Abstract

In modern companies business processes and information systems are highly integrated and transactions are executed system based and automated. The data generated in the course of processing transactions commonly provides the basis for internal and external financial reporting.

The financial statements are subject to audits due to regulatory requirements. Contemporary audit approaches take into account internal control frameworks over relevant business processes and underlying information systems, but they lack adequate audit procedures needed to handle voluminous data flows when business processes are highly integrated and automated.

We face a discrepancy between an integrated and automated transaction processing on the one side and manual audit procedures on the other. Financial audits would be more effective and efficient if an audit approach with system based and automated procedures would be applied.

This article describes how business process mining and reconstruction of mined processes can be used to overcome this discrepancy.

1. Introduction

The execution of business processes in companies is regularly based on information systems. The integration between business process and information systems ranges from support for manual executions to completely automated processing. Enterprise Resource Planning (ERP) systems represent the dominant type of information systems that are implemented to support and automate transaction processing. Depending on the industry and types of business processes that are integrated into the ERP systems millions or even billions of transactions may be processed within a financial period.

ERP systems do not only support or automate the execution of transactions but they also commonly provide the data basis for the internal and external financial reporting as well as integrated functionality for preparing the financial statements including the balance sheet and profit and loss statements. This means that the financial statements represent an aggregation of the information stored in the ERP system that is made up by the processing of myriad numbers of transactions.

Companies are required to prepare financial statements in order to inform addressees primarily about the financial situation of the company. To protect addressees from misinformation the financial statements are subject to independent audits by financial auditors. The requirements for the audit are specified in local or international laws, regulations and standards.

International Standards on Auditing require the application of a risk based audit approach that takes into account the internal control framework over relevant business processes and underlying information systems (ISA 315). A risk based audit approach requires the identification of relevant risks for material misstatements and the evaluation how internal controls are able to mitigate existing risks. When business processes are integrated with ERP systems application controls represent a significant type of internal controls that have to be considered in the audit. Contemporary audit approaches consider internal controls and application controls as a special type of internal controls that are embedded in the integrated system. Although relevant business processes and internal controls are taken into account contemporary audit procedures are generally not system based. The selection and test of controls is done manually.

This situation leads to a discrepancy. Business processes are highly integrated with ERP systems and transactions are processed automatically. Auditors identify significant risks and manually evaluate relevant internal controls that are in place to mitigate these risks. On the company side we observe system based and automated processing and on the auditor side a risk based approach with manual evaluation procedures. An approach with automated and system
The need for automated audit procedures has been pointed out by major market participants [17], but an approach that includes system based and automated audit procedures has not been developed yet due to the fact that adequate methods and software artifacts have not been available.

Recent research by GEHRKE et al. [14], [15] has revealed how financially relevant information can be extracted via financial business process mining from information systems. The mined information can be used to reconstruct processes based on that information. This paper presents how business process mining and reconstruction can be used to apply a risk based audit approach with system based and automated audit procedures.

The article starts with an overview of related theoretical work in section 2. Section 3 provides a brief summary of contemporary audit approaches and their limitations in system based and highly integrated environments. Section 4 presents the concepts of business process mining and reconstruction. Section 5 discusses the relevance of application controls for highly integrated and automated business processes. In section 6 we discuss how the concepts of business process mining and reconstruction can be combined with automated application control testing for developing system based and automated audit procedures. Section 7 closes with a discussion how stakeholders benefit, which limitations exist and what further developments are needed.

2. Related Work

The idea of process mining evolved in the 1990s. COOK and WOLF [9], [10], [11] investigated process mining in the context of software engineering. They describe different methods for process discovery. However, they do not provide an approach to generate explicit process models. The idea to apply process mining in the context of workflow management was first introduced by AGRAVAL et al. [8]. Further research was undertaken by MAXEINER et al. [28] and SCHIMM [33], [34], [35], [36] who developed mining tools. HERBST and KARAGIANNIS also address process mining in the context of workflow management using an inductive approach [18], [19], [20], [21], [22], [23].

