**The REA Accounting Model:   Intellectual Heritage and Prospects for Progress**

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# The REA Accounting Model: Intellectual Heritage and Prospects for Progress

ABSTRACT:  Researchers often equate database accounting models in general and the Resources-Events-Agents (REA) accounting model in particular with events accounting as proposed by Sorter (1969). In fact, REA accounting, database accounting, and events accounting are very different. Because REA accounting has become a popular topic in AIS research, it is important to agree on exactly what is meant by certain ideas, both in concept and in historical origin. This article clarifies the intellectual heritage of the REA accounting model and highlights the differences between the terms *events accounting*, *database accounting*, *semantically-modeled accounting*, and *REA accounting.* It also discusses potentially productive directions for AIS research.

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For more than 50 years, researchers and practitioners have noted the inability of accounting systems to facilitate non-financial decisions (Goetz 1939; Firmin 1966; Fisher 1994). In fact, this problem has contributed to what is considered to be a state of crisis in accounting systems (Andros, Cherrington and Denna 1992; Cushing 1989; Dunn and McCarthy 1991; Elliott 1992). The recurring theme in these studies is the need for accountants to change their role in organizations. Rather than providing only the services of producing financial statements and policing the control policies of firms, the accountant must become a business partner striving to meet all of the firm's information needs. Database accounting in general (for example, Colantoni, Manes and Whinston 1971; Geerts and McCarthy 1992) and the Resources-Events-Agents (REA) accounting model more specifically (McCarthy 1982) have been proposed as means of recording and storing accounting information in such a way that transaction details are available for non-accounting decisions. Maintenance and use of such accounting systems moves the corporate accountant toward the role of a full business partner and manager of the economic activities of an enterprise.

McCarthy (1981) reviewed the general nature of work done on multidimensional and disaggregate accounting systems. Since that time, however, inconsistencies in the perceived origin and nature of this work have arisen, such as the mistaken belief that REA modeling involves simply the use of database technology to implement the ideas of Sorter (1969) on *events* accounting and of Ijiri (1975) on certain aspects of accounting measurement fundamentals, particularly *causal double entry*. As use of the REA accounting model in AIS research increases (Schneider 1995; Leech 1995), it is important to dispel such misconceptions. Conflicting and overlapping use of the terms Events Accounting, Database Accounting, and REA Accounting also indicates a need for clarification and differentiation of these models. Making this distinction is one objective of this article. A second objective is to identify, based on the clarification of the models, potential research areas.

Section I discusses the intellectual heritage of the accounting approaches. Section II identifies equivalent or overlapping aspects of the approaches. Section III delineates the aspects of each approach that have been subject to validation and the results of such efforts. Section IV discusses research directions. Section V offers conclusions.

## I. INTELLECTUAL HERITAGE

### Events Accounting

Sorter (1969) coined the term "events accounting" as a solution to problems with the conventional approach to accounting (which he labeled the "value theory" ). He clarified his definition of the events approach with two operational rules (Sorter 1969, 16):

> A balance sheet should be so constructed as to maximize the reconstructability of the events being aggregated.

> Each event should be described in a manner facilitating the forecasting of that same event in a future time period given exogenous changes.

While Sorter advocated less aggregation than was present in financial statements then, examination of his rules and his later textbook (Sorter et al. 1990) reveals that he was not advocating storage and maintenance of transaction level detail. He defined his events

approach to accounting as stressing "the determination of accounting events from financial statements" (Sorter et al. 1990, 107). He suggested it is necessary to know the changes in the balance sheet accounts in order to deduce events. His was a reporting method rather than a proposal to reorient transaction processing systems.

After Sorter proposed his theory, Johnson (1970) defined several of its concepts more rigidly. He hinted at the need for multidimensional tracking of events by declaring that user forecasting capabilities "would be enhanced if the [event] reports were to include observations other than the monetary characteristic" (p. 649).

