Applications of Business Process Analytics and Mining for Internal Control

Contemporary enterprises have become aware of the need to intensively manage their business processes.\(^1\) Process flexibility and efficiency are generally considered important determinants for the ability to achieve operational excellence. However, less-strict information systems that provide high process flexibility implicitly enable the occurrence of process behavior that significantly deviates from a designed model.\(^2\)

In the ideal situation, this business process model takes into account the applicable legislation, directives and business policies.

Business process analytics and mining techniques address the problem that most internal control experts have very limited information about what is actually happening in the business processes. This article aims to introduce business process analytics and mining to the information systems (IS) audit and control community. Focus is placed on discussing the central concepts and on providing useful cases for process analytics and mining in the internal control setting.

**BUSINESS PROCESS ANALYTICS**

Business process analytics is a new and promising way of acquiring insights into an enterprise's business processes. This set of techniques enables the analyst to extract knowledge from previous process behavior, as described in the event logs of process-aware information systems (figure 1). These event logs contain a multitude of information on events that are of importance in the context of the business process supported by the information system (e.g., who performed an activity and when it was performed). In many enterprises, such event logs are already available and conceal an untapped reservoir of knowledge about the way employees and customers conduct everyday business transactions. For example, popular enterprise resource planning (ERP) systems, such as SAP and Oracle E-Business Suite, and workflow management systems, such as ARIS, TIBCO and Biztalk, already keep track of these events.

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**Figure 1—The Business Process Analytics Setting**

“World” organizations business partners regulation people machines

Information systems support interactions order processing.

Environment sets limit the operation (e.g., legislation, contracts).

Process-aware Information System

Event Log

Contains structured information on important business occurrences such as incoming order and delivery of goods.
The business process analysis techniques that are of interest for internal control experts can be roughly categorized into three classes:

- **Process discovery and visualization**—These techniques provide the analyst with a visual summary of a specific aspect of the business process (e.g., the activity sequences). A typical application is the heuristics miner algorithm, which provides easy-to-understand process graphs.

- **Conformance checking and delta analysis**—The second class of techniques aims at detecting inconsistencies between a prescriptive process model (i.e., a designed process model) and the corresponding real-life process behavior. The major difference between them lies in the comparison base for the real-life process: Conformance checking uses the event log, while delta analysis uses a process model obtained with a process discovery technique. The conformance checker is the most fundamental contribution in this technique subset.

- **Rule-based checking**—The third set of techniques enables the analyst to verify whether a specific business rule is satisfied (e.g., segregation of duties, execution of an approval cycle). The linear temporal logic (LTL) checker with configurable rule patterns can be considered one of the most influential contributions in this subset.

Business process analysis techniques have mainly focused on extracting knowledge on common activity sequences. However, each of the three technique classes consists of a wide spectrum of techniques that together cover the main aspects of a business process (i.e., the process perspectives).

**PROCESS PERSPECTIVES**

Business processes commonly cover several aspects of an enterprise’s operations. Consequently, business process management focuses on structuring, for example, what needs be done, who will be doing it and when it must be done. Accordingly, the business process management literature discerns the following four perspectives:

- **Functional perspective**—Deals with the occurrence of a particular process element in the entire process history or in the context of a specific process execution (e.g., presence of a certain activity)

- **Process-flow perspective**—Covers the process behavior in terms of when process elements can occur in a process instance. This includes a wide variety of ordering relations between activities, as well as complex decision-making conditions and activity preconditions. The process mining research primarily centers on this perspective.

- **Organizational perspective**—Focuses on the enterprise behind the business process, which agent performs the different process elements in a process instance, taking into account factors such as timing and environmental conditions. The term “agent” can have a broad interpretation, varying from a single person over a department to a whole enterprise.

- **Data perspective**—Handles the information elements (e.g., documents, messages) that are used, produced or manipulated during the process, as well as the prescribed relationships among them.

For each individual process perspective there exist a variety of business process analysis techniques. The following section elaborates on this topic and links the combinations with common activities in an internal control setting.

**BUSINESS PROCESS ANALYTICS AND INTERNAL CONTROL**

Each of the business process analytics technique sets allows for a wide variety of applications in the internal control setting.

An Overview of Business Process Analytics and Mining Applications for Internal Control

Figure 2 provides a detailed overview of the potential business process analytics and mining support for the activities performed by internal control experts. It also indicates for each general activity type which business process analytics and mining techniques are most suitable.

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In addition to post mortem analysis, the business process analytics techniques may provide adequate tool support for continuous process improvement. For example, an open-minded analysis in combination with a rule-based service-level analysis might uncover process deviations that frequently result in performance decreases. Consequently, timely and effective recommendations can be drawn up.

