Modeling the Assertion Based Audit Approach into REA and the Value Cycle Model

Robert Nehmer, Hans Weigand, Philip Elsas

Oakland University, Michigan, USA
Tilburg University, The Netherlands
ComputationalAuditing.com, Canada

Abstract: In Weigand and Elsas [2011], the authors considered the linkage of the REA business ontology to the Value Cycle Model (VCM) of auditing which appears in the Dutch tradition of auditing companies. Here we extend that model by considering REA in an assertion based audit approach (ABA). The assertion based approach has been used in the United States for a number of years but was best formalized by Leslie, et al. [1986].

1 Introduction

In this paper we consider the application of the REA business model to auditing as proposed by Weigand and Elsas [2011]. In that paper the authors provided a formalization of REA and considered the linkage of the REA model to the Value Cycle Model (VCM) of auditing which appears in the Dutch tradition of auditing companies. Here we extend that model by considering REA in an assertion based audit approach (ABA). The assertion based approach has been used in the United States for a number of years but was best formalized by Leslie, et al. [1986].

Lupasc et al. (2010) look at the REA framework as an ontology of accounting information systems. According to the authors, REA primitives are resources, events, agents, stock flows, control and duality. The paper treats the REA model as an ontological representation of accounting. The duality primitive is the give-and-take relationship originally mentioned in McCarthy (1982). To this the authors add a value chain concept. That concept defines the value chain as the acquisition, conversion and revenue cycles of an enterprise. This value chain is then seen to incorporate the three critical REA primitives. These three primitives are economic events, economic agents and economic resources. The authors note the extension of REA to include location. They also note that economic claims can be included in this ontology. Finally they add the concept of an economic contract with a resulting agreement and economic commitments to the ontological model. The authors characterize these extensions as adding knowledge reuse and knowledge sharing to the ontological representation of the REA framework.

Geerts and McCarthy (1999) exemplifies the evolution of REA. The paper takes an object oriented and semantic approach to REA. The paper contrasts traditional accounting systems designs with REA system designs. According to the authors, REA

designs will help to promote process orientated models, promote knowledge-based decision models, and support interoperability. The authors discuss REA accounting in its script like capabilities. As such REA designs can be used to incorporate value added exchanges to the basic REA data model. The combination of the REA data model with the value added process model helps to create an object infrastructure which can be used in enterprise design. These object oriented designs lend themselves to interfacing with knowledge-based decision tools. As such the authors believe REA helps promote a more efficient economic system. This system allows financial decision-makers to use financial information with fewer intermediaries. The characterization regards SEC EDGAR filings as being an unnecessary data stop intermediated by financial statement analyzers. The knowledge based systems could more easily represent these flows of information to the end users. This would lead to a more knowledge intensive enterprise design. As a research extension to this work, the authors note the ontological directions of REA. Here, the authors contend that REA must extend its ontological features to include enterprise knowledge management, supra-accounting theories in strategic management, and an explicit treatment of time. In addition to individual instances of cycle scripts need to be worked out.

Gailly *et al.* use the Unified Modeling Language (UML) profile to graphically represent REA ontologies. The authors look at ontology engineering methodologies to evaluate the development of the REA ontology. The authors argue that REA is a business domain ontology. The authors state that there are different schemes for classifying ontologies. Two dimensions of these classifications are the richness of the internal structure and the subject of the conceptualization. The subject of the conceptualization includes structured and semi-structured information in a formal specification with a shared conceptualization. Here formal means machine processable. In this view, there are several types of ontologies. These include representation ontologies, top-level ontologies, domain ontologies and application ontologies. The authors concluded REA is a specialization of a top-level ontology. Further they determine that REA is a business domain ontology which has a universe of discourse in business. However, REA does not support all business related subjects such as marketing strategies. According to the authors, business domain ontologies are high level ontologies. In order to be implemented, an application ontology or ontologies must be created. They conclude that REA is not an application ontology because it is not limited to a single application. In terms of the richness of REA's internal structure, the authors note that the REA model still uses a mixture of textual description and modeling references. Therefore, they conclude that a conceptual modeling language like UML will have the richness needed to represent REA ontological components. As such, they conclude that the REA ontology would have a semantically rich internal structure. However, the details of the structure are not explicitly specified. They then work out a specific specification in OWL for REA.

