

Conceptual Model of Accounts

Closing the Gap between Financial Statements and Business Process Modeling

Niels Müller-Wickop, Markus Nüttgens

University of Hamburg
Max-Brauer-Allee 60, Hamburg

{niels.mueller-wickop | markus.nuettgens}@wiso.uni-hamburg.de

Abstract: A comprehensive understanding of business processes is crucial for an in-depth audit of a company's financial reporting and regulatory compliance. Recent major financial scandals impressively demonstrate the insufficiency of today's audit methods. The most discussed method for improving the current state of things are process audits because well-controlled business processes lead to correct preparation, presentation, and disclosure of financial statements. In an attempt to improve the support of business process auditors, we present a conceptual model to close the gap between processes and their financial impacts. This conceptual model introduces accounts and associated booking-items making financial impacts visible. It is then integrated into the meta-model of a business process modeling language, namely the extended event-driven process chain. Moreover, this paper demonstrates an exemplary implementation with notational elements supporting the visualization of financial impacts. The paper ends with a questionnaire-based expert evaluation revealing that the proposed artifact is positively assessed overall.

Keywords: Conceptual Model of Accounts, Financial Impacts, eEPC Extension, BPML Extension

1 Introduction

Enterprise Resource Planning Systems (ERP) are complex and integrated systems used in most organizations worldwide. By now, organizations are strongly dependent on these systems since they not only manage the majority of data, but also support nearly all of the business processes. Along with the automation, the complexity of processes increases. In most countries worldwide, auditors are obliged by law to audit business processes relevant to financial reporting. For instance, the International Standards on Auditing (ISA) 315.81 require that: "(...) the auditor should obtain an understanding of the information system, including the related business processes, relevant to financial reporting (...)" [IFAC10]. Correctness of annual statements is vital to the business world as for instance investment decisions are based on them. However, widely recognized

cases of corporate fraud and bankruptcy including Enron (2001), MCI WorldCom (2002), Satyam (2009), and Olympus (2011) demonstrate the inability of auditors to provide reasonable assurance over financial statements. In order to master this challenge, auditors apply the following three approaches: 1. *Business risk audit* [Be97] 2. *Technical support of auditors* [BD03] 3. *Process audit* [Ru03]. However, only the first method is fully implemented in current audit approaches. Technical support of auditors is still lagging behind since documentation and mass-data analysis are broadly supported by tools while other tasks mostly remain unsupported (e.g. calculation of materiality for “material classes of transactions” [Re01] or scoping of relevant processes). Especially, the third method – process audits – lacks support. This method demands a supportive representation of business processes [Bo11] as auditors provide assurance increasingly based on business processes [HK10]. In his roadmap for research in business process compliance, Sadiq noted that “tools and methods are needed to annotate, enhance, analyze and simulate business models with compliance and risk modeling elements” [Sa11]. Based on the assumption that well-controlled business processes lead to correct preparation, presentation, and disclosure of financial statements, the most discussed method for improving the current state are process audits. That is because processes determine the financial statements. Therefore, it is of great importance for auditors to link financial impacts of processes to the financial statements in order to give assurance over financial statements. Moreover, in order to focus on relevant processes only, so called material processes need to be identified. Relevance (or materiality in this case) is defined as a certain predetermined threshold. This threshold is expressed in monetary units. Until now the link between processes and their financial impacts was not existent and therefore only vague knowledge about the actual connection between processes and their activities on the one side and financial impacts on the other side existed. This results in selection of irrelevant processes (from an audit perspective). In the end, supreme process compliance checking technics are of no use if applied to the wrong/not material processes. This aspect has been widely neglected by the academic community until now, leaving a significant gap. Consequently, Alencar et al. call to close the missing link between business processes and financial statements [Al08]. The development of Financial Process Mining (FPM) constitutes a first step towards closing this gap [GM10a], [GM10b] – capable of automatically mining processes and corresponding financial flows from ERP data. However, the results of FPM are graphs in databases, not being appropriately graphically represented. Kharbili noted that a graphical notation for modeling compliance, like financial impacts of processes, will help endorse existing audit approaches [Kh08]. FPM does not fulfill this requirement. As a result, the deplorable state of affairs persists in which auditors are still not able to close the gap between business processes and the financial statements of a company. Thus, a thorough detection of faulty processes is still not possible and accounting scandals as well as misguided investments are still likely.

To close this gap, the paper at hand presents a conceptual model of accounts as a basis for linking business processes and accounts. Recent research confirms that accounts are among the most important concepts in the course of process audits [Sc12], [Mu13]. The conceptual model represents a possible extension to existing business process modeling

languages (BPML) to incorporate financial flows in process models. Thus, financial impacts of business processes become evident, supporting the auditor in his everyday work and enabling him to provide a higher level of assurance. This, in turn, results in a smaller likelihood of corporate fraud or even bankruptcy.

