Towards Automated Financial Process Auditing: Aggregation and Visualization of Process Models

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Abstract: Internal and external auditors face an enormous amount of financial entries in accounting information systems. For many reasons - like legal regulations - a process-oriented view of these entries is urgently needed in order to understand the way financial entries are produced in accounting information systems and to infer the underlying processes. Traditional modeling languages focus on processes but pay no regard to the financial value-flows. Furthermore, automated process retrieval approaches only reconstruct single process instances, which need to be aggregated for reasons of comprehensibility, simplification and clearness. The paper wants to close this gap and integrate the process with the accounting perspective followed by an aggregation of single process instances. As a result we present a visualization form capable of integrating the financial view with process flows. In this way, auditors are able to trace how balance sheet items have been produced in the system during the fiscal year.

1 Introduction

Current technological support for internal and external auditors is very limited. The last decade painfully shows how weakly conducted audits result in unprecedented business turbulences with corporate fraud and partly followed by collapse (years of incidents: Enron 2001; MCI WorldCom 2002; Parmalat 2003; AIG 2004; Fannie Mae 2006; Satyam 2009). Combined with the so-called “Financial Crisis” beginning in 2008 and ongoing uncertainty for the global economy, political as well as scientific focus is on the way audits are done nowadays [EU10]. Even though auditors are increasingly recognized as playing a critical role within companies, their repertoire of supporting tools and methods is out-dated. To (at least partly) remedy this deplorable state of affairs is the main objective of the paper at hand.

Today’s internal and external audits focus on processes [Be97][Ru03][Ru06]. Within the bounds of process auditing an automated approach is to be developed. In this context, different aspects need to be taken into account. First, an automated approach for a retrograde reconstruction of process- and value-flows from Enterprise Resource Planning (ERP) and Accounting Information Systems (AIS) must be developed. This has been done by introducing Financial Process Mining [GM10]. The automated retrieval of process instances (a process instance can be described as the representation of one execution of a business process) from system data is followed by the presentation of mined results. Modeling these results needs to fulfill different requirements for different groups of stakeholders. This paper is focused on internal and external auditors as stakeholders. Additional stakeholders include - but are not limited to - business process managers, process owners, risk managers, the board of directors and the audit committee. Both, internal and external auditors, have mainly overlapping interests.

In the case of process audits an integrated view of value-flows and process flows is essential. While process flows are in the foreground, the corresponding value-flows also have to be considered in terms of risk and "materiality" (for a definition see ISA 320.3 [IFAC10]). An adequate visualization – integrating both views - has been developed and is described in chapter 4 "Related Work". In order to gain an overall-view of the process flow including the financial flows, mined process instances need to be aggregated into process models.

This paper was written to take an important step towards automated process audits. In a first step the motivation for this research problem will be explained to introduce the reader to this domain (section 2). For a further understanding the research method (section 3) as well as related work (section 4) will be presented. Following this introduction, an approach for the aggregation of financial process instances will be laid out (section 5). We conclude this paper with a summary and an outlook on work of future research in this field (section 6).

2 Motivation

An integral part of a modern approach for auditing company's financial statements is the process audit [Ru06]. This is justified by the fact that conventional auditing methods (substantive audit procedures performed for single business transactions, based on "Analytics" and "Test of Detail") seem more and more impracticable from an efficiency point of view in a world where the number of business transactions is dramatically increasing and all data is electronically available in ERP systems. The argument behind process auditing is that all business transactions running through well designed and controlled business processes will be properly represented in the financial statements of the company [Be97] [Ru06]. Following this approach the design of the business processes including relevant controls are reviewed. Furthermore the compliance with defined processes throughout the year is checked for a sample of business transactions. The audit results are then applied to all business transactions ran through the corresponding process in the financial period under investigation.