2 Model-Based Auditing

Weigand and Elsas [2011] define model-based auditing as follows. The main concept is that the auditing process and the internal control measures are designed into the business processes and that the business processes themselves are designed to be correct. *As such, the audit procedures and controls are not just added ex post to mitigate any risks these processes may contain but that they are designed to be fraud-resistant, etc.* In this design approach, the concept of "core business system" is key. It must identify the value transformation to be protected. Because of its central importance, the "core business system" must be designed in a disciplined way captures all business value and value transformation. After that, the business processes are designed to make sure that those processes interacting with value objects do so in a way which minimizes the possibilities of abuse or illicit extraction. The authors conclude that the best way to do that is to design these processes and the accompanying information systems by deriving them from the core business system on the basis of explicit control principles. They list the basic requirements for a model-based auditing approach as follows:

R1 – does it include an enterprise-wide normative model and a representative model of value objects and their transformations ("core business system")?

R2 – does it allow for a principled way of developing this core business system model (of identifying the value objects and their transformations) in both normative and representative modalities?

R3 – does it support explicit control principles?

R4 – is it possible to derive preventive control mechanisms from this core business system model, in particular, irreplaceable internal controls like segregation of duties on access controls?

R5 – is it possible to derive enterprise-wide comprehensive, encompassing detective controls, in particular, continuity equations from the normative model?

R6 – is there a systematic relationship between the core business system and the information system?

R7 – is it possible to identify relevant financial statements from the core model?

Weigand and Elsas[2011] define an REA business model as follows:

"A REA business *model* is defined as a tuple ⟨OT, *Stockflow*, *Control*, LT⟩ where OT is a set of Object Types. OT = RT ∪ ET ∪ AT (resource types, event types, agent types). *Stockflow* is a function ET → RT that specifies for each event type the resource type that it manipulates. Events are categorized according to StockflowCat = {produce, use, consume, take, give}. *Control* is a function ET → AT × AT that specifies for each event type two controlling agents, providing and receiving, respectively. LT is a set of links, defined as a relational subset of OT × OT. The links can be labeled using a function LT → LL, where LL is a finite set of labels.

"An operational REA business *system* for a given REA business model is defined as a tuple ⟨O, *Type*, *S*, *C*, L, *Date*⟩ where O = R ∪ E ∪ A (Resources, Events,

Agents); *Type* is a function O → OT that maps resources to resource types, etc.; *S* and *C* are functions between events and resources, respectively agents, corresponding to *Stockflow* and *Control*, i.e., for each e ∈ E, *Type*(*S*(e)) ∈ *Stockflow*(*Type*(e)), similar for *C*; L is a set of links, defined as relational subset of O × O, such that for each link $<o_1, o_2> \in L$, it holds that $\langle type(o_1), type(o_2) \rangle \in LT$. *Date* is a function E → Time

"Within R, we distinguish a subset called *commitments*. CT (commitment types) is a subset of RT. Each commitment type has a "fulfill" link (in LT) to one event type. Furthermore, in LT we distinguish a class of *responsibility* links between agent types."

Weigand and Elsas [2011] proceed to relate the REA model to the Value Cycle Model (VCM) of auditing. *The core of the value cycle approach from our perspective is the set of so-called BETA equations.* The general rule for the VCM is that the difference between the final state of a stock of resources or value, denoted "E" and the initial state of that stock, denoted "B", equals the difference between all the additions made to that stock, from the beginning until the end, denoted "T" and all the subtractions made from it, from the beginning until the end, denoted "A", i.e. E – B = T – A. This rule is known in the Dutch accounting and auditing tradition as the BETA-equation, since B – E + T – A = 0, and is applicable to every individual stock, (Starreveld et al., 1988), "The law of the coherence between state and event." As such, it is the core to the VCM audit model.

