LINKING ACCOUNTING AND PROCESS-AWARE INFORMATION SYSTEMS – TOWARDS A GENERALIZED INFORMATION MODEL FOR PROCESS-ORIENTED ACCOUNTING

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Abstract

Process-aware information systems (PAIS) have been proposed as a vital means to facilitate the adoption of BPM within organizations. Many studies exist that report on PAIS implementations with enterprise resource planning systems and workflow management systems being the most widely implemented types of PAIS. Accounting information systems (AIS) on the other side are among the first types of computerized information systems which have been adopted to support managerial tasks and decision making within organizations. However, despite their significance PAIS and AIS have been hardly integrated, so far. By providing a process-oriented accounting infrastructure it is expected to improve effectiveness and efficiency of both accounting and process management activities by improving data and information quality and raising conceptual synergies between the two disciplines. The paper examines the intersection of accounting and process-aware information systems which has so far received very little attention in both research and practice. Consequently, a first proposal for a generalized information model for process-oriented accounting is synthesized based on the ARIS information model and the REA accounting model.

Keywords: Accounting, Business Process Management, REA, Process-aware Information Systems

1 Introduction

Many researchers have described objectives associated with the adoption of business process management (BPM) within organizations (e.g. Davenport, 1993; Hammer and Champy, 1993; Harmon, 2007). Process-aware information systems (PAIS) have been proposed as a vital means to facilitate the adoption of BPM within organizations and many studies exist that report on PAIS implementations (Dumas et al., 2005) with enterprise resource planning systems and workflow management systems being the most widely implemented types of PAIS. Accounting information systems (AIS) on the other side are among the first types of computerized information systems which have been adopted to support managerial tasks and decision making within organizations. Since their advent in the 1960s, most AIS implement the conventional double-entry bookkeeping accounting model usually referred to as "traditional accounting" (McCarthy, 1982).

Despite their relevance for supporting management activities, AIS do not seamlessly integrate within the overall data and information processing facilities of an organization. In particular, contemporary AIS hardly or only partially provide information that is useful for decision making in the context of business process management. Despite some process-oriented extensions to the conventional accounting model, e.g. as proposed by Cooper and Kaplan (1991), AIS are still not process-aware (Geerts and McCarthy, 1999). Only recently this has been re-confirmed by a leading BPM practitioner's forum stating that current approaches to accounting do not provide information that is useful to support decisions about business processes (see Harmon, 2011). Regarding current "linkages" between PAIS and AIS it can also be observed that even modern ERP systems which are shipped with build-in reference processes and are often drivers towards process-oriented organizations still adhere to traditional accounting techniques which are not aware of business processes (O'Leary, 2004; Harmon, 2011). In order to provide accounting information that is useful for managing process-oriented organizations AIS should allow for deducting *process-oriented evaluation structures*. Given that PAIS explicitly consider *process-oriented organizational structures* and also provide basic data on process models and process instances it is expected that linking PAIS with AIS is a logically consistent step in an effort to establish process-oriented evaluation structures.

In order to design a link between PAIS and AIS we build upon the "events" approach to accounting theory which is fundamentally distinct from traditional accounting approaches. The "events" approach to accounting theory has been proposed (Sorter, 1969) and aims at overcoming the limitations of the traditional "value" approach to accounting. The "events" approach suggests that "the purpose of accounting is to provide information about *relevant economic events* that might be useful in a variety of possible decision models" (cf. Sorter, p. 13, emphasis added). The "events" approach can be characterised as being data-oriented since it is concerned with recording observations of events (cf. Johnson, 1970) in as most elementary, i.e. disaggregated, form as possible (cf. McCarthy, 1982; Sorter, 1969). It is claimed that the "events" approach is basically capable of providing process-oriented evaluation structures (cf. Geerts and McCarthy, 1999; McCarthy, 1982). Since the proposal of the "events" approach, several data models have been suggested to support the design of event accounting information systems (Weber, 1986). Until now, however, no requisite info-logical and data-logical structures necessary to establish a dedicated *process-oriented accounting infrastructure* have been presented so far. Such an infrastructure is vital for linking PAIS and AIS.

It is expected that a process-oriented accounting infrastructure may yield two significant benefits: First, such an infrastructure would resolve inconsistencies resulting from capturing economic events separately in both PAIS and AIS. Having a single source for capturing and persisting economic data promises to increase the *effectiveness* of both process management and accounting due to a better data and information quality. Moreover, a process-oriented accounting infrastructure may raise synergies thus fostering the *efficiency* of process management and accounting. Synergies may arise due to reuse of process models for accounting purposes or due to reuse of accounting data for process design decisions.

The paper aims at contributing an initial proposal of a generalized information model for process-oriented accounting. This information model is synthesized from a general business process management meta-model (i.e. ARIS, cf. Scheer, 1999) and a generalized accounting model (i.e. REA, cf. McCarthy, 1982). This represents a novelty since an integrated treatment of established concepts known from the accounting discipline and concepts known from the business process management discipline has not yet been conducted. The research follows a design-oriented approach (see March and Smith, 1995). The paper is structured accordingly (see Peffers et al., 2007): section two and section three present the considered knowledge base, i.e. relevant parts the ARIS information model and the REA accounting model and evaluates their contribution to the problem of linking PAIS and AIS. Section four analyses the intersection of the ARIS and REA information model and synthesizes them into an information model for process-oriented accounting (i.e. the artefact of the design research). Section five provides a proof of concept and demonstrates the overall applicability of the artefact. Section six concludes the paper and provides an outlook for future research.

2 Generalized information model of process-aware information systems – The ARIS information model

2.1 ARIS views and the ARIS accounting infrastructure

The information model of the Architecture of Integrated Information Systems (ARIS) has been considered here since it originates from academic research, it is well documented within the literature, and in particular it has proven its applicability and usefulness for practice. ARIS provides a framework to help dealing with the complexity of designing and implementing business processes and process-aware information systems (cf. Scheer, 1999). To this end ARIS distinguishes different views which have to be considered within process-aware information system designs: organization, function, output, control and data. Together, these views provide a holistic perspective on business processes by describing “who” does “what”, “how”, “when” and “why”. The relationships between these views are modelled in Figure 1 by means of an entity relationship (ER) diagram (Chen, 1976).