Process audits utilize interviews as means to survey the business processes of a company [Ru03]. A number of employees involved in a business process are interviewed. Based on the information gained through these interviews auditors are modeling their understanding of the actual processes including relevant controls with the help of flowcharts and/ or narratives [Ru03] (ISA 315 [IFAC10]). Software supporting the task of business process survey is rarely used in current audit approaches. There are several severe issues in this approach. One is the influence of perceptions, i.e. involved individuals are only able to express their subjective perception of reality or the gained information is normative in the sense that it states what is expected to be done rather than describing the actual process [Aa02]. Secondly an auditor has to rely on the information he obtains by the employees regardless if it is potentially erroneous on purpose or unintentionally. Thirdly interviews are time-consuming and therefore come along with high costs. Last and from audit perspective the main point is that processes are not derived from the business transactions stored in ERP systems itself although the results of the process audit are applied to them later. This is the key problem our process mining approach for financial audits is aiming at. Therefore the objective is the development of an automated approach for a retrograde reconstruction of processes from business transaction data stored in ERP and AIS.

Although motivated by efficiency arguments process audits are also obligate by international standards[1] as they are considered as important steps for understanding the client's business and so forming the basis for a well-founded audit of the financial statements. Starting point for this audit methodology was the introduction of the Business Risk Audit (BRA) by Bell et al. in 1997 [Be97]. BRA can be characterized as a top down audit approach starting with an analysis of the business strategy, significant business transactions and business risks of a client. Subsequently the key processes of the client are identified and analyzed regarding their conformance to business goals, handling of significant business transactions and the coverage of identified business risks. Detailed (transaction oriented) audit procedures are than effectively planned and performed based on the comprehensive knowledge gained during the previous steps. The BRA aims at focusing on audit procedures related to areas which have been identified as being exposed to high audit risks. The core idea of BRA is that a better understanding of the client's business significantly correlates with a better understanding of the audit risks [Be97]. According to the International Standard on Auditing (ISA) 200 “The risk that the auditor expresses an inappropriate audit opinion when the financial statements are materially misstated” is defined as audit risk. Therefore an important method for focusing the audit activities on areas with a high audit risk is the concept of materiality. According to ISA 320 (Materiality in planning and performing an audit) materiality is defined as follows ”Misstatements [in the financial statements], including omissions, are considered to be material if they, individually or in the aggregate, could reasonably be expected to influence the economic decisions of users taken on the basis of the financial statements.” [IFAC10]. Consequently for each audit a materiality (quantitative and/ or qualitative measure) is to be determined by the auditor. The materiality is than applied in planning and performing an audit of the financial statements (ISA 320 [IFAC10]).

The “Big Four”[2] turned towards the BRA, not only for its higher efficiency (reducing the amount of substantive audit procedures and test-of-details, as mentioned above), but also

[1] For instance ISA 315 states that “the auditor should obtain an understanding of the information system, including the related business processes, relevant to financial reporting (…)” ISA 315.81 [IFAC10].

[2] The “Big Four” are the four largest international accountancy and professional services firms: Ernst & Young (E&Y), Deloitte Touche Tohmatsu (Deloitte), Klynveld Peat Marwick Goerdeler (KPMG) and PricewaterhouseCoopers (PwC)

because of an increased value added for the client as well as a stronger link between risk management and audit [Ru06].

To support the auditors planning activities especially the decision which processes/ process variants will be subject to detailed audit procedures in due consideration of materiality our automated approach for a retrograde reconstruction of processes will not only consider the process flow itself but also integrate the corresponding value-flows. Two steps are necessary for this reconstruction task. First single business transactions which can be seen as process instances need to be reconstructed from the data stored in ERP systems. Secondly these process instances must be aggregated to infer the underlying processes/ process variants. The first step is described in [GM10]. This paper is dealing with the second step.

3 Research Method / Research problem and research methodology

Following the guidelines for Design Science Research in Information Systems [He04][MS95], this paper is focused on developing a relevant IT artifact (constructs, models, methods and implementations). This artifact represents a domain-specific modeling notation and rules for aggregation of process instances constructed from financial entries stored in ERP systems. Artifacts facilitate the analysis, design, implementation and use of information systems [He04][De97].

The research idea came from the awareness of a problem that became apparent in current audit practice (inductive reasoning) regarding process audits in the context of year-end audits. Referred to [Pe07] a problem-centered approach is on hand. The research problem can be described as follows. Process audits are in fact an integral part of the audit of the financial statements of a company. However process audits are based on information not directly derived from the financial entries constituting as a whole the financial statements. Process audits are performed based on process models constructed with the help of qualitative methods of collecting data (e.g. guided interviews). Nonetheless the results of the process audit are used to develop the auditor's opinion on the financial statements. There is a gap between the data source the audit results are based on (process audit) and the data source the audit results are applied to (financial statements). Theoretical considerations based on a literature review (deductive reasoning) helped to achieve a further understanding of the problem.