3 Assertion-Based Audit

The assertion based audit (ABA) model defined in Leslie et al. [1986] consists of the following core components. 1) The inherent nature of the item defined as the complement of its inherent risk. 2) Preventive internal controls which are related to the level of inherent risk. When the inherent risk is greater, then there is more of a need for preventive controls. These first two taken together assess the prior probability of error. 3) Compliance procedures which are the implementation of the preventative internal controls. Assessing these procedures helps to provide assurance over the control of the prior probability of error. 4) Detective internal controls which are applied after data entry and increase the likelihood of detecting any errors which may have occurred during entry or in processing and also support the assessment of prior probability of error. In this model compliance procedures on detective controls are part of the detective internal control identification process. 5) Analytical review where the degree of assurance from analytical review depends upon whether a judgmental or regression analysis-based analytical review is being conducted. 6) Other substantive sources which include traditional substantive testing together with other non-sampling substantive procedures. The approach also permits the explicit recognition of assurance from other audit procedures designed for other assertions.

Leslie *et al.* [1986] introduce some simple cycles which are sufficient for our purposes here. The results derived from their analysis would extend to more complex

situations. From these cycle elements, the corresponding accounting cycle equations can be written[1]:

Cash (t) = Cash (t -1) + REC(t) - DIS(t)

A/R(t) = A/R (t -1) + REV(t) - REC(t)

PAY(t) = PAY (t-1) + EXP(t) - DIS(t)

They call these the normal form of the cycle equations. They derive the accounting cycle assurance formula for the accounting cycle equation as follows where we use the A/R cycle as an example. As usual in auditing, we assume that the audit client is a continuing client and therefore that we have already audited the prior year's results.

REV(t) = A/R(t) + REC(t) - A/R(t-1)
audited in prior years

REV(Over/Understated) = AR(t) (Over/Understated) $\wedge$ REC(t) (Over/Understated)

This assurance formula shows how audit assurance on A/R Overstated and REC Overstated provides assurance on REV Overstated. The "$\wedge$" symbol in the formula indicates that only the minimum assurance can be carried over.

The following is the formulation as per Weigand and Elsas.
"If we want to check the outflow statement ("afgifte"), A is put on the right side.

$$B + T - E = A + \delta$$

Here δ stands for the deviation error. In the Soll modality, $\delta = 0$, which is the conjunction of (i) correctness - isn't A overstated? - and thus $\delta \geq 0$, and (ii) completeness - isn't A understated? - and thus $\delta \leq 0$."

What we see in this formulation is that Leslie *et al.*'s accounting cycle equations and the BETA equations from the Dutch audit tradition and Weigand and Elsas [2011] are equivalent. The revenues of this period should equal the ending receivables balance plus the cash receipts flow less the beginning receivables balance. What Leslie *et al.*'s formulation lacks is an explicit reference to a normative versus representative view of the model. But by implication, the normative *use* of the model

[1] We want to remark that from a VCM approach, one equation is missing: Products(t) = Products(t-1) + EXP(t) - REV(t). The advantage of adding this equation – closing the loop by linkage with the product cycle – is that it provides the auditor with 4 equations for the 4 variables REV, REC, DIS, EXP, and so provides *independent* deductive evidence on the value of REV. The claim that this fundamentally strengthens substantiation of addressing the completeness of revenues assertion in the ABA model is something that we would like to assess in future research.

occurs during the audit planning stage and its representative *use* occurs when the planned audit procedures are executed and the audit evidence collected. So from an assertion perspective an ABA and the VCM will produce equivalent results in the REA audit environment. What remains is to consider the considerable difference between the Weigand and Elsas formalization of internal control and the Leslie *et al.* formulation.

