Semantic Modeling in Accounting Education, Practice, and Research: Some Progress and Impediments

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Published in: *Conceptual Modeling: Current Issues and Future Directions*, Editors: P. P. Chen, J. Akoka, H Kangassalo, and B. Thalheim. Springer Verlag, Berlin and Heidelberg, 1999, pp. 144-53. All of the judgments of past, ongoing, and future research projects and of the ultimate viability of Entity-Relationship and REA commercial implementations in accounting represent the informed conclusions of the author alone

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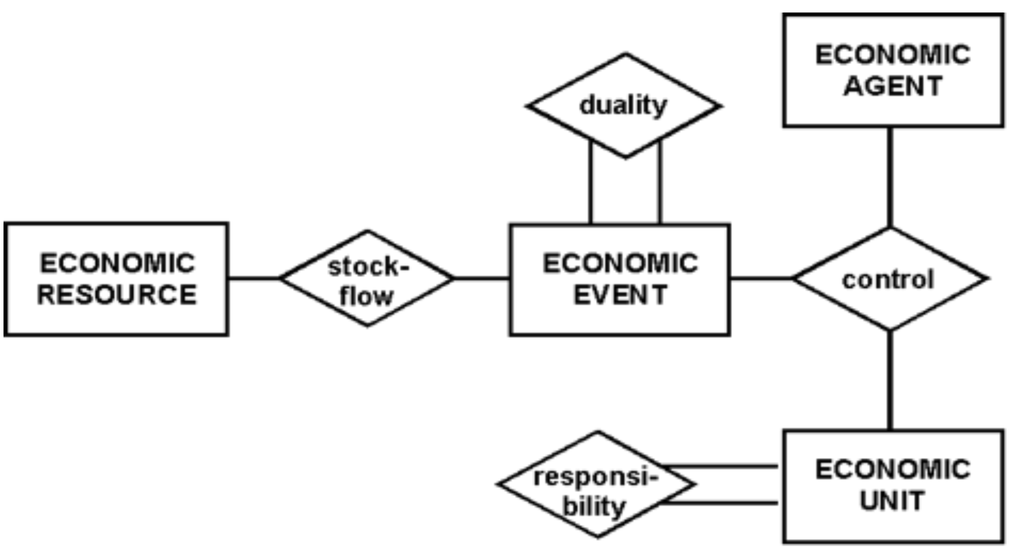
1.0 -- Introduction

In late 1979, the first Entity-Relationship (E-R) Conference was held at UCLA in December, and the first semantic modeling paper in the financial systems domain was published in *The Accounting Review* in October. Those two papers by McCarthy (1979; 1980) were actually based on his doctoral dissertation work completed in 1977 at the University of Massachusetts where a computer science professor -- David Stemple -- had introduced him to the groundbreaking E-R paper of Peter Chen (1976) that was published the prior year in the initial issue of *ACM Transactions on Database Systems*. An important additional component of that same thesis work was the development of a normative accounting data modeling framework, something which needed more theoretical development at the time of the first E-R Conference. By 1982 however, McCarthy had completed that additional work, and he followed the first E-R paper and conference presentation with a more general semantic theory of economic phenomena in business organizations - the REA accounting model (McCarthy, 1982).



The first and most basic form of the REA semantic framework is portrayed in the figure. This basic pattern has been extended both up to the more abstract level of enterprise value chains and down to the more specific level of workflow tasks in more recent work by Geerts and McCarthy (1997). However, its conceptual core remains the template portrayed here, and it is those components that will be the subject of this paper. Readers may see that the model has three types of primitive entities (economic resources, economic events, and economic agents with economic units being a subset of agents) and four types of primitive relationships (stock-flow, duality, control, and responsibility). The ternary control relationship is often split into two binary associations for simplicity sake. The acronym REA derives from the left-to-right economic entity constellation of **r**esources-**e**vents-**a**gents.