The financial impacts of business processes in focus here logically require the utilization of a modeling language for visualizing business processes. Business process modeling languages (BPML) have been developed for this purpose. However, no existing BPML combines process flows with financial impacts respectively postings to accounts. The latter represent financial impacts in the world of accounting: every activity in an organization with a financial impact mandatorily results in a posting to one to many accounts. For this reason, the paper at hand uses the expressions “financial impact” and “posting/booking to accounts” synonymously. In order to set a sound and broad foundation for a rigorous extension of BPMLs, this paper presents a conceptual model of accounts as a first step. Second, as an evaluation regarding the feasibility, the conceptual model will be inserted into the meta-model of one of the most widely spread BPMLs [MN06], [Pe08], [Aa99], namely eEPC [Ke92]. By this means, processes posting to accounts become evident and accordingly their financial impact. In conclusion, an example will evaluate the feasibility of the proposed extension.

The next section provides background information and describes related research, while *Section 3* presents the conceptual model of accounts. Subsequent sections make use of this to extend the eEPC meta-model and introduce new notational elements. *Section 6* presents an example process. The following section describes the results of the questionnaire-based evaluation. The paper ends with a conclusion and implications for future research work.

2 Background and Related Research

Due to the objective of this paper, the following paragraphs present a brief summary of conceptual modeling, BPML extensions, and first attempts to integrate accounts into BPM approaches. The literature review is based on a pivotal review. Due to restrictions in space this research work restrains from describing the approach in detail (for details please refer to [Br09], [LE06], and [WW02b]).

Conceptual modeling has been one of the core tasks within the information systems field for over 30 years. It involves the domain-specific construction of models for certain phenomena [WW02a]. Among other purposes, the facilitation of understanding and communication between stakeholders is most important [Si04]. Early approaches primarily focus on the organization’s data. For instance, Smith and Smith introduced the notion of generalization in database modeling according to the concept of strict inheritance in 1977 [SS77]. These initial approaches only consider processes as far as they interact with data [Re09]. This covers only half of the paper’s purpose: account entries can be understood as data. However, their corresponding processes need to be taken into account as well in order to fully cover the extent of process audits. In recent times, the application range of conceptual modeling has broadened. Uses now

comprehensively include processes and their diverse in- and outputs, leading to the so called process-aware perspective on information systems [Du05]. This broader perspective on conceptual modeling – including associated processes – is the foundation for the conceptual modeling of business processes, namely process modeling which forms the basis to this work [Re09].

Business process modeling is characterized by numerous fields of application which are promising in business practices. Consequently, research on business process modeling has attracted increasing attention in academia for the last 20 years. However, the long-discussed possible insufficient expressiveness of modeling languages [RD07] and the lack of coverage of all requirements demands the utilization of extensions. The underlying literature review comprises noteworthy BPML extensions in the field of compliance. There were great expectations that within the scope of compliance in combination with BPML extensions, similar approaches would already have been published. These could have been used as a blueprint to the approach presented here. Unfortunately no such work could be identified. The literature review identified 55 relevant articles focusing on BPML extensions. In order to evaluate these articles, the review considered three categories - *Type*, *Language*, and *Topic*. The latter two did not include subcategories, whereas *Type* comprises meta-model extensions and notational extensions. Regarding the objective of this paper, the category of *Type* is of great importance. This is because auditors need suitable graphical representation (notational elements) along with a rigorous and sound implementation that is comprehensible for third parties (meta-model). The category of *Languages* is of relevance because of the great differences between the usability and expressiveness of BPMLs [RD07]. However, in the course of research presented here, the category *Topic* is most interesting. A total of 29 articles focus on non-functional extensions, 18 make functional extensions their objective, and 5 map one BPML to others. Within functional extensions, the majority of publications add either configurable modeling elements, or new classes of connectors. Another well- represented group of functional extensions propose semantics for the languages, whereas non-functional extensions consider all kind of performance aspects (e.g. lead time), quality requirements (e.g. data quality), resource aspects (e.g. responsibility of departments), and compliance aspects. The last group of extensions primarily focus on the security and controls of processes [AW10], [AW11], [Fr12], [Mi08], [Ro07], [Sc10], [WS07]. From an audit perspective, the latter aspects are closely related to the topic of financial impacts of processes. Controls often require the consideration of financial flows. However, the integration has been neglected so far. In other words, the integration of financial accounts has not been considered in BPML extensions.

Apart from that, accounts are only rarely discussed in business process management (BPM) literature. The two most recognizable publications are those by Karagiannis et al. [Ka07] and vom Brocke et al. [Br11]. Besides those publications, Namiri et al. consider accounts but only the portion of it that interacts with process controls [NS08] [NS07]. They call to “identify all relevant business processes that affect those (significant accounts) accounts” [NS08]. Yet, they do not describe how to identify significant accounts. The publication by Karagiannis et al. takes a controls-focused compliance perspective as well. They state, that “some accounts affect financial reporting and

therefore also need to be controlled”. Vom Brocke et al. primarily focus on process-oriented accounting. Both publications form a basis for the paper at hand. However, they remain on an abstract level, incorporating the concept of accounts into meta-models only defining accounts as an abstract object without sub-concepts. Therefore, the following section proposes a conceptual model of accounts with sub-concepts. In addition, an extension to the eEPC meta-model including modeling instructions and an example for the missing concept of accounts is given.