Substantial research has been published by VAN DER AALST et al. [1], [2], [3], [4], [5], [6], [7], [26], [27], [38], [39], [40] that deals with the mining and rediscovery of process models from event logs. This research is especially relevant because the provided methods and algorithms allow the reconstruction of petri nets which represent the process models mined from event logs. They also cover considerations of workflow performance, concurrency, noise and conformance checking.

Although this research is valuable for the research subject of this article several limitations have to be considered. The process mining research by VAN DER AALST et al. focuses on event based logs and intends to reconstruct graphs that completely represent the processes that produce these event logs. Mining of business processes in ERP systems for the financial audit entails different environmental settings and intends to achieve different aims. First, the stored data in ERP systems includes much more detailed information than common event logs from workflow systems. They store accounting information about journal entries that provide more specific data usable for process mining. Second, for the proposed mining we intend to rediscover single representative process instances that are aggregated into process models, we do not intend to rediscover complete representations of the mined data.

The discipline of process mining is characterized by technical research approaches. The connection between process flows, process mining, process reconstruction and accounting has not been extensively covered in scientific work so far. We assume that the connection between informatics oriented process mining and the business management topics accounting and compliance has not been the focus of interest so far due to the thematically distance of the two disciplines.

An exception is the research work by GEHRKE et al. [13], [14], [15], [16] that has been derived from the research project Virtual Accounting Worlds [37]. The developed methods and concepts bridge the gap between accounting, compliance and process mining. They represent an application of fundamental concepts from VAN DER AALST et al. for mining of business processes that are relevant for financial accounting. Within this paper we relate to these methods and concepts and include them in a wider consideration in order to demonstrate how they can be applied for developing an audit approach that includes system based and automated audit procedures.

Further relevant research covers topics like process data warehousing by EDER et al. [12] and ZUR MÜHLEN et al. [29], [30], [31] which can be used for developing software artifacts needed to apply the discussed approach in practice.
3. Risk based audit approach in the context of integrated and automated business processes

Before we can understand the shortcomings of the application of contemporary audit approaches in business environments with integrated and automated business processes we need to clarify their relevant characteristics.

Companies are required to apply generally accepted accounting principles (GAAP) when preparing their financial statements. This ensures that the published statements display correct and comparable information to the addressees. External addressees are shareholders, creditors, tax and regulatory authorities, employees, clients, financial analysts, competitors and the general public [24].

In order to protect addressers from misinformation the financial statements are audited by financial auditors. The obligation to engage auditors for auditing the financial statements is generally mandated by law. Auditors follow standards on auditing to ensure that adequate audit procedures are applied. They assess if the audited statements give a fair and true view of the financial situation of a company and if the statements are free of material misstatements.

Standards on accounting and standards on auditing are issued by regulatory bodies such as the International Accounting Standards Board (IASB) for the International Financial Reporting Standards (IFRS) or International Auditing and Assurance Standards Board (IAASB) for the International Standards on Auditing (ISA). Laws, regulations and standards differ between countries. But in recent years we observe a convergence between internationally significant accounting frameworks especially between the IFRS and US GAAP [25]. We do not intend to focus on differences of the accounting and audit frameworks in this article. For our purpose it is sufficient to point out that a risk based audit approach is mandated by ISA (e.g. ISA 315) as well as local regulations or standards such as the Sarbanes-Oxley-Act in the USA. For the remainder of this article we primarily refer to IFRS and ISA while pointing out that the same considerations and conclusions provided in this article are applicable to other accounting and audit frameworks.

ISA 315 requires the application of a risk based audit approach: “The objective of the auditor is to identify and assess the risks of material misstatement, whether due to fraud or error (...) through understanding the entity and its environment, including the entity’s internal control (...)” (ISA 315.3). The auditor has to identify and to evaluate the risks that might lead to material misstatements. The auditor further needs to identify if internal controls do exist that mitigate existing risks: “The auditor shall obtain an understanding of internal control relevant to the audit (...)” (ISA 315.12). The underlying axiom of the approach is the assumption that well organized and controlled processes lead to correct financial reporting.