In the 16 years since 1982, REA theory has expanded considerably in accounting research, practice, and education (Dunn and McCarthy, 1997), and the original paper was honored by the Information Systems Section of the American Accounting Association with its bestowal of the first *Seminal Contribution to the Accounting Information Systems Literature Award* in 1996. However, the rate of this progress and the assimilation of REA work into the mainstream ideas of accounting have not been without problems and impediments. This is probably true of most theoretical and practical changes that an overtly semantic approach (like E-R modeling) causes, but these problems have been especially prominent in the very traditional discipline of accounting. This is a field whose practitioners are noted for their emphasis on conservatism, whose researchers are dismayingly preoccupied with experimentally rigorous evaluation of present methods to the exclusion of relevance and new ideas, and whose students are noted for their affectation with precision and numerical accuracy. A semantic re-orientation of bookkeeping ideas and a more conceptually-relative (and hence imprecise) universe of computerized accounting systems patterned on unfamiliar models are not changes welcomed with open arms by accounting educators, practitioners, or theoreticians. The REA accounting model has had to battle these challenges, and its progress has certainly suffered as a result. However, the recent emergence of certain trends in accounting education and practice (such as holistic curriculum changes in education and widespread acceptance of re-engineered and enterprise-wide accounting systems in practice) has made measurable progress possible again in the late 1990s. Additionally, as acknowledged early on by REA advocates, technological progressions like faster processing and cheaper storage, and conceptual innovations like systems whose semantics are embedded within their basic constructs (like objects) had to become widely available before REA-based implementations could become realistic goals.

This paper will explore both the REA successes in education, practice, and research and the REA impediments. More generally, the paper will discuss the difficulties that any new semantic theory must face when it clashes with an existing paradigm of thinking that is based on a different view (oriented toward paper and hand calculation) of the world. Challenging that traditional view directly is not always a good strategy, and the paper will discuss instances where such frontal challenges are bound to fail. In a greater context, these are challenges and inevitable failures probably faced in particular by many other semantic methodologists and in general by any group whose work attempts to challenge existing methods and entrenched mindsets.

Discussion of REA progress and impediments will be grouped under the three general headings of education, practice, and research. Each area is given a heading in the next section of the paper.

2.1 -- Semantic Modeling in Accounting Education

Although REA-oriented development of accounting systems was taught as early as 1979 at Michigan State University (MSU), its general use did not grow beyond the 10-15 schools affected by direct interaction with MSU faculty or doctoral students until the publication in 1995 of the first Accounting Information Systems (AIS) textbook to use REA as an integral foundation (Hollander et al., 1995). Other AIS books (such as Romney et al., 1997) soon followed suit with the result that more than 100 schools nationally now take at least part of this approach to AIS teaching. However, far more schools still cling to manually-oriented bookkeeping methods of teaching systems, and it appears also that at least some new adopters use REA only as a non-integrated topic among many to be covered instead of as a new fundamental way of conceptualizing accounting systems. Some possible reasons for this state of affairs follow.

Until recently, undergraduate accounting curricula across the USA were startlingly similar: two sophomore introductory courses, followed by two junior-level intermediate courses and a cost accounting course, followed by senior-level courses in taxation and auditing. These often were augmented by advanced and governmental accounting courses plus a few electives, but basically this set was the accepted core of the curriculum. Additionally, these courses all had somewhat standardized content nationwide -- a fact attributable in no small measure to the CPA exam and to the presence of well-accepted authoritative books like the Charles Horngren cost text or the Arens/Loebbecke auditing text. Such curriculum standardization is not uncommon across many other university departments of course; one only has to envision freshman composition, sophomore economics (with Samuelson of course), junior organic chemistry, or senior-level Shakespeare. In accounting however, the standardization seemed even more confining, at least until a national commission -- the Accounting Education Change Commission (AECC) -- was convened in the early 1990s to encourage innovation.

In this well-defined curricular environment, accounting information systems (AIS) courses have never fit well. Their content has varied widely from school to school, and the only efforts at national standardization simply resulted in impossibly long laundry lists of possible topics in computerized information system design and use that could be covered in any particular order or fashion. AIS course objectives often still include such diversities as completion of manual bookkeeping practice sets, instruction in spreadsheet fundamentals and web-site design, and coverage of auditing control checklists. Elementary AIS never had a central theme that was accepted at even a small percentage of accounting departments until conceptual modeling and REA came along. Now, books like Hollander et al. (1995) and a tentative recognition by the Information Systems Section of the AAA that a "conceptual database" approach should be a principle component of AIS instruction make increasing acceptance of REA approaches much more likely in business schools across the country. This conceptual database initiative by the IS section is actually in tune with other fields occupied with adaptation to the world of electronic commerce and the concomitant need to develop domain-specific ontologies (Gruber, 1993).