The *organization view* describes the organisation as a hierarchy comprising of organizational units, roles, responsibilities, as well as communication and reporting relationships between organizational units (cf. Scheer, 1999). In Figure 1, the entity type “Organizational Unit” relates to both human and technical output producers (e.g. machines, machine groups, workstations or data centres). The corresponding specialization relationships are not displayed in Figure 1. Hierarchical relationships are captured by the relationship type “Organization structure”. The smallest unit within an organization structure is the “Position” (Scheer, 1999) which can be filled with one or more roles.

The *function view* describes what has to be done, i.e. what function has to be executed, in order to achieve a specific goal or output. From a strategic point of view (strategic function view) “Value Added Functions” are connected to form a “Value Chain” (cf. Porter, 1985). Value added functions are complex functions that may comprise of one or more business processes. Each business process consists of one or more functions which can be further decomposed into smaller sub functions (business processes, support processes) or elementary functions. Predecessor and successor relationships of business processes and functions are captured by positioning relationships respectively.

The *output view* describes what (intermediate) products and services are expected from executing a business processes. On a high level the output is what is valued by the customer. On a lower level, intermediary outputs are modelled if there is a customer-supplier relationship between subsequent processing functions or organizational units (cf. Scheer, 1999, p. 95). In Figure 1 this is modelled with the “Output” relationship. With regard to accounting for input/output costs, “Cost Types” and “Cost Rates” (containing average values of a cost type) are considered.

The *control view* aims at connecting the function, organization, output and data view by specifying relationships between them. In Figure 1 the control view is not explicitly modelled but it is realized by means of relationship types connecting individual views. The function view and the organization view are basically connected by means of a "Function Association". Among other things, this allows for allocating functions to respective cost centres in activity-based costing (Scheer, 1999). The function view and output view are related by means of input/output relationships. Deliverables of each business process are allocated as an output of a function. Figure 1 also contains a relationship to capture the final output of a business process which could also be the characteristic output of a value chain. Capturing process output is a prerequisite for conducting process-oriented accounting, e.g. it focuses activity-based costing systems on relevant cost drivers (cf. Scheer, 1999).

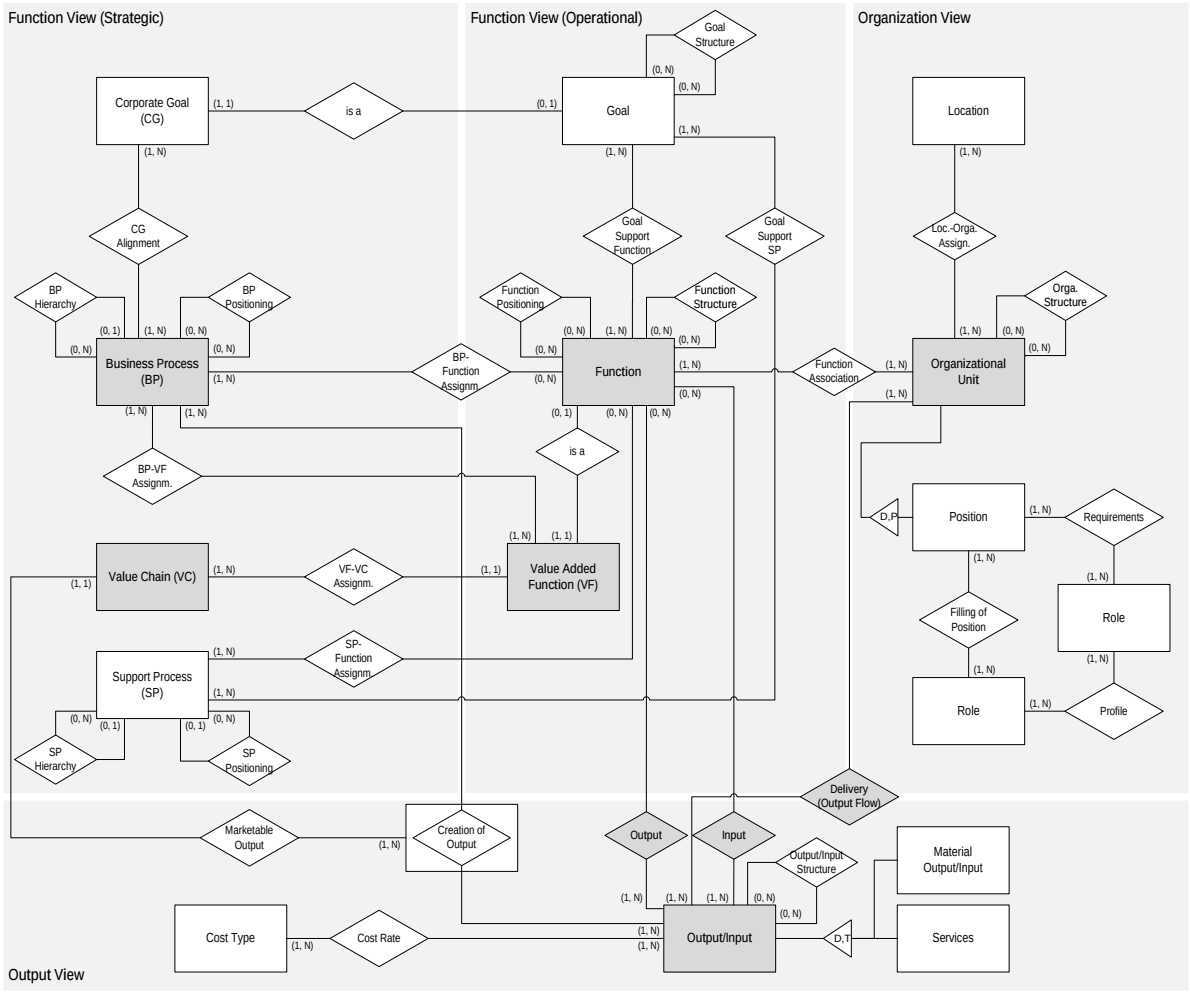

Figure 1. High level conceptualization of business processes

The organization view is usually connected to the output view for planning purposes, e.g. for the purpose of output oriented controlling. Therefore, "Organizational Units" are related with "Output" by means of a "Delivery" relationship. This relationship designates who delivers what output to whom. That way it is possible to model *output flows* between organizational units. Since organizational units also comprise of both *internal* and *external* actors it is possible to model value exchanges within a complete value chain on a high level of abstraction. Such a technique is usually applied for value or business modelling (cf. Andersson et al., 2006). With regard to accounting, modelling of output flows between organizational units is particularly important for cost centre accounting (Scheer, 1999).