In practice the audit takes place by identifying risks that are significant to the audit. A general significant risk is that business transactions are not recorded completely or correctly. Following a risk based approach it is not necessary to consider all business processes within a company but only those where errors in the processing might lead to a material misstatement in the financial statements.

Typical business processes relevant for financial accounting are purchase, sales, payroll, production and logistics processes.

When the scope of the audit is determined and relevant processes identified the auditor has to gain an understanding of the processes and the internal control over these processes. The auditor has to evaluate if the controls are properly designed and operative to achieve the desired control objectives. The procedure to understand business processes, to evaluate and test internal controls is a manual and highly time-consuming activity. It generally includes interviews with knowledgeable contact persons and manual reviews of provided documentation.

We illustrate the procedure for the following example. For producing goods a company creates purchase requisitions and orders individually and with paper based forms. The orders have to be approved by signature by the purchase representative. The responsible warehouse worker checks if the amount and quantity of the received goods equal the amount and quantity of the purchase order when the goods are delivered. When the invoice for the delivered goods is received from the supplier a responsible person in the accounting department checks if the billed amount and quantity equal the amount and quantity of purchase order and the goods received.

For understanding the process and for evaluating the relevant internal controls an auditor first performs interviews with the persons involved in the process. He evaluates if the controls in place are adequate to control the process and to achieve the desired control objectives. Based on the understanding of the process and the controls he performs tests to evaluate if the controls are carried out continuously and effectively throughout the relevant reporting period. The testing of the operating effectiveness requires the review of relevant documents. In the mentioned example the auditor would draw a representative sample of purchase transactions and verify if check marks and
signatures are available on the provided documentation.

The example illustrates that the audit procedures for auditing business processes and internal controls are highly manual and time-consuming in nature.

The described procedure is practical for manually executed business processes but it is insufficient when business processes are highly integrated with ERP systems and executed automated. Under such conditions contact persons from the relevant business functions generally lack sufficient knowledge about the integration and type of automation with the underlying systems. A common observation is that provided information does not correctly reflect the process implementation within the ERP systems. Second, with an increasing number of executed transactions manual review of available evidence becomes increasingly inefficient or even ineffective. A manual review of even hundreds of documents does not provide sufficient audit comfort when millions of such transactions are executed within the relevant period.

We illustrate the shortcomings of contemporary audit procedures in an integrated and automated business process environment with a second example.

A company has integrated its production and purchase processes in an ERP system. Production orders automatically initiate purchase requisitions and purchase orders based on item lists maintained in the system. The program routines initiate purchase orders only if required items are not available in the warehouse. Purchase requisitions and orders are approved automatically up to a certain amount. Only purchase orders exceeding that amount are subject to a system based approval by the purchase department. The system further blocks purchase orders randomly for manual but system based approval in order to prevent manipulation. The warehouse clerk can only accept received goods if the quantity and amount match the purchase order (two-way-match). Otherwise an exception handling sub-process is initiated. The accounting department can only process incoming invoices if the billed amount and quantity matches the amount and quantity of the purchase order and the goods received (three-way-match). Otherwise an exception handling sub-process is initiated.

The example demonstrates a highly integrated business process with automated executions and automated and systems based internal controls also referred to as application controls. In the described environment performing interviews with contact persons from the functional departments might not provide sufficient information because they may lack the information how transactions are processed automatically, when no human interaction occurs, and especially which application controls do exist. A common occurrence is that contact persons think application controls are in place and effective which in fact is not the case. A second dilemma becomes obvious when controls actually get tested. The automation of execution means that paper based evidence might not be available. In such a situation it is necessary to manually evaluate and to test relevant application controls. The evaluation and testing of application controls requires a specialized knowledge of the ERP system in use. Furthermore, the review of control settings, commonly based on the customizing settings, requires extensive access rights and is a manual time-consuming work. Third, even if these procedures are applied no information is available if the controls really cover complete transaction flows or if controls are bypassed by concurrent transaction flows differing from the general transaction flows, by manual journal entries or manipulation. Fourth, generally it is hard to test if the application controls were effective over the whole relevant period, for example if specific application controls were disabled for a specific timeframe.