It must be mentioned however that full acceptance of conceptual modeling ideas in AIS still faces many hurdles. The learning curves for REA instruction are very steep, as it most often seems to take more than a year and multiple passes through the AIS course before the normal accounting faculty member feels familiar enough with the material to use it in a completely integrated fashion. Such a time commitment is difficult for many in AIS, especially those who must also cover courses in the traditional parts of the curriculum. Additionally, it is clear that the *Debit-Credit-Account* (DCA) method is more than simply the core of manual bookkeeping systems to most accounting faculty; it is ***THE WAY*** to teach accounting principles, especially financial accounting principles. Any AIS course that hints at even partial abandonment of these bookkeeping artifacts in the practice of building systems is certain to draw at least some opposition from conservative quarters of a normal accounting faculty. Along this same line, it is interesting to note that there has been some preliminary mention among semantic theorists in accounting of pushing REA-type thinking down into the introductory principles (sophomore-level) of accounting courses. This of course is bound to draw even stronger opposition from traditional faculty.

In theory, conceptual or semantic modeling (like the E-R approach) of any practice domain should yield construct taxonomies and schemas (also called *ontologies*) which in turn could be useful as a basis for instructional development. This is what is happening with E-R modeling of REA process patterns in accounting system courses. It would be interesting to see if a survey of E-R use in other domain-specific courses such as supply chain or manufacturing management (as opposed to generic knowledge representation courses such as information systems or computer science) would reveal the development of other schematic and taxonomic structures like REA. If such educational infrastructures do exist in other areas, teachers intent on using them might certainly benefit from a review of the difficulties experienced in accounting departments before they attempt such curriculum innovation. A preliminary guess would be that the older methods in these other fields would not be quite as entrenched as accounting (which after all relies on the double-entry equation first promulgated by Pacioli in the late 15th century). If true, these more supple fields would find the acceptance of conceptually-based domain taxonomies much easier.

2.2 -- Semantic Modeling in Accounting Practice

When the REA accounting model was first published in 1982, it was proposed not only as a theoretical accounting archetype, but as a practical framework for building large-scale enterprise information systems whose databases required view modeling and view integration across accounting and non-accounting users (this dual purpose by the way differentiates REA from other expansionist-accounting proposals such as multidimensional bookkeeping which are conceptual toys with no implementation vision). The theoretical reconciliation between REA primitives and accounting concepts such as claims, matching, and immediate expensing of services came in the latter half of the 1982 paper, and they could be perceived to be as much as an argument for the robust utility of the database integration pattern than as an enumeration of all of the theoretical ramifications of the model. REA was born of practical use, and its seminal exposition even begins with an enumeration of weaknesses in double-entry systems that an REA orientation is intended to overcome in actual practice. This implementation imperative was reflected in many of the early REA papers (Gal and McCarthy, 1983; 1986; Denna and McCarthy, 1987) and even in some of the more recent ones (Geerts and McCarthy, 1992) where "proofs of concept" were demonstrated in different types of database and knowledge-base environments. In all of these systems, however, the Lilliputian scale of the transaction base was fully acknowledged, and the eventual problems with "scaling up" to realistic transaction volumes was discussed as an implementation barrier.

The database design methodology for which REA was proposed has four steps: (1) requirements analysis, (2) conceptual design, (3) implementation design, and (4) physical design. Initial REA use was concentrated in conceptual design, although later research has pushed it both forward into requirements analysis (Geerts and McCarthy, 1992) and backward into implementation design (McCarthy and Rockwell, 1989). To date, there has been no extensive research work on the physical design problems of REA-patterned systems, and it is here in physical design where "scaling up" problems make implementation of *Full-REA* systems still a future dream. This was a impediment acknowledged by McCarthy in 1982 (p. 572), and although present processing speeds have increased dramatically and present storage costs decreased dramatically as well, implementation compromise at the physical level is still theoretically necessary because no enterprise can afford to keep all of its events as part of the active database and to materialize certain conclusions from them only upon demand. Some preliminary work on loosening this constraint with design patterns has been started at the University of Illinois by students of Ralph Johnson (Nakamura and Johnson, 1998).