Figure 2 depicts the ARIS accounting infrastructure on a high level of abstraction by means of an ER diagram (cf. Scheer, 1994). This accounting infrastructure is part of the ARIS data view. The

accounting infrastructure can be divided into three areas: *accounts structure*, *organizational evaluation structure* and *accounting document structure*. The accounting infrastructure is centred on the entity type "Account". As can be seen from the attributes of this entity type, the ARIS accounting infrastructure incorporates the *double entry bookkeeping* principle (e.g. see the attributes "Total_Credit", "Total_Debit", "Balance_Forward"). Individual accounts are assigned to account categories according to the applied chart of accounts. The data structure allows for defining different charts of accounts for a corporate group which are then related to subordinate organizational units or business areas by means of "Company Codes" (cf. Scheer, 1994). Accounts can have a hierarchical relationship ("Account Structure") where a subordinate account is transferred to super-ordinate accounts for consolidation. Since an account can go into several super-ordinate accounts, an n:m cardinality is applied here. The ARIS accounting infrastructure also distinguishes between general ledger and subsidiary accounting systems. While the general ledger accounting system is employed to consolidate and report financial statements, the subsidiary accounting systems capture individual *business transactions* in detail.

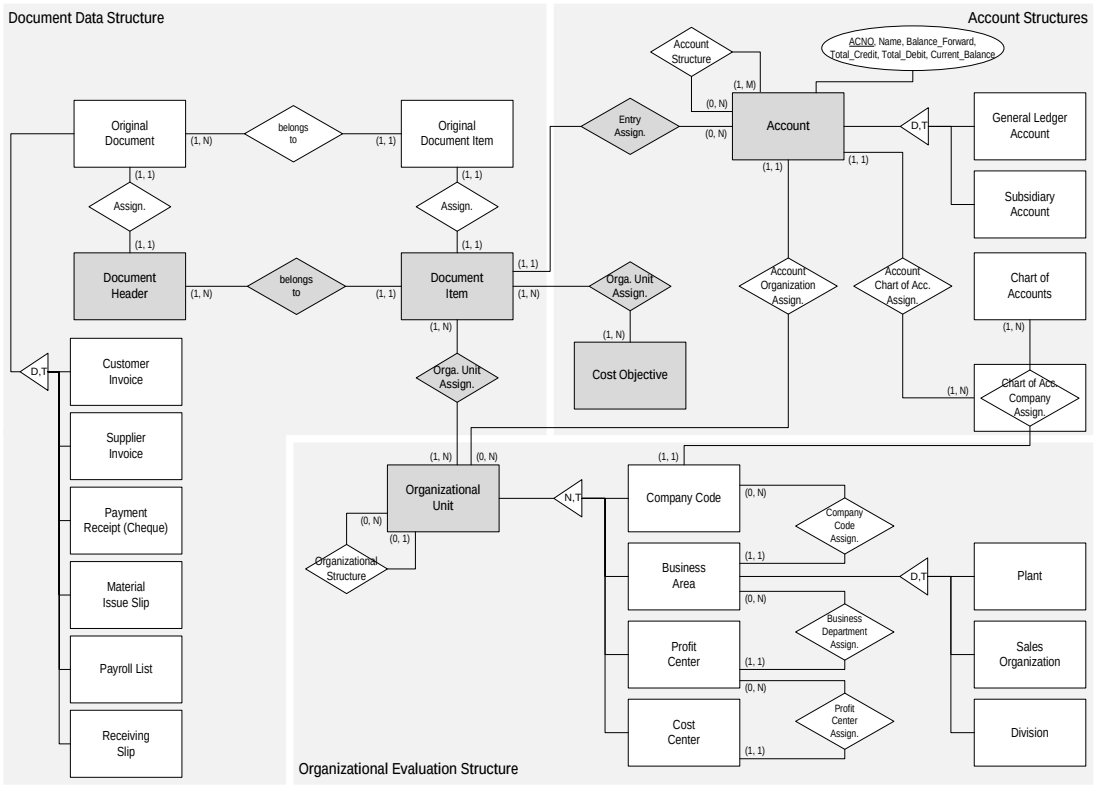

Figure 2. ARIS accounting infrastructure

Traditional accounting also involves the establishment of an *accounting-oriented organizational view* (Scheer, 1994) which is reflected in the organization evaluation structure shown in Figure 2. A company code is a specialization of an "Organizational Unit" and represents a separate legal entity producing its own financial statements (i.e. a company). This entity can be further subdivided into additional organizational units (e.g. profit and cost centres) according to individual reporting, analysis and controlling needs. The organizational evaluation structure presented in Figure 2 assumes a functional organization of a company. That way, it does not reflect any business process related structures. This is a typical situation where accounting data only hardly reflects process-oriented organizational structures. For organizations striving to become more process-oriented, it would be both desirable and necessary to also reflect process structures within an organization's accounting model.