Starting from this research question following objectives were derived for an artifact to be designed. There should be an automated approach for a retrograde reconstruction of process instances and corresponding value-flows from financial entries stored in ERP systems. Furthermore, there should be a modeling notation representing the reconstructed process instances and aggregation rules to infer a generalized view on all process instances constituting the financial statements.

In this paper a BPMN-based notation capable of integrating the financial view with the process flows is proposed. In [GM10] an algorithm is described for reconstructing process instances from financial entries. Based on this, aggregation rules for process instances are developed. These rules were developed with individual sample process instances from a standard SAP IDES system and are presented as narratives.

4 Related Work

4.1 Financial Process Mining

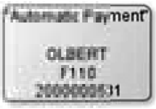
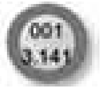
Financial Process Mining is a subset of the Process Mining family in which all kind of process, control, data, organizational and social structures are discovered in log files or other data stored in information systems [Aa11]. According to van Dongen and van der Aalst the goal of Process Mining is the construction of “a formal model describing a set of real life executions” [DA05]. By now, the research field of Process Mining as a whole is a fairly well researched. The first research was done in 1995 by Cook and Wolf for the software engineering process [CW95]. In 1998, process mining was adapted to Workflow Systems by Agrawal and Gunopulos [AGL98]. A full overview until 2002 is given by van der Aalst et al. in [Aa02]. Up to now most of the Process Mining techniques have been developed for event log data stored in different kind of information systems (e.g. workflow management systems, ERP or AIS) and therefore focusing on process flow reconstruction [Ra06]. Most research in this domain focuses on heuristics based algorithms searching for an order of relations between events in event logs [Me03]. Recent approaches like decision mining and social network/ organizational mining tend to broaden the considered data sources [RV06][VS04]. However, data of financial entries stored in ERP systems instead of using event logs as data source is not yet considered. In [GM10] an algorithm is described which mines financial entries and reconstructs the corresponding process instances by using information from the open item accounting. These process instances are the basis for the aggregation and inference of the underlying process models described in this paper.

A number of approaches for aggregating resp. merging process instances are suggested in literature. [Ro10] provide an algorithm that produces a single configurable process model encompassing the behavior of the input models. [GVJ08] use an abstraction called functional graph to merge event driven process chains. [SKY06] define four types of merge (sequential, parallel, conditional, and iterative) and describe corresponding algorithms for performing the merge operations. [LCW09] describe a heuristic algorithm to construct a generic process model from process variants which minimizes the average distance between the generic model and the process variants. [DDA06] offer three algorithms for discovering process models from process runs which differ regarding the information contained in these runs. In [DA05] a multi-step approach for inferring an overall process model from single processes instances is suggested. Moreover frameworks for comparing different merge approaches and for merging incomplete and inconsistent graph-based views are presented in [Br06] and [SE06]. However, these approaches do not fulfill the requirements from an audit perspective outlined in section 5.1 Data source, Requirements and Illustration.

4.2 Modeling Languages - BPMN(-Finance)

At present, there is a broad variety of different process modeling languages in research and practice. The main representatives are the Business Process Modeling Notation (BPMN) [BPMI04] and the Event Driven Process Chain (EPC) [SN95][SN00] [KNS92]. Other modeling languages include the Integrated Definition (IDEF) [MM06] [KBS10], Petri Nets [Pe62] and the Unified Modeling Language (UML) [OMG10] [Ru04]. In addition there are further scientific modeling languages, see e.g. [Za01] [KLL09].

Considering the objective of this paper only a modeling language capable of integrating the financial- and process-dimension is appropriate. Subsequently a notation is proposed to depict financial process instances including value flows using BPMN. For an evaluation see [LK06]. SAP was chosen as test ERP System. Therefore all properties are displayed with their SAP terms. The BPMN-Finance notation described below will later be used for an illustrative example of the aggregation algorithm.