To date, there have been a number of "directed-REA" implementations in actual businesses. *Directed-REA* means simply that use of the original REA model was an explicit part of the system building process, usually as a chosen alternative to a traditional accounting approach. The first of these cases was documented by Cherrington et al. (1996), and the continued use of REA in the GENEVA practice of Price-Waterhouse Consulting is described in a recent *Management Accounting* paper by Walker and Denna (1997). In all of these cases, REA use was concentrated in requirements analysis and conceptual design of the implemented information systems, and its use was explicitly rationalized as a cure for past problems involved with integration of bookkeeping artifacts within a larger enterprise system. At the physical design level, necessary implementation compromises were made to full-REA structures, although in some cases these compromises were not as severe as one might have predicted. This is especially true in the *GENEVA* systems where Price-Waterhouse has developed a proprietary algorithm to alleviate storage and processing problems.

Completely customized implementation of a new enterprise information system is not a common occurrence, and most installations rely heavily on packaged solutions. To date, there are no directed-REA enterprise packages. In at least one case of a proposed client-server suite several years ago, a developer did consider REA-based implementation. However, that vendor backed away because of the perceived risk in not using the traditional double-entry framework that manually-trained accountants are accustomed to.

There is presently an REA-based industrial system for value chain planning being prototyped by a company led by Haugen (1998). However, that system is still some time from fruition.

In the absence of an established base of directed-REA information systems implementations, David (1995) decided to test the issue of REA vs. DCA systems empirically. She hypothesized that most actual enterprise implementations were hybrids of these two models when one considers accounting systems on a spectrum with DCA anchored at one end and REA at the other. Furthermore, she hypothesized that certain types of advantages would accrue to companies with systems that tended more toward the REA end. In a limited sample of eight companies in the paper and pulp industry, she found evidence of advantages in administrative efficiency and gains in productivity associated with systems more strongly associated with REA. Her preliminary work here has led McCarthy, David, and Sommer (1996) to consider this entire issue of migration of systems toward a more enterprise-wide and more semantic perspective in the context of an evolutionary model based on *Economic Darwinism*. In the very simplest of terms, this theory of enterprise information systems evolution posits that such systems evolve toward an advanced archetype (like full-REA) with more semantics, more integration, and more inter-enterprise orientation as the result of changes in packages that the market responds positively to and which then become the basis for even more advanced information architectures. Both double-entry bookkeeping and REA are seen in this theory as branches in an overall hierarchical classification of information systems in much the same manner that fish, dinosaurs, birds, and mammals are seen as branches of the animal kingdom. Like animal classification, the information system taxonomy has some innate notion of progress toward more complex forms, and some accounting system advances achieved since 1982 (like activity-based costing, value-chain accounting, and more full accounting for human resource use) would actually have been predicted by such a progression toward full-REA. However, also like the animal system, the system evolution framework would predict cases or niches where the less advanced (admittedly, a value judgment) forms would prosper. This type of reasoning could explain for example firms where a bookkeeping system would be better than full-REA in much the same manner that a shark would have a "survival advantage" over a human in a bay of water.

It seems logical that accounting education would usually drive accounting practice, that is that the most advanced ideas would normally be introduced in university settings and carried from there by eager students to be implemented in actual businesses. Such is not the case for the most part in accounting today, and in fact, there is an interesting trend where quite the opposite is true. This is where practice drives educational change in the installation and integrated curriculum use of ERP (enterprise resource planning) packages. An increasing number of accounting departments have installed these packages in the last two years for across-the-curriculum use and then found that the traditional accounting frameworks do not describe well what they are demonstrating. In at least some cases, the solution to this conceptual mismatch has been achieved by moving the instructional models away from DCA frameworks and more toward conceptual frameworks like E-R models with REA patterns.