From the accounting model in Figure 2 only a single link can be made to business processes via the *document data* structure (see left side of the figure). Documents represent so called posting records and link business transactions to an account in the financial accounting system (Scheer, 1994). In the generalized data structure, individual document types ("Original Documents") are reduced to a uniform structure consisting of a "Document Header" (containing the business transaction context) and "Document Items" (containing accounting objects like materials or invoice items). Thus, the data structure allows for storing both original documents and corresponding accounting documents. Individual document items and associated amounts are assigned to accounts, to organizational units, and to cost objectives, therefore defining what is the item accounted for, for whom, and what is the reason for accounting this item. The entity and relationship types shaded in dark grey together form an *accounting document* which represents a *business transaction*.

2.2 Limitations of the ARIS accounting infrastructure

Strikingly, the ARIS accounting infrastructure hardly exhibits links to business process concepts (only documents as input or output of functions). Representing a part of the ARIS data view, the accounting infrastructure is decoupled, however, from the remaining views. It provides means to implement the double-entry bookkeeping accounting scheme but it does not provide any means to establish a process-oriented evaluations structure. E.g., integrating activity-based costing would require a separate data structure, i.e. a separate accounting information system (cf. Kaplan, 1991). As a result the ARIS accounting information model, in particular its organizational evaluation structure, is not process-oriented or process aware.

3 Generalized information model of accounting information systems

3.1 The Resource-Event-Agent (REA) model

The REA accounting model focuses on economic exchanges and transformations as the central unit of analysis. The underlying assumption of REA is that all business enterprises operate in the same manner (Geerts and McCarthy, 1999) according to an entrepreneurial script: acquiring financial resources, engaging in a chain of economic exchanges with other parties, each time giving up an economic resource in return for another resource of greater value (ibid). Applying REA patterns to the design of accounting information systems should overcome dysfunctional effects of traditional double-entry bookkeeping accounting schemes listed below:

- One-dimensional nature of accounting data (only monetary measurements) (McCarthy, 1982, p. 554).
- Inappropriate classification schemes for data on economic affairs, disregarding information needs of non-accountants (ibid, p. 555)
- Aggregation level of stored accounting information is too high, preventing decision makers to access information according to their decision styles and underlying conceptual structures (ibid, p. 555)
- Lack of integration with other functional areas in an enterprise is leading to inconsistencies, information gaps and overlaps (ibid, p. 555). Instead, all phenomena considered should be modelled in as consistent and non-redundant fashion (ibid, p. 567)
- Inability to accommodate *process-oriented models* of enterprises (Geerts & McCarthy, 1999, p. 1)

By addressing the deficiencies of traditional accounting systems and since REA aims at providing a pattern to derive general, non-redundant accounting infrastructure, it is further asserted that REA patterns should inform the overall design and implementation of enterprise information systems (Geerts and McCarthy, 1999, p. 1). In particular, REA enterprise models are said to be capable of providing information for process analysis, e.g. as required in business process reengineering or

workflow management initiatives (ibid). However, it has not yet been demonstrated in the literature which information on processes can be readily provided by REA enterprise models and how REA integrates into a process-aware context. Therefore, this paper aims at providing constructs to link process-aware information systems and accounting information systems on a conceptual level in order to support the explicit and *persistent semantic representation* of economic activities of a company across the value chain (cf. McCarthy, 1982).

The basic REA model is a stereotypical representation of an economic exchange as a core economic phenomenon (Geerts and McCarthy, 2002). This exchange is executed between parties inside and outside of a firm's boundaries and follows a particular object pattern (cf. ibid, see Figure 3 a) and b)). In order to conceptualize this pattern, the REA ontology suggests three concepts that constitute an exchange: *resource*, *event*, and *agent*. These concepts and their relationships are illustrated in Figure 3(a) by means of an ER diagram. Resources are things being exchanged between participating agents. In an exchange, an agent (inside agent) usually gives up control of a resource to an outside agent in order to gain control over another resource. Events occur in the course of executing economic activities. In REA basically two types of events are distinguished: *increment* and *decrement* events. Extensions of the REA ontology also distinguish between *transfer* (exchanges with external actors) and *transformation* (concerns value creation within the firm) events.