Most of the supporting business process analytics and mining techniques for each of the different process perspectives are supported by the open-source tool ProM. The tool, as well as more information on the specific techniques, can be found on the process mining web site of the Process Mining Group.6

Illustration of Business Process Analytics and Mining for Internal Control

This section provides an example of the application of business process analytics in an internal-control setting. Due to limited space, only three analysis techniques that produce strong and easy-to-understand summaries of certain process aspects are elaborated. Figure 3 provides the designed process model (in the business process modeling notation [BPMN]) of a rather straightforward purchase process, including a management approval cycle. An event log containing 300 process instances, including several process instances with harmful deviations, was artificially constructed.

<table>
<thead>
<tr>
<th>Risk identification and assessment</th>
<th>Process Discovery and Visualization</th>
<th>Compliance Checking and Delta Analysis</th>
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<td>Generation and communication of information</td>
<td>Creating clear, focused, honest, accurate and timely reports</td>
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Figure 3—Designed Prescriptive Process Model for Purchasing Goods

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Figure 4 represents an extract process model that was derived from the process history recorded in the event log. An open-minded analysis would immediately result in the identification of important irregularities:

- There exists at least one process instance in which the changed order was not approved afterward.
- It seems that there are process instances, including a pay activity, for which the information system did not record any handling activities performed upon receipt of the goods.
- The enterprise did not pay for all the goods it received.

The originator-by-task matrix in figure 5 provides a strong visual summary of the organizational perspective (i.e., who did what?). In figure 5, Richard is a clerk in an enterprise in which approving an order can be done only by management. As a result, the internal-control expert must investigate the six times Richard executed the activity “approve order,” as it may indicate fraudulent behavior. The results can be easily compared to a Responsible, Accountable, Consulted and Informed (RACI) chart.

Previously, the heuristics miner output enabled the internal-control expert to identify a potentially harmful issue: Some process instances did not contain an approval activity for a changed order. Figure 6 provides the output of a rule-based checking technique that was configured to evaluate the following statement: If a change order activity is executed, it must always be followed by an “approve order” activity. As the output in figure 6 shows, in 14 out of 48 process instances...
containing a “change order” activity (based on a total of 300 instances), there was no order approval after the order had been changed. This enables the internal-control expert to assess the likelihood of occurrence of this process deviation and to identify the exact cases that require further investigation.

OPPORTUNITIES

Business process analytics and mining techniques have multiple advantages that present opportunities for a more efficient and effective control environment. The following are the four major advantages:

1. **Acquiring detailed and objective information on the business operations**—Flexibility is becoming an important determinant for the operational excellence of an enterprise, resulting in business process behavior that significantly deviates from designed process models. Additionally, the business processes performed by knowledge workers often tend to be rather nondeterministic. In particular, process discovery and visualization techniques can help the internal control expert with exposing the business process reality, based on which the expert can make better informed decisions in the planning of further internal-control-related activities.

2. **Pursuing absolute assurance**—Business process analytics and mining techniques enable internal-control experts to perform their testing procedures on the full population, thereby offering (near) absolute assurance. While attaining an absolute level of assurance can be undesirable due to budget and time restrictions, it can be achieved with process analytics and mining techniques with only a marginally higher cost in terms of processor time compared to sample-based testing with the same techniques. Consequently, the risk of the evidence failing to uncover misstatements can be significantly reduced.

3. **Auditor independence**—The value of internal-control expert reports is largely determined by the controller’s independence from the daily operations in the enterprise under review. Business process analytics and process mining techniques do not directly affect the enterprise’s information systems, as they use only the event log system. Consequently, this approach does not require any cooperation from the process owner, which could result in a priori knowledge on the control procedures.
4. Obtaining persuasive evidence—The persuasiveness of the evidence obtained through process mining techniques is expected to be high because of the competence and the sufficiency that can be attained. The competence of the evidence is mainly determined by the independence from the enterprise, the internal-control expert’s direct knowledge, the degree of objectivity and the timeliness (referring to both the period covered and the ability to reduce the time delay). These determinants can be easily related to business process analytics and mining as discussed in the previous sections. Due to the fact that the whole population of transactions can be efficiently inspected, the sufficiency of the evidence can be optimal.

CONCLUSION
As business process management becomes more established, the need for appropriate analysis and evaluation tools grows. Business process analytics and mining techniques enable the internal-control expert to acquire detailed insight into the real process behavior and to perform a wide variety of control-testing procedures. Additionally, these techniques can provide adequate support for continuous process improvement, e.g., by monitoring compliance with directives and service level agreements (SLAs) or by providing warnings when harmful process deviations occur.

The business process analytics and mining approach is characterized by the ability to acquire objective and persuasive evidence, via the auditor’s independence and the pursuit of absolute assurance. Consequently, the use of business process analytics and mining techniques can contribute to a more effective and efficient control environment in process-oriented enterprises.

ENDNOTES
3 Weijters, A.; J. T. S. Ribeiro; “Flexible Heuristics Miner (FHM),” IEEE Symposium on Computational Intelligence and Data Mining (CIDM), 2011, p. 310–317
8 Op cit, van der Aalst, 2005, p. 150–147
9 Arens, A. A.; R. J. Elder; M. S. Beasley; Auditing and Assurance Services: An Integrated Approach, Pearson Education, 2005