Seven years prior to Sorter's article, Schrader (1962) touched on many of the same issues addressed by Sorter and Johnson. Schrader's article is not recognized by many as events accounting, perhaps because he did not emphasize the term *events*. However, the content focuses on the recording and storing of the details of events. He claimed to be applying Goetz's (1939) notion of a Basic Historic Record to the accounting domain, emphasizing the need for accountants to focus on the objects given and received and to record the who, what, when, and where for each relevant event. Relevant events were defined as exchanges. In a textbook (1981) co-authored with Malcolm and Willingham, Schrader emphasized the difference between observed data recorded in an exchange and other analysis or manipulation of the data. In a section entitled "Basic Historic Record" he suggested that it may be desirable to furnish different accounting statements to various users, depending on their desires. However, the ensuing discussion indicates that what Schrader meant by a basic historical record was not a data bank of primitive raw data (as Goetz intended), but simply a separation of accrual accounting entries from entries representing transactions.

## Database Accounting

The idea of using databases or similar innovations in accounting and financial reporting is even older than events accounting concepts. Goetz (1939, 1949) criticized accounting because of its inability to support management functions. He argued that accountants are not qualified to select, classify, or measure business phenomena unless they fully understand the nature of the issues to be decided. At the same time, users cannot evaluate information unless they fully understand the methods used to produce the information. In addition, Goetz argued that multiple values should be recorded since "different answers serve different purposes or fit different situations" (1939, 152).

As a solution, Goetz proposed the creation of a Basic Historic Record or Basic Pecuniary Record that would be an objective record of occurrences (transactions) indicating what was obtained and surrendered by the company including the date of the transaction. Adjustments necessary for legal or for financial accounting purposes may be made as supplements to the record, but they would not permanently alter the record itself. The main requirement of the proposed system was flexibility. Goetz's goal was to preserve the original data in its most primitive form so it could be organized in the most appropriate form for each decision maker.

While Goetz was advocating the maintenance of a Basic Historic or Pecuniary Record in the American literature, Schmalenbach was making similar arguments in Germany (Schweitzer 1992). Back-Hock (1995) discussed Schmalenbach's ideas and noted that he coined the term *Grundrechnung* for the collection of data necessary in such an accounting system. According to Back-Hock, the Grundrechnung supplies data undistortedly so as to satisfy a great variety of potential information requirements. It may not contain results from arbitrary distribution operations and valuations; instead quantities and their monetary aspect must be stored explicitly. Its design must be flexible enough to

accommodate new attributes when requirements change or grow. Back-Hock (1995) identified the basic types of data units in the Grundrechnung as:

1. Objects of decisions, e.g., events and states,
2. Factors that influence these objects (e.g., decision parameters or aspects to be taken as given, or functional relationships between these objects), and
3. Domain values of objects and influence factors.

By storing such data units separately, the Grundrechnung would probably be able to satisfy a variety of potential information requirements.

Colantoni, Manes and Whinston (1971) were the first accounting researchers to explicitly connect database technology with the problem of building more powerful disaggregate and multidimensional accounting systems, although others like Firmin (1966) and Eaves (1966) had broached the issue in more general terms. Colantoni et al. described a technique for coding each event with both monetary and non-monetary characteristics and extended this scheme by using a tree-type (hierarchical) data structure to parallel the normal chart of accounts for coded event types. They also introduced a data management language. In our opinion, however, they misinterpreted Sorter (1969) when they proposed his ideas as a call for computerized disaggregate databases. As we explain later, our interpretation of Sorter's 1969 article (especially when it is read in the light of his later events ideas) is quite different. We see no strong proposal for newer kinds of transaction processing systems, only a suggestion for different types of financial statement disclosure.