Weigand and Elsas differentiate two major components of internal control: preventative controls and detective controls. Leslie *et al.* consider these two components as well as several others. We proceed by taking the six core components of the ABA mentioned above and formulating those missing in Weigand and Elsas into the REA/VCM model. Weigand and Elsas define the process of designing internal control as follows. "Basic internal controls must be designed and analyzed on their effectiveness in either preventing illicit events (preventive internal control) or in being able to notice them when they occur (detective internal control), including ability to notice violations of the internal controls themselves (compliance procedures)." From this we see that both the design and compliance of preventative and detective internal controls have already been considered by them. These are core components 2, 3 and 4 of Leslie *et al.* That leaves components 1, 5 and 6 for further consideration. Component 1 is the inherent nature of the item or the complement of its inherent risk. If we reconsider the REA business *system* for a given REA business model, it is defined as the tuple $\langle O, Type, S, C, L, Date \rangle$ where $O = R \cup E \cup A$ (Resources, Events, Agents); *C* is a function between events and agents, corresponding to *Control*, i.e., for each $e \in E$, $Type(C(e)) \in Control(Type(e))$; L is a set of links, defined as relational subset of $O \times O$, such that for each link $<o_1, o_2> \in L$, it holds that $\langle type(o_1), type(o_2) \rangle \in LT$. So the inherent controls of the system are defined both explicitly through the set *C* but also implicitly through the construction of the possible links defined in LT. It is here that the close consideration between *value* and *business process* is required during the design of the REA business system.

Component 5 is the analytical procedures performed during the audit. Leslie *et al.* consider two types: regression based and judgment based. According to them, regression based analytics rely on the strength of the software system running the regressions. We believe that a current view of this topic would expand the consideration as follows: the quality of the output of the regression will depend on *both* the quality of the processing *and* the quality of the data inputs. Now, as already noted, the quality of the data inputs is assured by the inherent, preventative, detective and compliance controls. So there is the regression analysis software itself which lies outside the REA business system. We might argue from an independence point of view that that is an acceptable circumstance. The final component, substantive tests and other non-sampling substantive procedures falls into the category of the operationalization of the difference between the normative and representational models. So this is evidence which is represented in the REA business model and has evidence available to substantiate its existence.

Finally, the ABA also recognizes the possibility of supporting or corroborating assurance coming from tests of other cycles. This possibility however is not reflected in the accounting cycle equations which they developed. In order to do this type of

modeling, some of the variables in the accounting cycle equations must become endogenous. While we admit this is an intriguing possibility, we leave it for a further research extension.

References

Elsas, Philip; Computational Auditing, dissertation, Free University Amsterdam and Deloitte & Touche, 1996.

Gailly, Frederik, Wim Laurier and Geert Poels, "Positioning REA as a Business Domain Ontology," http://ideas.repec.org/p/rug/rugwps/07-460.html

Geerts, Guido L. and William E. McCarthy, "An Accounting Object Infrastructure for Knowledgebased Enterprise Models," IEEE Intelligent Systems (1999), July/Aug, pp. 1 - 6.

Leslie, Donald A., Steven J. Aldersley, Donald J. Cockburn and Carolyn J. Reiter; An Assertion Based Approach to Auditing, Proceedings of the Eighth University of Kansas Auditing Symposium, 1986.

Lupasc, Adrain, Ionna Lupasc and Gheorghe Negoescu, "The Role of Ontologies for Designing Accounting Information Systems," The Annals of "Dunarea de Jos" University of Galati
Fascicle I (2010), Economics and Applied Informatics. Years XVI, no. 1, ISSN 1584-0409.

Starreveld, R.W., H.B. de Mare and E.J. Joëls: Bestuurlijke informatieverzorging, deel 1: Algemene grondslagen, deel 2: Typologie der toepassingen; Alphen aan den Rijn, Brussel: Samson; 1988 (Vol.1) and 1986 (Vol.2) (all in Dutch).

Weigand, Hans and Philip Elsas; Model-based Auditing Using REA, paper presented at UWCISA symposium 2011.