Besides the afore-mentioned publications further research was taken into account: (Everest & Weber 1977) (Wand & Weber 2002) (Shahwan 2011)(McCarthy 1979) (McCarthy 2003) (Du & Wang 2011). But again, their work can only be used as a foundation for two reasons: firstly, financial aspects are incorporated in their models but on a data centric perspective (mostly ER-models) rather than on a process oriented view (e.g. EPCs). Secondly, although their work is object oriented the central object is missing (bookings / account entries). As has already pointed out, this suggestion for improvement has been integrated in the paper at hand.

3 Conceptual Model of Accounts

Accountants worldwide use the concept of accounts for their everyday work. Virtually all booking techniques base on accounts, e.g. double-entry book keeping or fiscal accounting. Consequently, the concept of accounts and corresponding sub-concepts are highly standardized [E185]. This standardized – and to the authors knowledge only – representation of accounts is used as a basis. As this paper aims at closing the gap between business process modeling and financial impacts, it takes advantage of this standardization by introducing a conceptual model of accounts in the context of BPMLs. As vom Brocke and Buddendick call for reusable conceptual models [BB96], the conceptual model presented here facilitates reuse by clearly indicating on how a subsequent integration into different BPMLs is possible. This is achieved by introducing connection classes to BPMLs within the conceptual model, viz. *Group* and *Data*. Most BPMLs readily provide these classes. For this reason, the conceptual model of accounts uses these as connection classes.

Figure 1 depicts the general structure of accounts in as UML class diagram [OMG11b]. The conceptual model incorporates the classes *Account*, *DebitAndCredit*, *AccountEntry*, and *Balance*. Furthermore, the model depicts the general BPML concepts of *Group* and *Data*.

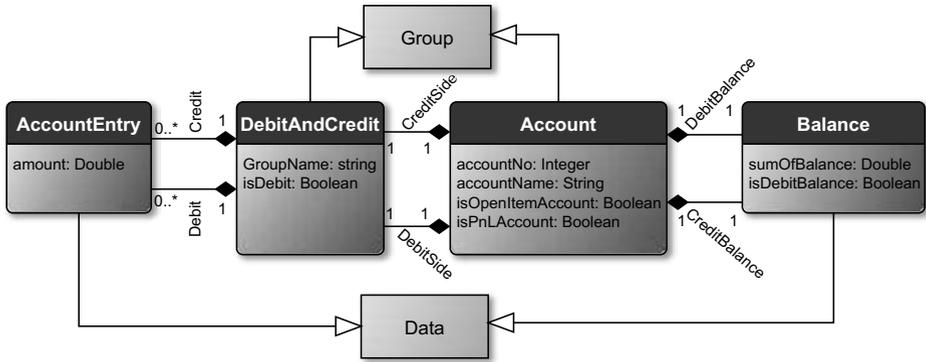


Figure 1: Conceptual Model of Accounts

Accounts are groups including two *DebitAndCredit* groups. Thus, both (sub-) concepts resp. classes are child classes of *Group*. These classes have attributes according to their usage in the accounting domain. Accounts own names (attribute: *accountName*), a unique identifier (attribute: *accountNumber*), are either involved in open item accounting or not (attribute: *isOpenItemAccount*), and are either profit and loss or balance sheet accounts (attribute: *isPnLAccount*). The *DebitAndCredit* class provides a name (attribute: *GroupName*) and a boolean value defining its being a debit or credit group (attribute: *isDebit*). Each Account exactly contains one credit and one debit group. These debit and credit groups include none to many so-called account entries (class: *AccountEntry*). Account entries are bookings or, in technical terms: entries in the database of a system. Therefore, an account entry will be a child class of *Data*. Nearly all BPMLs include the concept of *Data*. *AccountEntry* owns the attribute *amount* (= value of the account). In addition, the conceptual model adds a credit and a debit balance (class: *Balance*) for the quick recognition of the transaction volume of each account. *Balance* again is a child class of *Data* and has the attributes *sumOfBalance* and *isDebitBalance*.