Two more articles proposing hierarchical database accounting models (Lieberman and Whinston 1975; Haseman and Whinston 1976) incorporated many of the early 1970s' advances in database technology. Lieberman and Whinston proposed a logical framework for an events-accounting information system and described a possible implementation of such a system. Haseman and Whinston described the processes involved in self-organizing databases involving the transformation (based upon a stream of user inquiries) of unstructured data files into logical data banks.

Everest and Weber (1977) applied some concepts of Codd's relational database model (1970, 1972a, 1972b) to accounting. To derive relational models for both managerial and financial accounting, Everest and Weber took conventional accounting frameworks and normalized them using Codd's decomposition process (1972a). They then illustrated the use of relational algebra operations to derive information from the normalized database. They observed that application of the relational database model to accounting frameworks was a procedure fraught with major problems. For example, they noted that the duality of double-entry (i.e., the double-entry accounting equation) seems at odds with efficient computer processing. Also, the normalization process embedded naming and classification artifacts in the database schema when it was applied to a conventional chart of accounts framework. They noted that much accounting theory concerns efficient classification schemes or naming conventions, whereas database management theory is more concerned with the objects to be classified. Everest and Weber called for further research to make accounting systems fit advanced data structures better.

McCarthy (1979, 1980a) developed a database accounting system to accomplish the better fit of accounting systems to advanced data structures. He did so by applying Chen's (1976) entity-relationship (E-R) design process to the accounting domain. This resulted in a database schema with a high level of semantic expressiveness and without embedded procedural aspects of conventional accounting.

**REA Accounting**

McCarthy (1982) extended his E-R approach, exploring the issue of database design in a larger organizational context. He emphasized that a change in perspective is needed if accounting is to become a constituent part of an enterprise database system rather than remaining an independent and non-integrated information system. He explained that the view modeling and view integration phases of database design require that accounting phenomena be characterized in terms compatible with non-accounting decision use. He proposed the REA accounting model as such a characterization.

Figure 1 about here

Figure 1 illustrates the entities and relationships of an REA model. In addition to the resource, event, and agent entities, there are four different types of relationships in the REA model. **Stock-flow** (including inflow and outflow) relationships denote events which increase or decrease economic resources. **Duality** relationships associate the dual parts of a single economic exchange, i.e., what is **given** up is linked to what is **taken** in. An example would be a sale that is linked to a resulting cash receipt. The **control** relationship is a ternary connection between an inside agent, an outside agent, and an economic event. For example, a purchase typically involves a buyer (inside agent) and a vendor (outside agent). Often, however, this ternary relationship is divided into two binary ones; this is a common implementation compromise that makes the model easier to understand and implement. **Responsibility**relationships were also defined by McCarthy (1982) for REA, although they are not shown in Figure 1. A responsibility relationship indicates that higher level units control and are accountable for the activities of subordinates. Economic units are a subset of economic agents. The role declarations for each of the four types of relationships are portrayed in McCarthy (1982, 564).

McCarthy proposed that the REA framework be used as a starting point for enterprise-wide database design. He suggested modifications that may be useful, depending on specific corporate information needs. One such modification is the use of generalization as advanced by Smith and Smith (1977). Generalization relates different subtypes or subsets of entities to a generalized type or superset. McCarthy used the example that the entities raw material, work in process, and finished goods generalize to the entity inventory. The modeling of generalization hierarchies allowed much closer correspondence of system primitives with the real-world phenomena they represented.

McCarthy (1982) also enumerated many of the procedural enhancements that would be needed in a working REA system to materialize accounting conclusions. This same topic was treated in more detail in McCarthy (1984).

### Influences of Mattessich and Ijiri on the REA model

When McCarthy first formulated the REA model, he did so by abstracting from current practice in the structure of accounting systems with the data modeling techniques of aggregation and generalization (Chen 1976; Smith and Smith 1977). The concepts he produced as a result, however, bore clear resemblance to the works of theorists such as Mattessich and Ijiri, and McCarthy used elements of their work to describe REA components. It is important to remember that those concepts are not identical but only similar. Although the precise definitions of REA constructs are those in McCarthy (1982), the ideas of Ijiri and Mattessich strongly influenced the choice of terms.