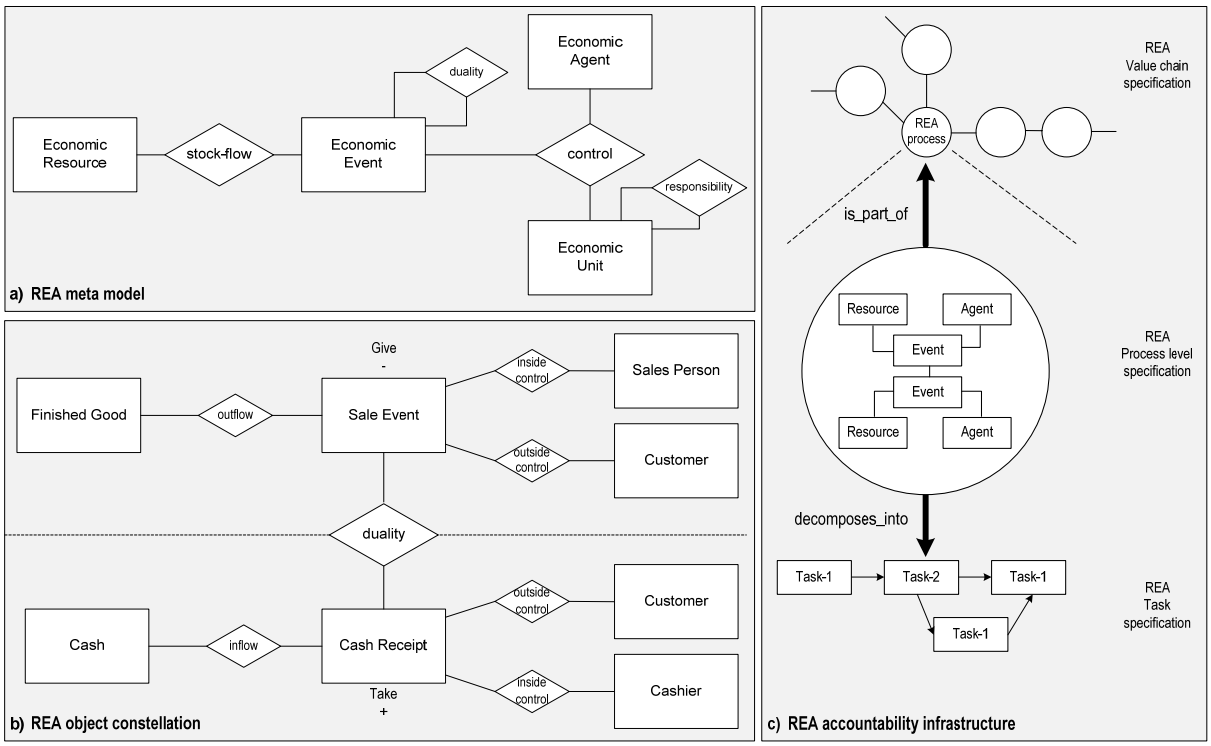

Figure 3. Basic REA model and REA accountability infrastructure

Furthermore, the following economic primitives (relationship types) are specified by the REA: *duality*, *stock-flow*, and *participation*. A duality relationship connects decrement events with corresponding increment events and thus provides the rationale of individual economic activities. Stock-flow relationships connect economic resources with economic events (decrement or increment events). Depending on the connected event type, the following stock-flow relationship types are distinguished: *give* and *take* (transfer events), *use*, *consume*, and *produce* (transformation events). Participation relationships describe the involvement of agents in economic events.

The REA accounting model is said to accommodate a process-oriented model of an enterprise (Geerts & McCarthy, 1999; O'Leary, 2004). It therefore provides an *accountability infrastructure* (see Figure

3c) that relates actual business events with process concepts like value chains and tasks. In particular, REA distinguishes between three hierarchical levels which together form the REA *process model*. The following section explores the REA process model in more detail.

3.2 The REA process model

The REA process model considers a three level hierarchy (see Figure 3c): (1) the value chain specification level, (2) the process specification level, and (3) the task or workflow level (Geerts and McCarthy, 2002). A *process* in REA terms generally includes eight entities comprising of two events or event sets (increment and decrement) paired in duality, two participating agents for each event as well as a resource for each event (cf. Geerts and McCarthy, 1999, see also Figure 3b depicting a REA object constellation). A REA process thus describes an *economic exchange* by means of *economic events* connected by a duality relationship. A REA process can be further decomposed into the *tasks* needed for the execution of exchanges. However, tasks are typically excluded from REA analysis as they are considered to be "of more practical than conceptual significance in the present stage of REA development" (Geerts and McCarthy, 2002, p. 5). A *value chain* in REA terms is defined as actual configurations of processes within a firm, i.e. an entrepreneurial script (Geerts and McCarthy, 1999). It is further described as a set of *economic activities* assembling purposeful exchanges which are linked through *stock-flow relationships* (Geerts & McCarthy, 1997).

3.3 Limitations of the REA model

The REA model and in particular the associated REA process model does not clearly define hierarchical relationships between the value chain level, the "process level" and the task level. It thus might remain vague on what level of granularity a process-oriented accounting might occur in a particular context. Having a (semi-)formal approach to describe hierarchical relationships between REA process levels would allow decision makers to more consistently define the level of analysis needed in a specific situation.

A further limitation is given by not clearly specifying the meaning of key terms like value chain, economic exchange, process, economic activity, or tasks. From a business process management perspective, it might also be questionable if the task level should be excluded from economic analysis. Tasks or sets of tasks (in ARIS they are called functions, see discussion above) are key constructs applied in process-aware information systems. If REA is to be seamlessly integrated into a process-aware context in order to provide a process-oriented accounting infrastructure then tasks as well as the *business events* which are distinct from *economic events* have to be conceptually linked with REA constructs.

4 Integrating accounting and process information models

4.1 Comparison of REA and ARIS process semantics

According to the REA literature, the REA accounting model is said to accommodate a process-oriented model of an enterprise. However, the REA process model presented in the previous section is not fully consistent with the process semantics frequently adopted within the BPM domain. This section aims at resolving terminological and conceptual inconsistencies between the ARIS process model and the REA process model. Therefore, key entity types specified within the models of Figure 1, 2, and 3 (shaded in grey) are contrasted with each other (see Table 1).

By comparing the ARIS process model with the REA process model it stands out that REA is not aware of the "Function" concept. A function is, however, a key concept within the BPM discipline and the focal point of process design and implementation. Instead, REA employs the concept of an

"Economic Event" and treats it as a substitute for an economic activity or function. Since REA stems from accounting where business transactions, i.e. economic events, are posted into accounts there has been no need to consider the function concept. However, from a BPM perspective, events are triggers or outcomes of functions. A process-aware accountability infrastructure has to deal consistently with both concepts.

	REA	ARIS
Focus	Accounting infrastructure to capture economic exchanges	Logical and temporal ordering of functions to create an output
Meaning of an event	Economic event: representing an economic activity Documents occurrence of resource increments and decrements	Business event: triggering and coordination of function sequences Documents the state of process execution
Concepts for capturing the		
"What"	Economic event/duality	Function
"How"	Economic event sequence	Function sequence
"When"	Economic event	Business event
"Who"	Economic agent	Organizational unit/role
"Why"	Duality/resource stock flow	Output (marketable)
Accounting concepts		
Account	No	Yes
Accounting document	No, but can be modelled as a combination of events, duality, stock-flow and participation relationships	Yes
Organizational unit	Yes	Yes
Double-entry bookkeeping	No, but can be emulated via dualities	Yes
Supports activity based management (ABM)	Yes, cost drivers are modelled as economic agents (see Grabski and Marsh, 1994)	No, separate data structure needed

Table 4. Contrasting the REA accounting model with key ARIS concepts

Another conceptual gap between REA and ARIS arises with regard to the logical ordering of activities. REA supports the analysis of high level activities (in ARIS they are called value-added functions) which are within a value chain. A logical ordering of economic activities is achieved in REA by connecting stock-flow relationships with each other (see. Sonnenberg et al., 2011). The REA pattern does not envision an analysis on a more fine-grained level of granularity, i.e. the task level (see above). Regarding the analysis of stock-flow relationships the ARIS process model provides two corresponding patterns on different levels of abstraction. The first pattern is an input/output relationship between individual functions. The second pattern would capture output flows via "Delivery" relationships between organizational units (see Figure 1). For accounting information to be useful in supporting decisions about business processes, a process-oriented accounting infrastructure should be grounded in BPM concepts to allow for different levels of granularity in process analysis and for considering different perspectives on business processes. However, the design of such an infrastructure would benefit from incorporating the REA pattern in order to comply with the "events" approach to accounting on which the integration of PAIS and AIS is based upon in this paper.