4 Extending the eEPC Meta-Model

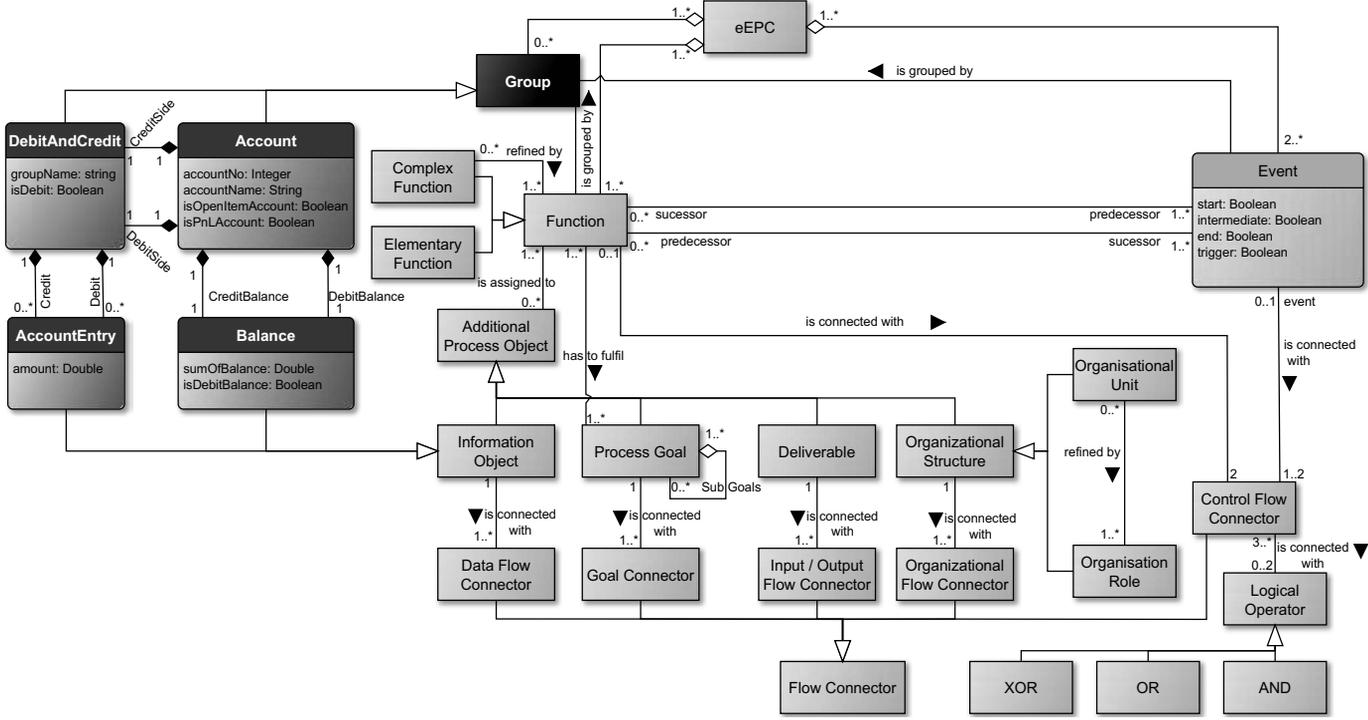
This section demonstrates how to implement the concept of accounts into a BMPL as a first evaluation regarding feasibility. For that purpose, the approach extends the eEPC, one of the two most widespread BPMLs (the other being BPMN by now [OMG11a]). The approach is generalizable and therefore transferable to other BPML. In order to extend the eEPC in a sound and rigorous way, the extension proposes a meta-model extension. Moreover, this approach can be understood as a manual for the transfer of the extension to other BPMLs.

This paper uses the most recognized and comprehensive meta-model of the eEPC published by Korherr et al. [KL07] due to the fact that no standardization committee is in charge for the (e)EPC and no standardized meta-model is provided by the first publications of the eEPC. It is derived from the ARIS House meta-model [SN00].

Figure 2 depicts the eEPC meta-model (light classes) including the proposed concept of accounts (dark classes). As *Section 3* already described, the conceptual model of accounts has two connection classes: *Group* and *Data*. The eEPC meta-model provides one of these two necessary classes – but the concept of *Groups* is not yet implemented in eEPCs. Moreover, the literature review revealed that until now no extension of the EPC with the concept of *Groups* has been implemented.

For this reason, the concept of *Groups* is implemented in the meta-model as a first step. Following the BPMN2.0 Standard [OMG11a], these groups provide a visual mechanism to cluster elements of the eEPC without affecting the process flow. They offer the possibility to include one to many elements of all provided eEPC elements. Groups are often used to highlight certain areas of a model without providing additional functionality. The grouped elements can be separated for reporting and in-depth analysis purposes. In order to implement these properties *Group* is an aggregation of the class *EPC* and it is associated with the classes *Function* and *Event* (“is grouped in”). Additionally, it is the parent class to *Account* and *DebitAndCredit*. Thereby, the extension is halfway integrated. The second connection to the eEPC meta-model is the implementation of the classes *AccountEntry* and *Balance* as child classes of *InformationObject*, which represents the class *Data* of the conceptual model of accounts in the eEPC meta-model. This linkage ensures the connection between functions (part of the process) and account entries, thereby ensuring the visibility of financial impacts of processes. This two-staged approach is transferable to other BPML. It represents a rigorous way of implementing the proposed concept of accounts into meta-models. This in turn ensures an unambiguous usage of the new (sub-) concepts. Moreover, the general concept of *Groups* is usable in eEPCs.

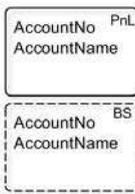
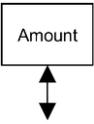
Figure 2: Extended eEPC Meta-Model



5 Extending the eEPC Notation

As eEPCs constitute a graphical modeling language [Aa99], a notational extension is necessary. Groups are new notational elements in eEPCs. The extension proposes boxes with dotted and solid lines for their representation. Account entries as well as credit and debit balances are represented by the same notational elements as information objects in order to keep the look-and-feel of eEPCs. However, every information object in an account group either represents a debit or credit balance and every information object in a debit or credit group is an account entry. For details please refer to *Table 1*.