Computer assisted audit techniques (CAAT) for supporting the testing of application controls and business processes integrated into ERP systems do exist [13]. But they only support the manual execution of tests or provide functionality to analyze mass data for journal entry testing. The described fundamental problems are not solved.

An audit approach is needed that counters the system based and automated processing by applying system based and automated audit procedures.

4. Business process mining and process reconstruction

Business process mining and process reconstruction provides the concepts and methods needed to implement system based and automated audit procedures.

VAN DER AALST et al. [1], [3], [4], [5], [6], [26], [27], [38], [39] focus on event logs in order to mine and reconstruct workflows. We can rely on these concepts to mine and reconstruct process models in ERP systems. In contrast to the systems and log files described by VAN DER AALST et al. ERP systems provide much more detailed information about the processed transactions. Every financially relevant business transaction executed in an ERP system is recorded as a journal entry posted to an account in a main or sub ledger. Basically, entries in the accounting of an ERP system are structured in a simple way [32].
Each entry consists of an accounting document and at least two items posted as credits and debits.

Technically documents and items are stored as entries in data tables in the underlying database of the ERP system. The stored data for each transaction contains information that allows identifying relationships between the transactions. The transactions can be traced back to the executed instance of a business process they belong to.

Mining of business processes that are relevant for financial accounting can be applied where open item accounting is enabled, which is the case for most relevant processes. If open item accounting is in use for a particular account, each item contains a flag that indicates if the item has already been cleared or not. If an item has been cleared, it also contains a reference to the entry/document which cleared the item.

Figure 1 shows the general data structure of an accounting entry in a database. One document consists of two or more items posted on different accounts. Each item can be linked to one (other) document (=item cleared) or does not refer to (another) document (=item still open).

We illustrate the data structure with the example of an execution of a purchase process. The receipt of an ordered material (transaction 1) is recorded as a debit posting on raw materials and a credit posting on the goods received / invoices received account. Upon receipt of the incoming invoice (transaction 2) the posting on the goods received / invoices received account is cleared with a corresponding credit posting on the creditor account. The document number of transaction 2 becomes the clearing document number for the posting item from transaction 1. With the payment run (transaction 3) the creditor account is cleared. The document number of transaction 3 becomes the clearing document number for the posting item of transaction 2. The example illustrates how the execution of a business process instance is recorded in the system and how the processing produces a chain of journal entries within the system that is traceable.

If we abstract from this example we can conclude that transactions processed in an ERP system leave a digital trace within the system. Gehrke and Müller-Wickop [14], [15] present an algorithm that is able to mine these traces. The algorithm takes off with a start document and iteratively mines corresponding documents by identifying the relevant clearing document. If no further documents can be found the algorithm terminates. The mined information can be used for graphically reconstructing and representing the mined process instance.

Figure 2 shows a section of the reconstruction for a mined purchase process instance from a SAP system. Transactions are represented as rounded orange rectangles. Simple rectangles represent items of financial entries involved in open item accounting. The rectangles with black borders represent cleared items of financial entries. Items illustrated as rectangles without borders are not cleared and still open. Hexagons represent entries not involved in open item accounting. The color of the rectangles and hexagons indicates if the item is a debit or credit posting on a general ledger or a profit and loss account. An arrow from a business activity to an item means that the business activity has produced the item as a part of the
complete entry. An arrow from an item to a business activity means that the item has been cleared by the corresponding accounting document. Detailed information such as item number, account and amount is displayed for each item.

The shown process instance starts with the transaction MB01 (post goods receipt for purchase order). The open items are cleared by the transaction MR1M (enter incoming invoice). When entering an invoice via MR1M it is possible to explicitly reference corresponding open items. In the mined instance MR1M was executed without such explicit references. In this case the items are cleared by the ERP system automatically via the execution of transaction FBS1 (clear G/L account). FBS1 does not represent a separate business transaction and therefore does not follow the structure displayed in Figure 1. The open item posted by MR1M is cleared by transaction F110 (payment run).