Besides the differences between REA and ARIS, the two information models have also significant overlaps. Both models rely on the notion of events (although not explicitly modelled in Figure 1). An event denotes a fact occurring at a certain point in time. Thus, events capture the "what" and "when" of an economic phenomenon (cf. Scheer, 1999). ARIS focuses on so called business events which can trigger a function or are created when a function has been performed. REA captures economic events that incur costs or a change in a company's assets. With regard to integrating REA with ARIS economic events can be considered as a specialization of business events. A further correspondence

between REA and ARIS is given between REA economic agents and organizational units as well as between REA resources and the input/output entity type in ARIS.

As has been shown above, the ARIS accounting model is not process-aware except for capturing business transactions by means of accounting documents. These accounting documents are posted into accounts. REA on the other hand provides an accounting infrastructure that is said to be basically process-oriented. However, it does not provide separate account structures. Accounting documents are implicitly considered within REA, comprising of an economic event, a stock-flow relationship between an event and a resource, and participation relationships between events and economic agents.

In order to derive a process-aware accounting infrastructure, REA concepts have to be extended to better and more consistently interface with the ARIS *process model*. Finally, the extended REA accounting model has to be integrated with the ARIS *accounting model*. The resulting *process-aware accounting* model is then expected to consistently address process concepts for accounting purposes, i.e. to enable the design of process-oriented evaluation structures.

4.2 Extending and integrating the REA accounting model with the ARIS framework

This section presents a process-aware accounting infrastructure which interfaces with the ARIS process model, the ARIS and the REA accounting model (see Figure 4). The accounting infrastructure basically builds on the entity types known from the previously discussed information models. Superfluous details (e.g. function structures, positioning relationships, and specializations of organizational structures) are omitted here to focus on the novel relationships to be considered.

At the heart of the accounting model in Figure 4 is the “Economic Event”. It is a specialization of a “Business Event” and can occur as a result of performing a function. Via the “Function-BP” assignment and the “BP-Value Chain” assignment relationships it can be determined which economic events have been created within which business processes and value chains. An economic event is associated with an increment or decrement in available input/output (i.e. economic resources). This is captured as a “Stock Flow” relationship. Depending on what level of analysis a stock flow relation is considered it is regarded as “Input”, “Output”, “Process Ouput”, or “Marketable Output” respectively.

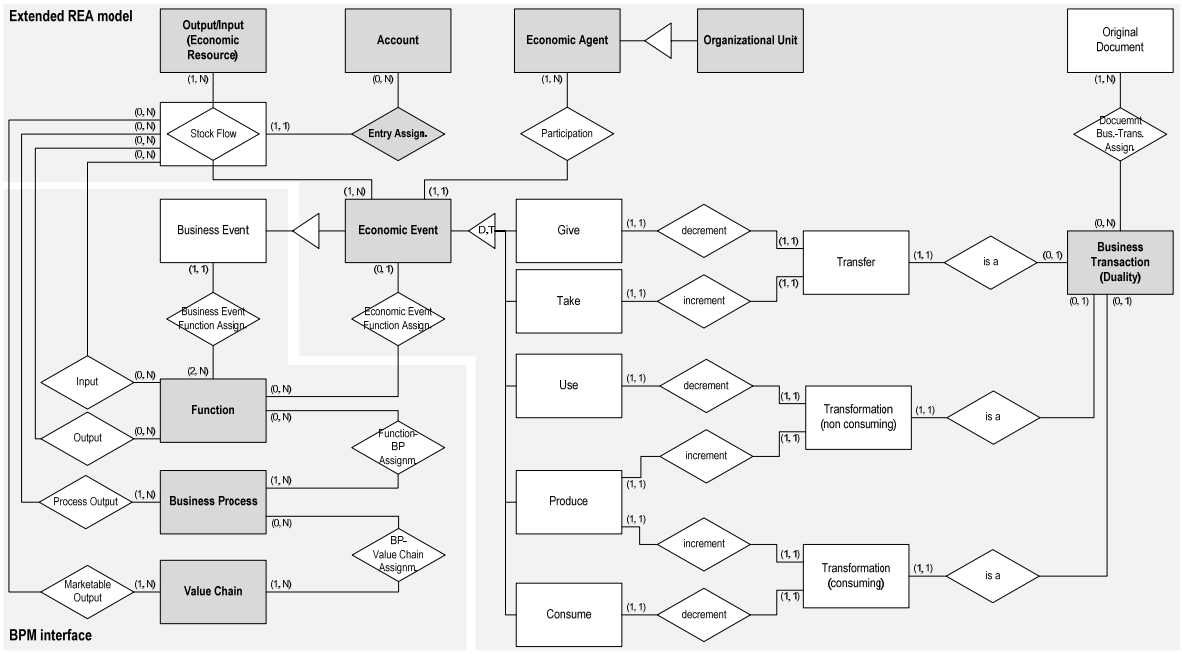

Figure 1. Process-aware accounting infrastructure

Since accounting captures events that result in a change of a company's assets, the occurrence of stock-flow relationship ultimately leads to a posting of the associated event into a corresponding account. The model in Figure 4 only provides a minimum specification of an interface to traditional accounting structures and does not specify how the correspondence between economic events and accounts is realized. However, account postings are related to economic events which occur in the course of process executions. Economic events are related to "Economic Agents" with "Organizational Units" being a specialization of economic agents. REA duality relationships between economic events are considered in a more explicit way then originally proposed by McCarthy (1982). As a core concept in REA dualities link resource increments with corresponding decrements, where increments and decrements represent individual economic events. The accounting model in Figure 4 considers two types of duality relationships: *transfers* (exchanges with external actors) and transformations (value creation inside a company). In the case of transformations we distinguish between resource-consuming and non-resource consuming transformations. In the case of a transfer the decrement event is called "Give" and the increment event is called "Take". The decrement of a non-consuming transformation is denoted as "use" and the one of a consuming transformation is denoted as "consume". Finally a duality denotes a particular *business transaction* which can be associated with original accounting documents. Ultimately, a business transaction together with associated "Economic Event" and "Entry Assignment" relationships constitute the accounting document within this accounting infrastructure.