Mattessich (1964) was one of the best sources for abstract descriptions of accounting phenomena available in the 1970s. His axiomatization of accounting gave substance to the notions of economic agents, economic objects, and duality. None of the

REA primitives match the 1964 definitions exactly, but overall they are close in spirit. The most notable difference was in Mattessich's explanation of duality which diverges sharply with REA duality because it concentrates on classificational double-entry, a circumstance noted later by Ijiri (1975).

Ijiri's (1967, 1975) accounting measurement work had a clear influence on the REA accounting terms used by McCarthy and later by Geerts and McCarthy (1994). His differentiation between causal and classificational double-entry laid a foundation for the REA notion of duality, and his causal networks presaged the concept of connecting REA processes into an enterprise value chain like that popularized by Porter (1985). It should be emphasized, however, that although Ijiri's causal double-entry is similar to REA's duality, the concepts are clearly not identical, a disparity accentuated by Seddon (1991, 5-11). Ijiri stressed equality of values for resources incremented and decremented in an exchange while there is a clear presumption in REA accounting systems that increments are expected to exceed decrements in value (Geerts and McCarthy 1994) in normal exchanges. Additionally, Ijiri (unlike a full REA model) did not advocate full traceability as evidenced by his allowance of procedures such as periodic matching. Ijiri (1975) introduced the concept of intentionally degenerate exchanges such as spending money on general and administrative services. REA does not model such expenditures as unrequited decrements, but as decrements that will be traceable to future increments.

In later years, Ijiri's work on triple-entry bookkeeping and momentum accounting took him further and further from the world of REA modeling as he moved toward a preoccupation with classificational systems. However, Ijiri (1967, 1975) undeniably influenced the development of REA accounting concepts in a very substantial way. In many ways, the differences between Ijiri's fully explicated ideas and REA primitives are ones of focus and orientation. Ijiri's early work emphasized accountability-driven measurement and valuation based on historical cost concepts, while McCarthy was most concerned with semantic representation of enterprise economic phenomena leading to actual information system implementation.

## Section Summary

This section has presented the intellectual heritage of REA systems. The citation history of REA accounting includes events accounting works such as Sorter (1969) and database accounting works such as Colantoni et al. (1971). Works of theorists such as Mattessich and Ijiri, which do not fit into either of these categories, helped give McCarthy a theoretical foundation for his REA primitives. However, the differences between the REA model and its intellectual predecessors are significant. The next section proposes a means of differentiating among REA and other accounting models. These criteria are then applied to the papers discussed in this section to provide clarification as to the extent to which equivalence and overlap can be identified between events accounting, database accounting, and REA accounting.

## II. DIFFERENTIATING ACCOUNTING MODELS

### Criteria for Differentiation

Three core features of the REA accounting framework--its database orientation, its semantic orientation, and its structuring orientation--can be used to compare and contrast events, database, and REA accounting models. Each of these orientations is explained in this section. Subsequently, each of the papers discussed in section I is analyzed as to what extent these features are included.

### *Database Orientation*

A database orientation as defined here requires three conditions:

1. Data must be stored at their most primitive levels (at least for some period),
2. Data must be stored such that all authorized decision makers have access to it, and
3. Data must be stored such that it may be retrieved in various formats as needed for different purposes.

These conditions **do not** require the use of database technology--object oriented, artificial intelligence, or other technologies that allow storage and maintenance of primitive detail accommodate this orientation. This also allows for systems built using database technology that do **not** have a database orientation. An example is a system built with microcomputer database management software that uses tables to represent journals and ledgers, but does not keep information about multiple line items for sales or purchases (or that keeps such information only until the accounting period is closed).