BPMN-Finance	
	BPMN activities are business activities. In SAP these are implemented as transactions or subprograms. In this example the transaction name (Automatic Payment), the user who carried out the transaction (OLBERT), the actual transaction code (F110) and the document number which was created when the transaction was executed (2000000531) are shown. It is possible to add any data of the document header. Moreover, it is feasible to mark transactions representing control activities by color coding them.
	Events are items on accounts. The first number represents the item number of the document (001), the number below indicates the actual amount which was posted to the account (3.141 €). In addition to the conventional BPMN meaning (start-, intermediate- and end-event) the color of an event has a meaning:
Blue	The item has been posted to a balance sheet account on the asset side. This means an additional asset has been posted or a liability has been compensated (= Debit).
Yellow	The item has been posted to a balance sheet account on the liability side. This means an additional liability has been posted or an asset has been compensated (= Credit).
Green	The item is an income posting (= Debit, Profit & Loss is affected).
Red	The item is an expense entry (= Credit, Profit & Loss is affected).
⟶	BPMN sequence flows connect activities, gateways and events. Their function is to specify the process flow in BPMN models. In the proposed notation the sequence flows connect transactions (activities) and items on accounts (events). The process flow does not always reflect the chronological order of the processing in an ERP system (here in SAP). For a better understanding our notation depicts the logical order of events and activities. Another advantage of this approach is the independence of a particular ERP system, as different systems may have deviant internal processing logic. Regardless of the process flow, a connection between an activity (transaction) and an event (item) indicates that the item was posted by

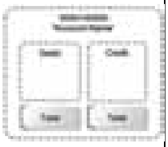
	this transaction. Activities within accounts (see below) constitute an exception. They represent a clearing of open items. Including them is necessary as a manual execution is technically possible posing a risk of incorrect assignment. Edges between events depict the assignment of a clearing item and the corresponding cleared item.
	BPMN groups represent accounts in BPMN-Finance. In the top middle the account number and the account name is shown. The design is following conventional accounting practice. By coloring the account open-item managed accounts are indicated.
Orange	The financial account is not involved in open item accounting.
Black	Financial account is involved in open item accounting.

Table 1: BPMN-Finance modeling elements

5 The Financial Process Data Aggregation (FPDA) Algorithm

5.1 Data source, Requirements and Illustration

Process instances reconstructed from financial entries can be described as directed graphs. Nodes are classified in two fundamentally different groups: activities (transactions in SAP) and events (items in SAP). Items are grouped into accounts. In a simplified representation of a process instance accounts are depicted as a node, not a single item. These two groups are differentiated by their properties. Each account and each transaction can be included more than once in the same process instance. A process instance starts and ends with 1-n accounts. Accounts are linked by transactions. Each transaction can be linked to 2-n accounts. Accounts cannot be linked directly with each other. The linkage is depicted by edges representing the process flow within the process instance. Process instances include no cycles resp. can be represented as an acyclic directed graph. Reason is that the linkage between transactions and accounts is based on financial entries. A financial entry cannot be posted twice, there are uniquely identified by their document number in the ERP systems.

From a data perspective following can be stated: for inferring the aggregated process model the data source is globally complete. Considering the domain of financial audit only a certain time period (e.g. fiscal year) is relevant. Hence there are a finite number of relevant financial entries which can be determined in the ERP system and used for the aggregation. Provided that the used ERP system fulfills generally accepted accounting principles the source data is free from noise.

For the aggregation algorithm following requirements can be specified from an audit perspective:

Completeness: Each process sequence being part of the process instances which are used for the aggregation need to be included in the aggregated process model. In this context sequence means a possible way in a process instance (graph).

Rationale: An auditor has to give an opinion on the financial statements as a whole. Hence, the method of materiality would suggest reducing the aggregated processes model to process sequences with a value flow on or above materiality level. But auditors are obliged to apply also qualitative materiality measures and are forced to put specific attention to sources for material misstatements (e.g. accounting errors, fraud) (ISA 240, ISA 320, [IFAC10]). Therefore rare or abnormal process sequences are potentially of high interest for the auditor's opinion.

No new process sequences: Exclusively process sequences included in the process instances which are used for the aggregation should be incorporated in the aggregated process model.

Rationale: As described above only a certain time period (in most cases a fiscal year) with finite number of financial entries is relevant from an audit perspective. The aggregated process model should only contain process sequences at least one financial entry can be associated with. Otherwise the process sequence was not executed in real world and is therefore not relevant for the audit.