5 Application Example

The simplified example called "Sy's Fish" is used to demonstrate how the accounting infrastructure could be applied (see Figure 5 containing process models and data base tables): *Sy's Fish is a distributor of seafood and provides his base of restaurant customers with over 50 types of fish. Fish are purchased from local fishers, cleaned at the store, and then sold to restaurants (customers). Customers are allowed to buy on credit, and all pay on the last day of the month. Sy's also possesses a fleet of trucks, used to bring fish from the docks and to deliver fish to the restaurants. Both the truck and the employees involved in each purchase and sale of fish are noted. All trucks are leased on yearly contracts, and lease payments are made monthly. Cash receipts and disbursements are made to/from one of the multiple checking accounts of the firm.*

The (ARIS) process model instance comprises of a value chain which is disaggregated into single business processes and functions. The event-driven process chain (EPC) is used here as a modelling notation (see Scheer, 1999). Within the process model economic events are shaded in gray colour, business events remain white. Economic events are associated to functions which require some form of input and provide an output. The economic events directly correspond to business transactions specified by the process-aware accounting infrastructure. Within Figure 5 these business transactions are numbered (black circles). The data base tables are populated with sample data representing a single run through the whole value chain of Sy. What can be seen from the tables is that the process-aware accounting infrastructure easily supports traditional accounting information system structures or it is at least capable of emulating double-entry bookkeeping (see account references and values in the table "Economic Event". The accounting infrastructure may also inform business process management decisions. It allows for querying resource interdependencies or handoffs (two different economic agents), thus supporting process analysis and design decisions. It enables not only the reporting of economic activities on an aggregate level by means of income statements and balance sheets. Instead, it enables analysis of resource consumption patterns on a macro and a micro level. The accounting infrastructure potentially enables management to illuminate exactly what economic activities (i.e. functions and business processes) are associated with what part of the business (i.e. organizational units) and how those activities are linked to the generation of revenues and resource consumption (see Cooper and Kaplan, 1991). It may also serve as a basis to identify process areas which create or destroy significant value, thus supporting the selection of candidates for process redesign. Another synergy results from the possibility to reuse and enrich existing process models for accounting by visually highlighting accounting relevant business transactions. Process-aware information systems

may also leverage the accounting infrastructure to persist business as well as economic events within a central data store thus avoiding data redundancy.