### *Semantic Orientation*

Integrated semantics is a fundamental idea of modern database management, reflected in Abrial's (1974, 3) definition, "a database is a model of an evolving physical reality." Re-stated in terms of design methodology, this means that all potential users of a database pool their notions of important information concepts and use that integrated set of ideas to build **one** conceptual data model that serves everybody. The objects in this conceptual model are required to correspond closely to real world phenomena, hence the accentuated use of the term *semantic* to describe this activity. In an accounting domain, integrated semantics means that accounting models should depict the economic exchanges or processes that produce the firm's accounting data (such as the revenue process shown in figure 2). Components of the models should reflect real world phenomena, a situation that precludes the use of basic double-entry artifacts (e.g., debits, credits, accounts) as declarative primitives. Semantically-modeled accounting systems allow representations of economic exchange phenomena to be integrated well with descriptions of non-accounting phenomena (as displayed by some of the dotted lines in figure 2). Both of these types of data can be accessed and used extensively by non-accounting decision makers, something not facilitated by traditional accounting systems.

Figure 2 about here

### *Structuring Orientation*

A structuring orientation mandates the repeated use of an occurrence template as a foundation or accountability infrastructure for the integrated business information system. There are two core structuring ideas within the REA accounting model.

First is the use of a template that records and stores data associated with sets of economic events, as illustrated in both halves of figure 1. For each economic event, data are recorded and stored pertaining to resources and agents connected to the event. For example, Sales is a set of events about which businesses record and store data. Along with capturing data about each sale event (e.g., invoice number, date, amount, etc.), REA structuring requires that data be captured about the associated resources (e.g., inventory, delivery truck, labor) and agents (e.g., salesperson, customer) involved.

The *r*esources,*e*vents and *a*gents are referred to as entities or things of concern to organizational decision makers. The REA model also requires that data about relationships

between or among the entities be maintained. Therefore, the data must be stored in such a way that the links (1) between an event and its resources involving inflows and outflows (stock-flow relationships) and (2) among an event and its agents involving participation (control relationships) are preserved.

The second structuring idea is that there are two basic types of economic events-- resource outflows (give) and resource inflows (take)--and that these types are normally coupled through duality relationships. For a transaction cycle, this means that two mirror-image REA templates are connected in a give-take pairing that models an exchange. This is shown above and below the dotted line in figure 1.

A simplified example of the two structuring ideas being used together is portrayed in figure 2 where sale event templates are related to cash receipt event templates and where some types of resources are given in consideration for others (i.e., there must normally be at least one cash receipt associated with a sale). At any time, there may be exchange imbalances (e.g., a sale for which cash has not yet been received) that result in claims such as accounts receivable (McCarthy 1982, 568).

The structuring orientation of REA accounting enables the maintenance of a centralized data bank, structured such that the resultant accounting system can serve as a framework for the integrated business information system. Full REA modeling as described by Geerts and McCarthy (1994) considers the firm as a set of exchanges or activities where some resource is given up (the decrement) in return for a resource taken (the increment) in each process (Geerts 1993). At the highest level of abstraction, the entire enterprise is considered as one process with an input of cash (initial financing) and an output of cash (debt or equity repayment plus profit). The abstract organization of such processes downward into successively finer levels of data detail and upward into an enterprise value chain is a theme explored extensively by Geerts and McCarthy (1994).

**Application of the Differentiation Criteria**

***Events Accounting***

Although the events accounting papers discussed in section I advocate less aggregation than had previously been present in accounting systems, they do not have a database, semantic, or structuring orientation. Providing users with financial statements that are prepared in sufficient detail that they can deduce underlying events (by emphasizing cash flows and removing accruals) is a very different concept than providing users with a database of information from which they can extract event data in various levels of focus and aggregation.