No cycles: The aggregation algorithm should not create cycles.

Rationale: As the process instances are acyclic itself the aggregated process model should also be acyclic to reflect the characteristics of the underlying process instances and consequently the characteristics of the underlying financial entries.

Given the requirements listed above algorithms mentioned in the literature can be evaluated regarding their applicability. As said before the focus of most research in the domain of process mining is on heuristics based algorithms. Statistical and heuristic approaches do not necessarily ensure completeness as certain sequences in the process instances may have a low probability and therefore remain undetected [Me03]. In addition, as the data source in the domain of financial processes is globally complete purely algorithmic approaches seem to be more appropriate [CW98][SKY06][Ro10] [GVJ08][DA05][DDA06][Me04]. However, these approaches either create cycles in or add additional behavior (new process sequences which are not included in the input process instances) to the aggregated process models. As explained above these are undesired properties in our use case.

Therefore we present a new aggregation algorithm. It operates with process instances reconstructed according to the mining algorithm introduced in [GM10]. For demonstration purposes a payment run instance and a manual payment instance were chosen and simplified. The automatic payment run has three generic activities: 1. "Receive goods", 2. "Receive invoice" and 3. "Pay invoice". The actual mined process instance had 26 "Post Goods Receipt for PO" transactions and 26 corresponding "Post invoice document" transactions. Out of these 26 concurrent process flows, two were randomly chosen. The manual payment instance has the same three generic activities. However, for the 3rd activity a different SAP transaction was used. The used accounts are also the same besides two Accounts: "400100 - Purchase Raw M." and "305000 - Packaging Material" The basic process instances look like the following (please note the sequence flow from the right to the left), see Figure 1:

128

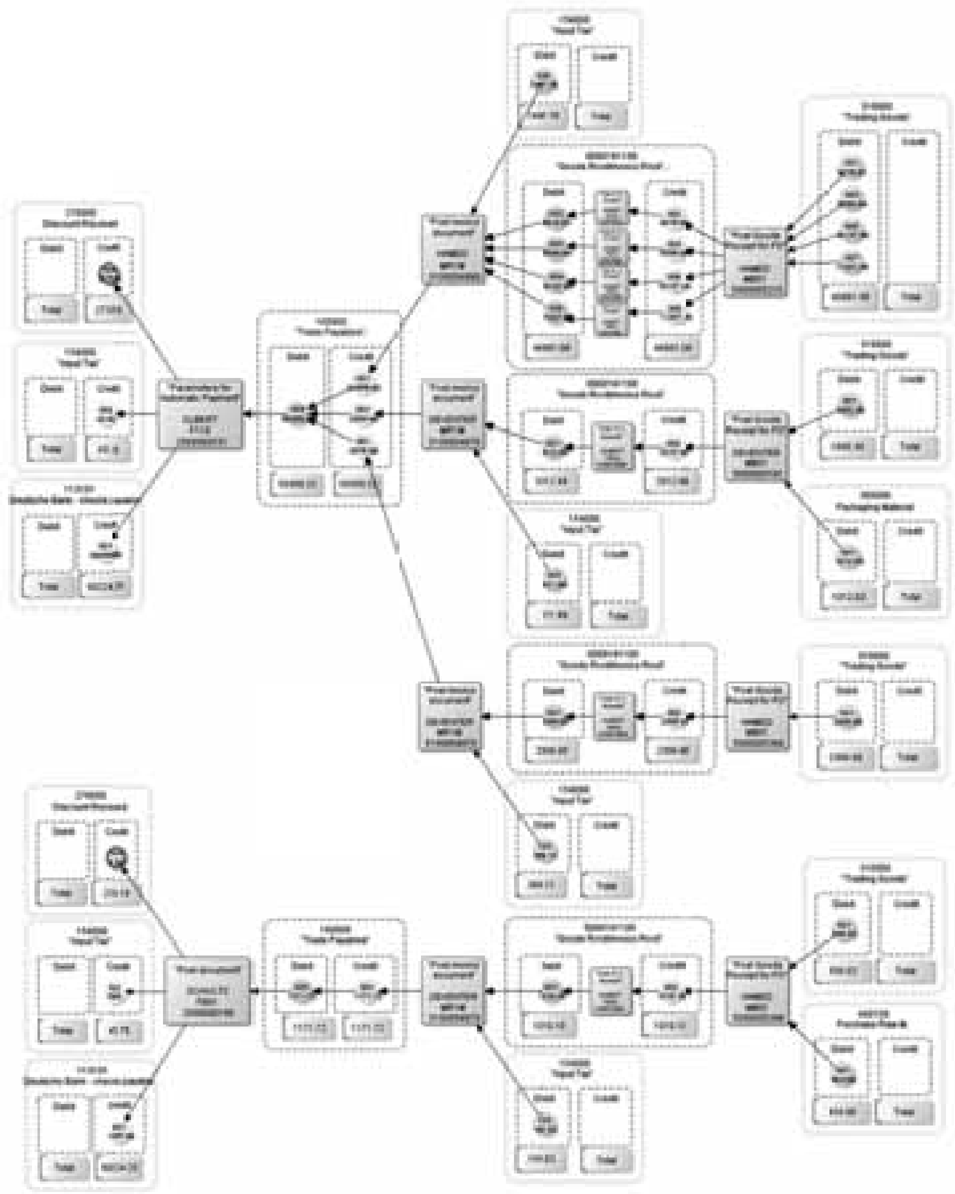


Figure 1: Initial process instances (22 accounts; 10 transactions)

5.2 Defining start and end events

Start- and end-events (items) need to meet at least one of the following two conditions:

1. The account they are posted to is not involved in open-item-accounting
2. There is no clearing-document for this item

For all identified items (e.g. debit item) meeting one of these conditions it is to be determined whether they are start- or end-events. This is done by examining their offsetting item (e.g. credit item). If this offsetting item cleared an item the selected item is an end-event. On the contrary, if the offsetting item got cleared the selected item is a start-event. By applying this rule all start- and end-events are identified and marked as such.

5.3 Defining internal, start and end nodes for the algorithm

All accounts either exclusively containing items which are identified as start- or end-events are marked as start or end nodes depending on their items. All other accounts and activities are marked as process model internal nodes distinguished by their names. Accounts are named after their account names, activities are named after their activity names.

For demonstration reasons a generic model of the payment run instance depicted in Figure 1 is created. Accounts are represented by nodes named with capital letters and activities / SAP transactions are represented by nodes named with numbers. The generic model in Figure 2 represents the above presented model. Green nodes are start nodes, red nodes are end nodes and yellow nodes are internal nodes.

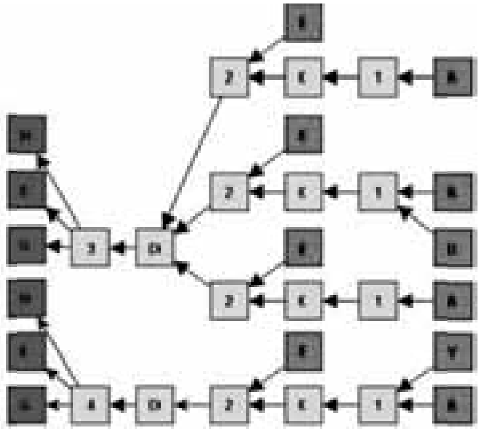


Figure 2: Generic process model

5.4 Perform the aggregation

Apply rule no1: All identical start and end nodes are merged.

Merging accounts is done by inserting all items to one combined account. In general activities are also united straight away. Please note that some transaction specific information could be lost when merging activities, e.g. the user who executed the activity. The generic process model in Figure 3 illustrates this step:

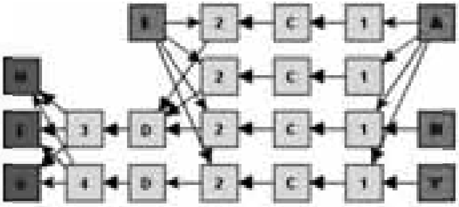


Figure 3: Generic process model after merging start and end nodes

After merging all start and end nodes the algorithm identifies all possible sequences from start to end nodes. When referring to sequences a possible way from a start to an end node is meant.

Apply rule no2: All identical sequences (including the predecessor sequences of each node) beginning from the start nodes are merged.