Table 1: New and modified eEPCs Elements

Parent Class	Symbol	Description
Group		<p>Account</p> <p>Based on the attribute <i>isPnLAccount</i> each account displays whether it is a profit and loss account (<i>PnL</i> sign in the top right corner) or a balance sheet account (<i>BS</i> sign in the top right corner). Furthermore, depending on the value of the attribute <i>isOpenItemAccount</i>, the frame of an account is either dotted (= account involved in open item accounting) or solid (= account not involved in open- item accounting).</p>
		<p>Credit / Debit</p> <p>The <i>Debit</i> and <i>Credit</i> groups have two attributes, the first being <i>isDebit</i>, defining if it's a debit or credit group. Exactly one of each group is always part of an <i>Account</i>. The second attribute defines the name (<i>groupName</i>).</p>
Information Object		<p>AccountEntries</p> <p>Account entries always display the attribute <i>amount</i>, representing the value of each item.</p>
		<p>DebitBalance / CreditBalance</p> <p>The <i>DebitBalance</i> and <i>CreditBalance</i> information objects are associated with one function. They display the amount of all associated debit or credit items. As the associated function needs updating the balance each time a posting is done, it first queries the previous amount. Hence, the association is a two-sided arrow.</p>

6 Application Example

This section presents an application example based on the notational extension. This example demonstrates how the conceptual model of accounts incorporated in a BPML closes the gap between processes and their financial impacts and therefore the financial statements. Moreover, it proves the feasibility and usefulness of the conceptual model of accounts presented in *Section 3*.

The example is taken from the training documentation of a Big4 audit firm and is set in the purchase department of a company. The company uses SAP as ERP system. Additionally, the document describes employees involved in the process. *Figure 3* depicts the resulting process, modeled as an eEPC. This model already includes the newly proposed extension. The process model starts with the event “Items posted - Account not involved in Open-Item Accounting”. Subsequently, Mr. Maasberg triggers the function “Create Billing Document”. The function posts to two different accounts, namely “Revenues” (account number 800000) and “Account Receivables” (account number 140000). As “Revenues” is a profit and loss account, the group is tagged with “PnL”. In contrast, “Account Receivables” is a balance sheet account and therefore tagged with “BS”. The revenues account has a solid frame indicating that it is not involved in open-item accounting whereas account receivables is involved in open-item accounting and consequently has a dotted frame. The two postings triggered by the function are one credit posting to the credit side of the “Revenues” account and its corresponding offsetting item to the debit side of the “Account Receivables”. The process continues with the event “Items cleared”, which is because the next function “Post Incoming Payments” posted the clearing item to the “Account Receivables”. The corresponding offsetting item is posted to the account “Bank”. This account is again a balance sheet account involved in open-item accounting (indicated by the “BS” in the top corner and the dotted frame). As the “Bank” account is involved in open-item accounting, a clearing item must be posted at some point in time. However, in this case a posting has not yet taken place. Hence, the process ends with the event “Items not yet cleared”.

The process continues with the event “Items cleared”, which is because the next function “Post Incoming Payments” posted the clearing item to the “Account Receivables”. The corresponding offsetting item is posted to the account “Bank”. This account is again a balance sheet account involved in open-item accounting (indicated by the “BS” in the top corner and the dotted frame). As the “Bank” account is involved in open-item accounting, a clearing item must be posted at some point in time. However, in this case a posting has not yet taken place. Hence, the process ends with the event “Items not yet cleared”.

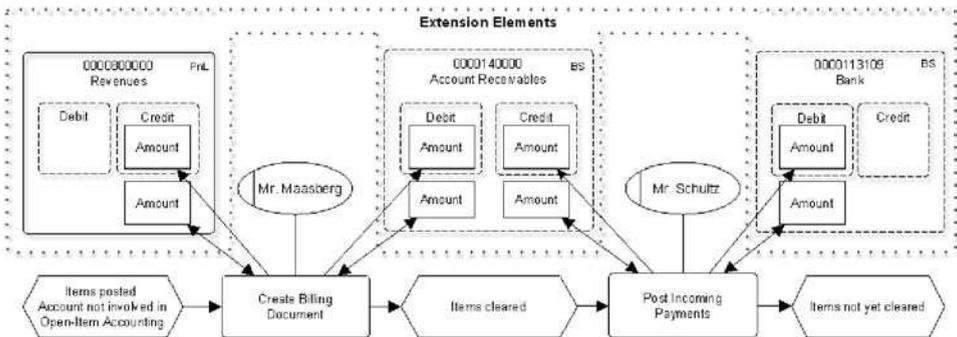


Figure 3: Example Purchase to Payables Process

The experts confirmed the following advantages (see *Section 7*) demonstrated in the example:

1. All accounts posted to by the process are evident. This is accomplished by the unambiguous link between functions and items, which again are clearly assigned to accounts.
2. Activities with a financial impact are visible. Again, this is caused by the link between functions and items. Each function linked to an information object in an account group (= accounting item) has a financial impact.

