried out in the context of process execution. As a consequence, processes have to be re-designed, new process models have to be developed, and the re-engineered composite processes as well as the supporting software services need to be implemented. The SAP NetWeaver Composition Environment allows both business analysts and IT specialists to model and implement suchlike composite processes and applications (SAP AG, 2007). For the modeling part, the SAP NetWeaver Visual Composer is used within the Composition Environment. This tool can reference both transactional and analytic (BI) software services (SAP AG, 2006).

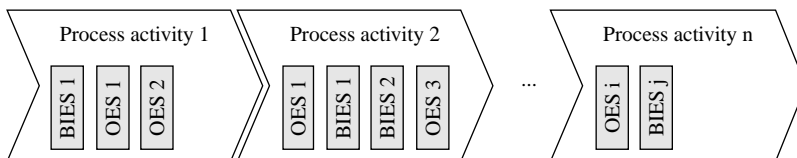
### 6. Summary and conclusion

The paper at hand is aimed at imparting a better understanding of PCBI as well as at raising awareness among various stakeholders from both corporate practice and academia for potential use cases, benefits and the technical implementation of this concept.

A comprehensive introduction to the subject-matter is provided in the first two sections of the paper. After motivating the topic and discussing its relevance in the Section 1, the terminological foundation for the subsequent analysis is established in the Section 2. Based on the generally accepted understanding of the BI concept, PCBI is defined as all business intelligence capabilities that are dedicated to the analysis as well as to the systematic, purposeful transformation of business-relevant data into analytic information and that are at the same time embedded into an operational process.

The Section 3 is dedicated to the discussion of use cases of PCBI. At first, a classification matrix is derived and justified (Section 3.1). This matrix is based on two dimensions: the differentiation between management processes, business processes, and support processes as well as between structured processes and unstructured processes on the one hand, and the differentiation between narrow and broad views on data taken in the use cases on the other hand. Second, two exemplary PCBI use cases are briefly introduced and classified according to the aforementioned matrix (Section 3.2). The first example describes the PCBI use case “fraud detection in banking” whereas the second one explains the “impact analysis of incidents on production”.

In the Section 4, beneficial effects of the concept are analyzed. We report on the findings of a short survey that was conducted in order to develop a deeper



**Figure 7.**  
Composite process

understanding of potential benefits that can be realized through the implementation of PCBI (Section 4.1). Thereafter, the identified benefits are discussed in the context of the exemplary PCBI use cases (Section 4.2).

Finally, a vision for the technical implementation of PCBI is sketched in Section 5. The concept of SOA is introduced as it is regarded to deliver strong business and IT benefits for business intelligence (Section 5.1). Using this as a basis, BI front-end and back-end services are identified as well as their requirements are elaborated (Section 5.2).

Finally, the integration of process management and BI services as a vision for the technical implementation of PCBI is outlined (Section 5.3).

Based on our research results, further research should address the validation of the identified benefits. Furthermore, the usage of a SOA to implement PCBI should be explored in more detail. Thereby, not only technical but also organizational aspects should be kept in mind (Besemer, 2007).

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