2.3 -- Semantic Modeling in Accounting Research

Social science models for generating and evaluating research projects create a less-than-hospitable environment for researchers who are trying to create new constructs, methods, and tools for building better information systems, and there is no place where this is more true than in academic accounting. The mainstream financial and managerial accounting research establishment has for the last 30 years been trying (with increasing degrees of success) to exclude work whose specific purpose has been to develop "better ways of doing accounting," a focus which this establishment pejoratively labels "normative" or "engineering-oriented." This creates a situation that is quite surprising to most computer scientists where accounting researchers are most acutely aware of and responsive to the effect of their ideas on the corpus of present research papers while seemingly being almost indifferent to the effect that their endeavors have on actual practice. This ivory-towered attitude is unexpected in an applied field like accounting, but there is no disputing its inhibitive effect on the ability of the semantic modeling community within accounting to establish a beachhead in the mainstream literature. For example, even if they had significant accounting or economic content, the seminal database papers of both Codd (1970) and Chen (1976) would have been returned to the authors without review as "normative essays" if they were submitted to accounting journals today.

As a result of this narrowing attitude in accounting research, most conceptual or E-R oriented research has been concentrated either in "systems accounting" journals or in journals outside of accounting. This is both a positive and a negative. It is good because it keeps the semantic modeling community in accounting from falling into the irrelevancy trap of the mainstream and because it keeps them acutely aware of how advances in their field interact with advances in the larger computer science or information systems community. It is bad in the sense that it keeps important conceptual work like the development of accounting ontologies or the development of advanced accounting systems concepts out of the mainstream literature where their influence could accelerate change. An unfortunate side effect of this exclusion is that badly-applied conceptual modeling or ontological efforts are allowed to succeed in the mainstream because they are not subject to review either by the practical world or by the systems accounting community. A good example of such an effort is the paper on taxonomic and schematic knowledge structures by Frederick (1991). This was a cursory and incorrect exposition of basic conceptual modeling ideas that would have been informed greatly by a person familiar with the aggregation and generalization work of Smith and Smith (1977) or by a person who had faced the challenge of building actual systems with implemented taxonomic/schematic structures.

A summary of the effect of E-R modeling on accounting systems was published in the *Journal of Information Systems* by Dunn and McCarthy (1997) who reviewed all the major database work done in this field since the 1960s (with some conceptual work dating back to the 1930s). For those authors, the advent of conceptual database work like Chen's was a watershed because it enabled for the first time realistic assessment of alternative foundations (like REA) for implementing better accounting systems.

At the end of their paper, Dunn and McCarthy use a conceptual framework proposed by March and Smith (1995) to outline future research directions for conceptual modeling work of both a normative (design science) and positive (natural science) nature. Those conceptual directions were augmented and examined more closely in more recent work by David, Dunn, Poston, and McCarthy (1998). To date, the most active ongoing forum for discussion of such research projects has been the annual *Semantic Modeling of Accounting Phenomena (SMAP) Workshop* which started meeting in 1995 and which is next scheduled for August 1999 in San Diego.

3.0 -- Summary

The use of Entity-Relationship modeling in particular and of semantic modeling in general has had very noticeable effects in accounting over the last 20 years. The most pronounced impact has certainly been on accounting education where REA models of the type first proposed by McCarthy (1979; 1982) and later extended by Geerts and McCarthy (1994) have permeated the undergraduate and graduate curriculum. REA conceptual modeling of various business processes (or cycles as they are called by accountants) provides a taxonomy of conceptual objects and structures for use in describing and teaching the accounting information architecture of typical business enterprises. These conceptual structures are now embedded in AIS textbooks and used nationwide.

The effect of REA on accounting practice has been less pronounced, partially because the technological impediments to REA implementations are just now starting to be removed. Some progress is being made with prototype directed implementations in actual practice, and additional research insights are being uncovered with empirical investigations that posit evolutionary movement in the enterprise software marketplace toward full-REA conceptualization.

Progress in research on semantic modeling of accounting phenomena is difficult to characterize exactly. Several design science projects intended to extend REA principles both declaratively and procedurally are ongoing at present. However, the achievement of a critical mass of researchers in this field has been hampered by high learning curves and by the inadaptability of mainstream accounting journals who view the outcomes of such projects as more development than research. More promising for the long term of REA research is work on the empirical end where the needed research skills are already possessed by most accounting academics and where the outcomes of the research projects will be more acceptable to traditional publication outlets.

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