5. Application controls

ERP systems provide control mechanisms in order to govern and control the processing within the system. Control mechanisms that are inherently embedded in software are called application controls. Application controls represent a type of internal controls [13]. Examples are automatic reconciliation procedures, prevention of entering duplicate transactions, system forced approvals or system based two- and three-way-matches.

Application controls play a key role for auditing system based and automated processes. They provide a means for overcoming the problem that manual testing of business transactions becomes inefficient for integrated and automated processes. Instead of testing single business transactions it is possible to test the design and effectiveness of application controls that cover whole process flows independent from the number of business transactions that are processed.

By relying on application controls provided by the system for the purpose of the financial audit automated processing of transactions can be countered by automated control mechanisms.

Unfortunately the testing of application controls itself is a manual and time-consuming procedure. Application controls are generally configured and enabled during the implementation of the system by setting relevant customizing settings. These settings need to be evaluated. However, settings for application controls are stored within the ERP systems and methods and software artifacts exist that allow to extract relevant settings and to test them in an automated way [13].

6. System based and automated audit procedures

In the previous sections we illustrated how process instances can be automatically mined and reconstructed. We point out that business process mining and reconstruction does not merely represent another CAAT. Indeed it allows introducing a new audit procedure that is adequate for the audit of companies with highly integrated and automated business processes as shown by the following considerations.

When applying a contemporary audit approach the auditor decides which financial accounts are in scope from a risk perspective and evaluates which business processes have to be considered. This decision is based on professional judgment derived primarily from experience. The scoping may be appropriate or not. It is a manual procedure and highly dependent on the knowledge and experience of the auditor. Information from the underlying information systems is not considered or only to a marginal extent although the information systems indeed provide all necessary information for a precise scoping.

Business process mining and reconstruction provides the possibility to analyze how the transactions flow throughout the system and which processes affect relevant accounts. The methods to reconstruct and visualize a single execution of a business process were presented in section 4. In order to implement automated and system based audit procedures it is necessary to aggregate mined process instances to process models that represent the process flows within the system. The aggregation of mined process instances is possible but adequate algorithms for automated aggregations are currently still under research.

We define a process flow as a collection of executed similar business activities. The process flows can be made explicit and the auditor can virtually see how they interact with the relevant accounts.

For illustrating the possibilities that business processes mining offers, we use the following analogy. We compare the financial statements of a company to a lake of water. The auditor has to provide an opinion if the lake only contains water from specific sources with a defined quality. This requirement is the analogy to the real life requirement that financial statements present a fair and true view of the financial situation of the company. Rivers feed our imaginary lake.
rivers represent transaction flows and the water transaction data. Following a contemporary audit approach the auditor would manually take samples from different places in the lake to verify the water quality (=substantive testing). Based on experience and professional judgment he would also choose several rivers for inspection and verify manually if control mechanisms are in place (=manual controls testing) that regulate the flow and quality of the water, but without knowing which rivers and concurrent flows indeed exist and how much water they actually carry into the lake.

By applying business process mining and reconstruction the auditor first develops a map with all relevant rivers that flow into the lake with information which control mechanisms control the flow and quality of the water. The auditor gathers information about how much water each river carries and which rivers or concurrent streams flow uncontrolled (=business process mining and reconstruction). Based on this understanding the auditor can decide precisely which rivers are significant and instead of taking random samples the auditor can decide specifically which controls mechanism should be tested to cover relevant process flows (=automated controls testing). Process flows with no application controls in place can be identified for targeted samples.

![Figure 3 Process flow map](image)

Figure 3 illustrates on an aggregated level a map of process flows. It illustrates how different process flows feed the financial statements. The diagram further shows how application controls interact with the process flows and how they control them.

In the upper left corner of the diagram we illustrate how a typical automated purchase process as already described section 3 would be represented.