Figure 3 about here

Figure 3 illustrates specifically the main difference between events accounting per Schrader (1962), Sorter (1969) and Johnson (1970) and REA accounting per McCarthy (1982). As illustrated in figures 2 and 3, semantic data models easily accommodate the notion of generalizing from entity sets and typifying class attributes of those concepts. Figure 3 generalizes the entity set types of *sale, cash-receipt, cash-disbursement*, and *purchase* to the set of all economic events. Doing so causes an expansion in the aggregation plane (McCarthy 1982) as seen on the middle left of figure 3. In the notion of event type, there is the clear intent of Sorter in his events accounting. He was **not proposing** an accounting model that would maintain transaction level detail (as designated in the individual events of figure 3), but only the disaggregation of certain lines on financial

statements. The table[1] representing the relationship between *event type* and *time period* in figure 3 (the *Period-Event Categories* table) comes close to the meaning of Sorter's events accounting. He called for less accrual and fewer combination judgments, not for a different kind of accounting data model.

### Database Accounting

The database accounting work described in section I varies as to the extent it includes database, semantic, and structuring orientations. An analysis of each follows.

The Goetz (1939, 1949) idea of a Basic Historic Record was startlingly similar to the notion of a modern computer database, especially a semantically built database that models reality. Goetz's ideas are consistent with the use of a template to capture data in primitive form, and he also hinted at the notion of duality, although he did not discuss it specifically. Thus, database and semantic orientations are clearly evident in Goetz's work, and a structuring orientation is partly represented. Schmalenbach's (1948) *Grundrechnung* appears to be equivalent to Goetz's *Basic Pecuniary Record* and is likewise consistent with the database and semantic orientations.

The work of Colantoni et al. (1971) is important, because it was the first to recognize that the events concept (at the instance level) could only be realized by a thorough integration of accounting concepts with concepts of database management[2]. Their work is also very important, because they were among the first to propose a computerized accounting system that was not based primarily on double entry accounting. Their lack of immediate classification of events into debit and credit terms and the ability of their proposed system to create multiple views of data are consistent with a database orientation, and at least partly consistent with a semantic orientation (although they still cling to the account artifact in their declarations). There is no clear structuring orientation in their system.

Lieberman and Whinston (1975) and Haseman and Whinston (1976) focus on events at the instance level, thus demonstrating some level of database orientation. However, the example implementations they discuss use list processing that (as Everest and Weber (1977) point out) negates the database orientation by eliminating data independence. There is also no strong evidence of a semantic orientation; they use debits, credits, and accounts. There does not appear to be a structuring orientation.

Everest and Weber's (1977) work demonstrates a database orientation, but their attempt to support classificational double-entry artifacts make their model inconsistent with a semantic orientation. As mentioned in section I, they recognized that the problems they encountered probably resulted from this lack of semantic orientation, and they suggested that future database systems not model accounting artifacts. No structuring orientation is evident in their work.

McCarthy (1979, 1980a) included database and semantic orientations, advocating shared use of elementary data without accounting artifacts embedded into a system. The full structuring of the REA model is not specified in this work, but many of its elements (such as stock-flow and duality relationships) are discussed and demonstrated.[3]

### REA Accounting Systems

McCarthy (1982) extended his earlier work by keeping its database orientation, by expanding its semantic orientation[4] to including generalization hierarchies, and by adding a full structuring orientation as described earlier in this section. The result of adopting all three of these orientations is a semantic theory of how an information system that tracks

economic phenomena should be structured in a shared use environment without regard for ever changing technology platforms.

Figure 4 about here

**Section Summary**

Figure 4 summarizes how all the different works discussed in this section fit together. The outer circle represents those accounting models that focus on event types as  primitives and advocate less aggregation than the traditional double-entry bookkeeping model provides, yet have no database, semantic, or structuring orientation. We label this category *Events Accounting* because the events articles all fit this criterion. The next circle toward the center represents those accounting models that have a database orientation but do not exhibit a semantic or structuring orientation. We have labeled this category *Database Accounting* because most of the articles in that heading fit these criteria with exceptions of Goetz (1939, 1949), Schmalenbach (1948), and McCarthy (1979, 1980a).  These exceptions constitute a new category, the third circle toward the center of the diagram. This circle represents accounting models that have a database and a semantic orientation, but do not specify a structuring orientation. We label this category *Semantically-Modeled Accounting*. The center circle represents accounting models that encompass all three orientations. We label this *REA Accounting* because REA is the only accounting model that contains all three orientations. Table 1 portrays the works in this categorization, and it also summarizes[5] some of each work's major ideas.