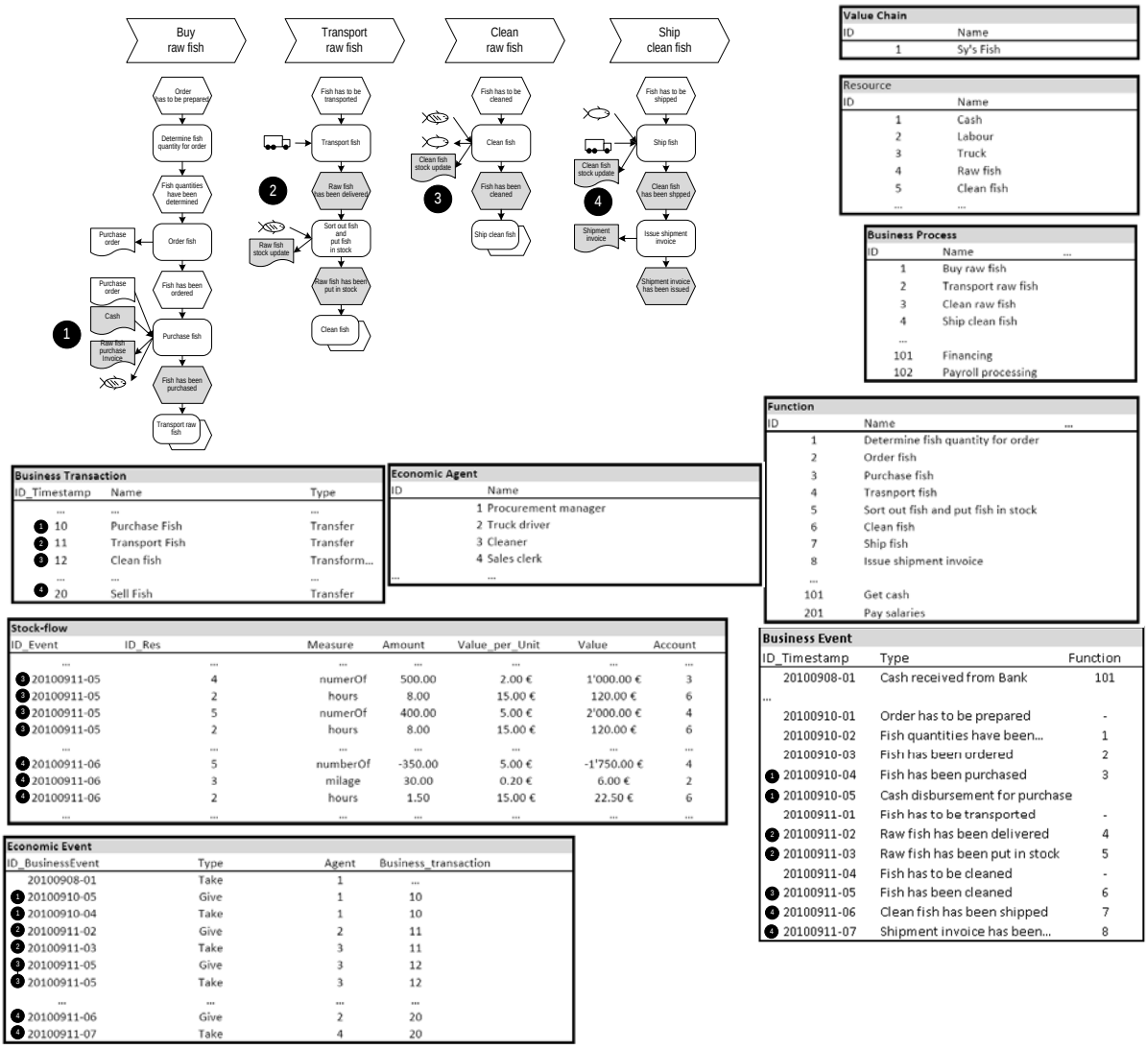

Figure 5. Applying the process-oriented accounting infrastructure

However, what can also be seen is that additional work is required to clearly define how business transaction should be posted within the accounting infrastructure. For example, the business transaction "3" refers to the same event. Resource consumption and production coincide here. To really comply with the REA pattern here, the process model should be extended with an additional function in order to have two distinct events (one increment and one decrement event). Future work should define *posting patterns* in order to ensure that the accounting infrastructure can be consistently applied in practice.

6 Conclusion

The paper examined the intersection of accounting information systems (AIS and process-aware information systems (PAIS) which has so far received little attention in both research and practice. As a result a first proposal for a generalized information model for process-aware accounting has been synthesized based on the ARIS information model and the REA accounting model. It is expected that due to the consistent specification of accounting and business process management concepts within the process-aware accounting infrastructure, both effectiveness and efficiency of accounting and

management in process-oriented organizations can be improved. However, this has to be proven by applying the infrastructure in practice. Future work thus has to focus on evaluating the artefact, i.e. to inquire if the proposed accounting infrastructure has really utility for practice. Posting patterns are required to guide the application of the process-oriented accounting infrastructure. Future research should also investigate how process mining could benefit from the process-oriented accounting infrastructure, since PAIS already provide means to analyse process structures from recorded business events.

References

Andersson, B., Bergholtz, M., Edirisuriya, A., Ilayperuma, T., Johannesson, P., Gordijn, J., Grégoire, B., Schmitt, M., Dubois, E., Abels, S., Hahn, A., Wangler, B. and Weigand, H. (2006). Towards a Reference Ontology for Business Models. In Proceedings of the 25th Int. Conference on Conceptual Modeling, Springer LNCS, pp. 482–496.

Chen, P. P. (1976). The Entity-Relationship Model. Towards a unified view of data. ACM Transactions on Database Systems, 1 (1), 9-36.

Cooper, R. and Kaplan, R. S. (1991). Profit priorities from activity-based costing. Harvard Business Review May–June, 130–135.

Davenport, T. H. (1993). Process Innovation. Reengineering Work through Information Technology. Harvard Business School Press, Boston, MA.

Dumas, M., van der Aalst, W.M.P. and ter Hofstede, A.H.M (2005). Process-Aware Information Systems: Bridging People and Software through Process Technology. Wiley & Sons, Hoboken, NJ.

Geerts, G.L. and McCarthy, W.E. (1997). Modeling business enterprises as value-added process hierarchies with resource-event-agent object templates. In Business Object Design and Implementation, 94–113.

Geerts, G.L. and McCarthy, W.E. (1999). An Accounting Object Infrastructure for Knowledge-Based Enterprise Models. IEEE Intelligent Systems, 14 (4), 89–94.

Geerts, G.L. and McCarthy, W.E. (2002). An ontological analysis of the economic primitives of the extended REA enterprise information architecture. International Journal of Accounting Information Systems, 3 (1), 1–16.

Grabski, S. and Marsh, R. (1994). Integrating accounting and manufacturing information systems: an ABC and REA-based approach. Journal of Information Systems, 8 (2), 61– 80.

Hammer, M. and Champy, J. (1993). Reengineering the Corporation: A Manifesto for Business Revolution. HarperBusiness, New York, NY.

Harmon, P. (2007). Business Process Change. A Guide for Business Managers and BPM and Six Sigma Professionals. 2nd Edition. Morgan Kaufmann, Burlington, MA.

Harmon, P. (2011). Activity-Based Costing. In: BPTrends – Advisors. http://www.bptrends.com-/deliver_file.cfm?fileType=publication&fileName=advisor20110329%2Epdf Accessed on: April 10th 2011.

Johnson, O. (1970). Toward an “Events” Theory of Accounting. The Accounting Review (October 1970), p. 641-653.

March, T. S. and Smith, G. (1995). Design and Natural Science Research on Information Technology. Decision Support Systems , 15 (4), 251-266.

McCarthy, W.E. (1982). The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment. The Accounting Review 57 (3), 554.

O’Leary, D. E. (2004). On the relationship between REA and SAP, International Journal of Accounting Information Systems, 5 (1), 65-81.

Peffers, K., Tuunanen, T., Rothenberger, M. A. and Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems, 24 (3), 45-77.

Porter, M. E. (1985). Competitive Advantage: Creating and Sustaining Superior Performance. The Free Press, New York, NY.

Scheer, A-W. (1994). Business Process Engineering. 3rd Edition. Springer, Berlin.

Scheer, A-W. (1999). ARIS – Business Process Modeling. Springer, Berlin.

Sonnenberg, C., Huemer, C., Hofreiter, B., Mayrhofer, C., and Braccini, A. (2011). "The REA - DSL: A Domain Specific Modeling Language for Business Models". In Proceedings of the 23rd International Conference on Advanced Information Systems Engineering, London, United Kingdom. (2011).

Sorter, G. H. (1969). An “Events” Approach to Basic Accounting Theory. The Accounting Review (January 1969), pp. 12-19.

Weber, R. (1986). Data models research in accounting: an evaluation of wholesale distribution software. The Accounting Review (July 1986), p. 498-519.