The process flow of purchase orders (process flow 1) is controlled by a system based approval (application control A), the combined process flow of purchase orders and goods receipt (process flow 2) is controlled by an automated two-way-match (application control B). When transaction flows 1 and 2 combine with the process flow of incoming invoices (process flow 4) the combined flow is controlled by an automated three-way-match (application control C). The diagram also shows that the concurrent process flow of receipt services (process flow 3) is not controlled by the two-way-match (application control B). The reason is that commonly no receipt data for the delivery of services is available that could be subject of an automated control activity. A matching for delivered services commonly takes place between the purchase order and the invoice via application control C.

7. Conclusion

In modern companies business processes and information systems are highly integrated and transactions are executed system based and automatically. In section 3 we have shown that contemporary audit procedures for financial audits are not adequate in environments where business processes are highly integrated and automated. It is ineffective and inefficient to audit automated business processes and internal controls with manual audit procedures.

Business process mining and reconstruction provides methods and procedures that base directly on the information stored in the underlying ERP systems. These methods and procedures combined with methods and procedures usable for automated application control testing can be applied to implement system based and automated audit procedures for financial audits. Business process mining and reconstruction allows visualizing process flows within an ERP system and how these process flows interact with application controls embedded in the system. The automated and system based analysis and its graphical representation enables auditors to handle the complexity of integrated and system based business processes and internal controls.

Auditing firms have recognized the need to introduce automated audit procedures in order to keep up with technological progress [17]. Via the
application of system based and automated audit procedures as introduced in this article it is possible to meet this requirement. It is expected that the introduction of system based and automated audit procedures will lead to significant gains in effectiveness and efficiency of financial audits.

The conclusions presented in this paper base on the research work derived from the research project Virtual Accounting Worlds (VAW) [37]. A major market participant of the auditing industry participates in the project as an associated project partner. The prototype for financial business process mining and reconstruction as well as the prototype for automated application control testing has been developed within the VAW project. It is intended to develop a software artifact providing the functionality for system based and automated audit procedures as described in this article in further research.

Internal and external auditors are not the only stakeholder that would benefit from the availability of methods and artifacts for automated auditing. The process mining, reconstruction and visualization provides the basis for analyses, performance and optimization consideration that are of interest for process owners and managers, risk management and business management in general.

We have to point out that in order to implement system based and automated audit procedures further issues need to be researched. The prototypes referred to in this article [13], [14] provide software artifacts that proof the correctness and applicability of the underlying concepts and methods. Nevertheless no information is available how the artifacts will behave and perform in real live environments. The described methods for process mining allow the mining of single process instances. In order to analyze and to visualize reconstructed process flows it is necessary to aggregate mined process instances to process models. Adequate algorithms for the automated aggregation of mined process instances are still under research as well as methods for an automated visualization. Further attention has to be paid to the selection of representative process instances if the complete mining of all instances is not a viable option due to the amount of processed instances which will be a common occurrence in real life settings.

The aspects discussed in this paper focus on methods for automating business process and internal controls testing. The overall audit of financial statements is a complex and difficult task carried out by qualified experts. Process and controls testing is only a part of a financial audit. The possibilities for automating audit procedures are limited to the extent to how the underlying transaction processing is automated. Due to the fact that companies act as market participants in changing and volatile environments there will always be unique business transactions such as mergers or acquisitions that need to be evaluated by manual and substantive audit procedures. The aim of introducing system based and automated audit procedures is to counter automated processing with adequate audit procedures and to set free resources for more sophisticated audits of unique, uncontrolled or exceptional transaction that generally comprise higher risks than standard transactions.

Although further research is needed for developing mature software artifacts that allow the implementation of system based and automated audit procedures for financial audits presented in this article we conclude that the basic methods have already been developed and proofed valid.

Further research has to focus on issues such as process instance selection and automated aggregation, visualization, complexity and viability of developed algorithms. These aspects will be the focus of further research within the VAW project that has already been initiated. Specific information concerning these topics and the developed software artifact will be provided in subsequent publications.

8. References