Each identified sequence starting from a start node is compared to all other sequences - the longest possible match between each pair is marked for merger if all predecessor sequences of each node included in the two selected sequences are identical. The generic process model in Figure 4 illustrates this step:

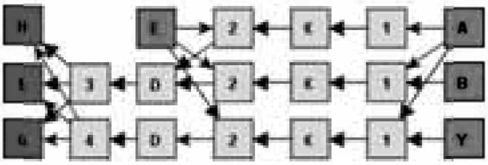


Figure 4: Generic process model after applying rule no2

In theory, a complex process model would have various node sequences and therefore the possible number of combinations to be compared would be enormous. For real world data we did not experience this as a problem. Sophisticated process instances which result in a great number of comparisons were very rare.

Apply rule no3: All identical sequences (including the successor sequences of each node) beginning from the start and end nodes are merged.

First the algorithm compares all identified sequences beginning with a start node to each other. The longest match between each sequence is marked for merger if all successor sequences of each node included in the two selected sequences are identical. This step is repeated for all end notes. The generic process model in Figure 5 illustrates this step:

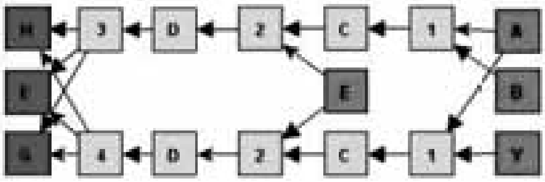


Figure 5: Generic process model after applying rule no3

Transforming the above shown generic process model back in the original format we obtain the process model presented in Figure 6. As you can see a considerable simplification of the original process instances is achieved. Never the less all initial process instances are fully included and no new process sequences are created. Furthermore, it is evident that a purchase of raw material (account “400100 Purchase Raw M.”) is always accompanied by manual payment (activity/ SAP transaction FB01 "Post document") by Mr. Schultz. On the other hand, a purchase of inventory goods always comes along with an automatic payment run.

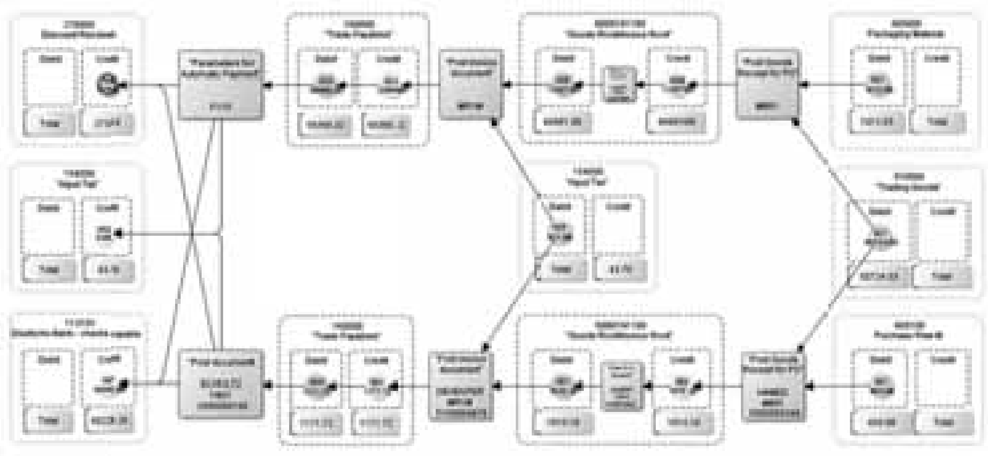


Figure 6: Aggregated process model (11 accounts; 6 activities / SAP transactions)

6 Summary and Future Work

In this paper we have provided an approach for the visualization and aggregation of process instances extracted from ERP systems or AIS. The development and the demonstration were based on SAP as a well-known and widely-used ERP system. With this approach two goals have been achieved. Firstly, process flows and value-flows are integrated in a notation (BPMN-Finance). Secondly, rules for the aggregation of process instances were provided to infer a less complex process model representing all process instances considering audit requirements. The visualization of financial processes shall help external and internal auditors to shift their view towards financial processes: from financial statements being a set of items on accounts to a process-oriented perspective. This perspective explains which processes and procedures produced the financial entries and therefore the financial statements throughout the fiscal year. Using an appropriate notation and aggregation this process view aims at a better and faster understanding of the interdependencies and procedures within the accounting function by allowing an easier cognitive processing. Future work will include research in the area of rule based abstraction and document property oriented visualization.

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