7 Evaluation

Venable et al. present a comprehensive framework for the selection of an evaluation method [Ve12]. A choice was made based on this framework: having a socio-technical artifact potentially relevant for diverse stakeholders and planning on the evaluation with different methods, a naturalistic ex-post evaluation strategy appears appropriate. As a first step, 17 domain experts were consulted with a questionnaire-based survey. The selection of domain experts followed the purposeful sampling approach described by Patton for the selection of experts. A combination of type five “Typical Case Sampling” and six “Stratified Purposeful Sampling” was used [Pa90], p. 182. Thereby, two criteria defined the sampling population. First, the individual must be familiar with process audits. The expertise required for process audits combines accounting as well as process knowledge, both of which are needed to evaluate the BPML extension presented here. Second, the sampling procedure defined persons with a work experience of more than five years in the business process audit domain as experts. For further information on the experts please refer to [Sc12]

The questionnaire presented four statements and asked the expert to evaluate it on a five-option Likert-Scale along with a detailed narrative description of their assessment. Each statement examined a characteristic of the BPML extension. The questionnaire inquired on the following characteristics:

1. *Completeness*: The business process model comprises all relevant information in the context of financial impacts on accounts.
2. *Suitability*: The artifact corresponds to a mutual understanding of accounts.
3. *Usability*: Improvement compared to the current state regarding the representation of financial impacts on accounts – regardless if current practice includes graphical models or not.
4. *Perceived added value*: The expert was asked to give his expert opinion on the suspected added value.

The survey revealed that all 17 experts assessed the artifact positively overall. Regarding the characteristic *completeness*, a few experts mentioned notational aspects that could be added (indicator for active/ passive accounts, distinction between profit and loss accounts, ledger type of the account, chart of account, and currency). As these only

constitute minor changes, the next evaluation cycle might consider them. Their inclusion will be based on an investigation into the balance between provided information and the concomitant possible cognitive overload. Assessing the characteristic *suitability*, all experts emphasized the explicit presentation of accounts and the linkage to corresponding processes. Regarding the characteristic *usability*, two experts made the suggestion to distinguish between account types, not based on different group colors (as in the first draft) but rather on signs. This suggestion was implemented. The last characteristic - *perceived added value* – is possibly the most subjective one. However, it seemed promising to receive a first feedback of possible users and their perception of the possible value added. To our full satisfaction, the experts rated this category also positively. They stated that the applied accounting procedure becomes more obvious and a general view is provided by the BPML extension. According to the experts, the latter will provide a good starting point for process audits.

8 Limitations and Future Work

The evaluation of this research work implies certain limitations. As the evaluation of Section 7 only represents an explorative first step, the next evaluation cycle will focus specific characteristics in more detail. The starting point will be the application of a comprehensive evaluation framework for the usability of modeling languages, e.g. Schalles et al. [Sc11]. Different shortcomings of the questionnaire- based evaluation should be resolved by utilizing this framework. The objective is to tackle the following open questions and therefore existing limitations:

1. How much information is too much in this particular application scenario? Auditors demand supplementary information to business process managers in the usual sense. For this reason, previous investigations on the best possible ratio of information are partly inappropriate.
2. Business processes can become very complex structures. The extension needs to be tested with regards to large models.
3. The questionnaire only raised expert opinions based on an example process. A possible expansion of the evaluation is towards the everyday work of auditors. This way the characteristic *perceived added value* could be determined in an inartificial environment.
4. The eEPC extension forms only one of the possible BPML extensions. Other BPMLs could be extended and results could be benchmarked.

Tackling these open questions in the future would contribute to a further understanding of the topic at hand.

9 Conclusion

The goal of this research was to close the gap between financial statements and processes by making financial impacts of transactions visible. By doing so auditors, are

supported in their everyday work and enabled providing a higher level of assurance in business process audits, resulting in a smaller likelihood of corporate fraud or even bankruptcy.

As no existing BPML combines process flows with financial impacts respectively bookings on accounts, a literature review was carried out in order to examine BPML extensions and the topic of accounts in BPM. It was established that none of the extensions would close the gap between financial impacts and processes. Regarding the topic of accounts in BPM, two publications could be identified. However, both remain on an abstract level not proving sub-concepts for the application in the everyday work of auditors. Consequently, this paper proposed a conceptual model of accounts in order to combine the process flow of BPML and the financial impact of bookings. This model provides two connection classes in order to integrate the general conceptual model in BPMLs. To demonstrate the feasibility and to evaluate the proposed extension, we integrated it into a well-known and wide-spread BPML, viz. eEPC. We utilized the meta-model proposed by Korherr et al. and integrated the conceptual model of accounts into it for this reason. The implementation ensures that accounts always include one debit and one credit side. Moreover, functions of the underlying process are enabled to book items to accounts. This assures a connection between functions and items respectively accounts. Notably, nearly all experts emphasized the improved visibility of financial impacts of processes enabled by this extension.

The contribution of this paper is threefold. First, a conceptual model of accounts with connection classes to most BPMLs is proposed. Second, an exemplary integration in the eEPC is presented. This implementation is to be understood as an exemplary instruction on how to implement the extension to other BPMLs. Moreover, it demonstrates the feasibility of the extension. Finally, this paper presents an evaluation based on four different characteristics, confirming the usefulness of the conceptual model of accounts as an extension to an existing BPML.

Literature

- [Aa99] Van der Aalst, W.M.P.: Formalization and verification of event-driven process chains. *Inf. Softw. Technol.* 41, 10, 639–650, 1999.
- [Al08] Alencar, P. et al.: Business Modeling to Improve Auditor Risk Assessment: An Investigation of Alternative Representations. *Proceedings of the 14th Annual International Symposium on Audit Research, ISAR*. pp. 30–31, 2008.
- [AW10] Awad, A., Weske, M.: Visualization of Compliance Violation in Business Process Models. In: Rinderle-Ma, S. et al. (eds.) *Business Process Management Workshops*. pp. 182–193, Springer, Berlin / Heidelberg, 2010.
- [Aw11] Awad, A. et al.: Visually specifying compliance rules and explaining their violations for business processes. *J. Vis. Lang. Comput.* 22, 1, 30–55, 2011.
- [BB96] Vom Broecke, J., Buddendick, C.: Reusable conceptual models–requirements based on the design science research paradigm. *Proceedings of the 1st International Conference on Design Science Research in Information Systems and Technology (DESRIST 2006)*, Claremont. pp. 576–604, 2006.

- [BD03] Braun, R.L., Davis, H.E.: Computer-assisted audit tools and techniques: analysis and perspectives. *Manag. Audit. J.* 18, 9, 725–731, 2003.
- [Be97] Bell, T.B.: *Auditing Organizations Through a Strategic-systems Lens: The KPMG Business Measurement Process*. KPMG Peat Marwick LLP, Montvale N.J., 1997.
- [Bo11] Boritz, J.E. et al.: The Effects of Business Process Representation Type on the Assessment of Business and Control Risk: Diagrams Versus Narratives. SSRN ELibrary., 2011.
- [Br09] Vom Brocke, J. et al.: Reconstructing the giant: on the importance of rigour in documenting the literature search process. *Proceedings of the 17th European conference on information systems (ECIS)*, 2009.
- [Br11] Vom Brocke, J. et al.: Linking Accounting and Process-aware Information Systems—Towards a Generalized Information Model For Process-oriented Accounting. *Proceedings of the 19th European conference on information systems (ECIS)*, 2011.
- [Du05] Dumas, M. et al.: *Process-Aware Information Systems: Bridging People and Software Through Process Technology*. John Wiley & Sons, 2005.
- [El85] Ellerman, D.P.: The Mathematics of Double Entry Bookkeeping. *Math. Mag.* 58, 4, 226–233, 1985.
- [Fr12] Friedenstab, J. et al.: Extending BPMN for Business Activity Monitoring. *Proceedings of the 45th Hawaii International Conference on System Science (HICSS)*. pp. 4158–4167, 2012.
- [GM10a] Gehrke, N., Mueller-Wickop, N.: Basic Principles of Financial Process Mining A Journey through Financial Data in Accounting Information Systems. *Proceedings of the 16th Americas Conference on Information Systems (AMCIS 2010)*. , Lima, Peru, 2010.
- [GM10b] Gehrke, N., Mueller-Wickop, N.: Rekonstruktion von Geschäftsprozessen im Finanzwesen mit Financial Process Mining. *Proceedings of the Informatik*, 2010.
- [HK10] Heese, K., Kreisel, H.: Prüfung von Geschäftsprozessen. *Wirtschaftsinformatik.* 63, 18, 907–919, 2010.
- [IFAC10] International Federation of Accountants (IFAC): *Handbook of International Quality Control, Auditing, Review, Other Assurance, and Related Services Pronouncements*, 2010.
- [Ka07] Karagiannis, D. et al.: Business Process-Based Regulation Compliance: The Case of the Sarbanes-Oxley Act. 15th IEEE Int. Requir. Eng. Conf. 2007 RE 07. 315 –321, 2007.
- [Ke92] Keller, G. et al.: *Semantische Prozeßmodellierung auf der Grundlage Ereignisgesteuerter Prozeßketten (EPK)*. Universität des Saarlandes, Saarbrücken, Germany, 1992.
- [Kh08] Kharbili, M.E. et al.: Business Process Compliance Checking: Current State and Future Challenges. Presented at the MobIS, 2008.
- [KL07] Korherr, B., List, B.: Extending the EPC with performance measures. *Proceedings of the 2007 ACM symposium on Applied computing*. pp. 1265–1266, 2007.
- [LE06] Levy, Y., Ellis, T.J.: A systems approach to conduct an effective literature review in support of information systems research. *Informing Sci. Int. J. Emerg. Transdiscipl.* 9, 181–212, 2006.
- [Mi08] Milanovic, M. et al.: Combining Rules and Activities for Modeling Service-Based Business Processes. *Enterprise Distributed Object Computing Conference Workshops*, 2008 12th. pp. 11 –22, 2008.
- [MN06] Mendling, J., Nüttgens, M.: EPC markup language (EPML): an XML-based interchange format for event-driven process chains (EPC). *Inf. Syst. E-Bus. Manag.* 4, 3, 245–263, 2006.
- [Mu13] Mueller-Wickop, N. et al.: Towards Key Concepts for Process Audits – A Multi-Method Research Approach. Presented at the 10th International Conference on Enterprise Systems, Accounting and Logistics (ICESAL 2013) , Utrecht, The Netherlands, 2013.
- [NS07] Namiri, K., Stojanovic, N.: Pattern-Based Design and Validation of Business Process Compliance. In: Meersman, R. and Tari, Z. (eds.) *On the Move to Meaningful Internet*

- Systems 2007: CoopIS, DOA, ODBASE, GADA, and IS. pp. 59–76, Springer, Berlin / Heidelberg, 2007.
- [NS08] Namiri, K., Stojanovic, N.: Towards a formal framework for business process compliance. *Multikonferenz Wirtsch. GITO-Verl. Berl.* 24–27, 2008.
- [OMG11a] OMG (Object Management Group): Business Process Model and Notation (BPMN) - version 2.0, 2011.
- [OMG11b] OMG (Object Management Group): Unified Modeling Language (UML) Specification 2.4.1, 2011.
- [Pa90] Patton, M.Q.: *Qualitative Evaluation and Research Methods*. SAGE Publications, 1990.
- [Pe08] Pedrinaci, C. et al.: *Semantic Business Process Management: Scaling Up the Management of Business Processes*. Presented at the, 2008.
- [RD07] Recker, J.C., Dreiling, A.: Does it matter which process modelling language we teach or use? An experimental study on understanding process modelling languages without formal education. *ACIS Proceedings.*, Toowoomba, 2007.
- [Re01] Rezaee, Z. et al.: Continuous auditing: the audit of the future. *Manag. Audit. J.* 16, 3, 150–158, 2001.
- [Re09] Recker, J.C. et al.: Business process modeling: a comparative analysis. *J. Assoc. Inf. Syst.* 10, 4, 333–363, 2009.
- [Ro07] Rodríguez, A. et al.: A BPMN Extension for the Modeling of Security Requirements in Business Processes. *IEICE - Trans Inf Syst.* E90-D, 4, 745–752, 2007.
- [Ru03] Russell, J.: *The process auditing techniques guide*. ASQ Quality Press, Milwaukee, 2003.
- [Sa11] Sadiq, S.: A Roadmap for Research in Business Process Compliance. In: Abramowicz, W. et al. (eds.) *Business Information Systems Workshops*. pp. 1–4, Springer, Berlin / Heidelberg, 2011.
- [Sc10] Schleicher, D. et al.: Compliance scopes: Extending the BPMN 2.0 meta model to specify compliance requirements. *Service-Oriented Computing and Applications (SOCA), 2010 IEEE International Conference on*. pp. 1–8, 2010.
- [Sc11] Schalles, C. et al.: Usability of Modelling Languages for Model Interpretation: An Empirical Research Report. *Wirtsch. Proc.* 2011. 787–796, 2011.
- [Sc12] Schultz, M. et al.: Key Information Requirements for Process Audits – an Expert Perspective. *Proceedings of the 5th International Workshop on Enterprise Modelling and Information Systems Architectures (EMISA)*. pp. 137–150, Vienna, Austria, 2012.
- [Si04] Siau, K.: Informational and Computational Equivalence in Comparing Information Modeling Methods. *J. Database Manag.* 15, 1, 73–86, 2004.
- [SN00] Scheer, A.-W., Nüttgens, M.: ARIS Architecture and Reference Models for Business Process Management. In: Aalst, W. van der et al. (eds.) *Business Process Management*. pp. 376–389, Springer, Berlin / Heidelberg, 2000.
- [SS77] Smith, J.M., Smith, D.C.P.: Database Abstractions: Aggregation and Generalization. *J. ACM Trans. Database Syst.* 2, 2, 105–133, 1977.
- [Ve12] Venable, J. et al.: A Comprehensive Framework for Evaluation in Design Science Research. In: Peffers, K. et al. (eds.) *Design Science Research in Information Systems. Advances in Theory and Practice*. pp. 423–438, Springer, Berlin / Heidelberg, 2012.
- [WW02a] Wand, Y., Weber, R.: Research commentary: information systems and conceptual modeling—a research agenda. *Inf. Syst. Res.* 13, 4, 363–376, 2002.
- [WW02b] Watson, R.T., Webster, J.: Analyzing the past to prepare for the future: Writing a literature review. *MIS Q.* 26, 2, xiii–xxiii, 2002.
- [WS07] Wolter, C., Schaad, A.: Modeling of task-based authorization constraints in BPMN. *Proceedings of the 5th international conference on Business process management*. pp. 64–79, Springer, Berlin / Heidelberg, 2007.