Table 1 about here

Obviously, this delineation cannot exhaustively and precisely type all research efforts aimed at building better accounting systems, but it can be used to give some structure to a field where ambiguity of terms is widely present. As with most categorizations, there are gray areas. For example, Colantoni et al. (1971) have at least a partial semantic orientation. Thus they probably belong on the border between Database Accounting and Semantically-Modeled Accounting. Also, the benefits of the three different orientations are only hypothesized; they have not been directly subjected to empirical tests. The next section therefore examines to what extent the accounting models presented in this categorization have been subject to validation, and what the results of those validations have been.

### III.  EXISTING VALIDATIONS OF ACCOUNTING MODELS

A representation model's value can be assessed in various ways. One is by seeing if other researchers have found the model's concepts useful in their own conceptual research and if they have used variations of the basic themes and ideas in their own model-building efforts. Assessment also occurs with the development of a proof of concept--the building of a working implementation of the model--which is often done in computer science (Newell and Simon 1976; McCarthy et al. 1992). Most convincingly in accounting research, a model may be validated through empirical examination. This section reviews the extent to which events, database, semantically-modeled, and REA accounting models have been refined, implemented, or validated in both research and in practice.

**Events Accounting**

In summarizing Sorter, Johnson, and Schrader's work, it is important to emphasize that these authors concentrated primarily on the external reporting aspects of events

accounting. In other words, they did not attempt to develop specifications for disaggregate and multi-dimensional transaction processing systems  but chose instead to expound on the disclosure methods (and the effects of such methods) that could be realized with an events approach. These works were very important in that they sparked several more articles that used their themes and proposed implementation of the events theory with varying forms of computer science techniques. However, as discussed in section II, the proposed implementations actually added a database orientation that was clearly not present in the original events accounting theory.

Revsine (1970) did not conduct an empirical test of Sorter's ideas, but he identified the need to test the practicability of events accounting from a user standpoint. He agreed with the potential benefits of events systems. However, he cautioned that the user processing constraint of finite channel capacity would cause events systems to result in user information overload, an assertion that had clear empirical implications. Benbasat and Dexter (1979) tested the events hypothesis at an individual user level (loosely stated, users are better off with disaggregate data) by comparing decision performances in an operational control context. The paper-based implementation they tested was one of an event-type nature, consistent with the concepts advanced by Sorter; it had no database orientation. They found no significantly better (profit) performance attributable to disaggregated information and additionally found that the disaggregate data user took more time to make decisions. The task users performed was highly structured, so designers would be likely to know users' information needs and would aggregate accordingly. Benbasat and Dexter recommended that events systems be tested using different (unstructured) tasks as well.

**Database Accounting**

While all four articles in this section described proposed implementations of  the events accounting model (as augmented with a database orientation) none of the four described an actual working implementation.[6] This is probably because of the problems identified by Everest and Weber (1977) as inherent in trying to implement accounting artifacts in database format. Parrello et al. (1985) attacked this implementation of accounts problem with a more abstract approach. However, their models became overwhelmingly complex and less generalizable very quickly, and there was no further implementation work done with them. Additionally, there was no empirical testing involving these database accounting systems.

**Semantically-Modeled Accounting**

Because the works of Goetz and Schmalenbach appeared before technology was available on which to implement their proposed accounting systems, there are no direct working implementations of their ideas. However, the seeds planted by Schmalenbach clearly had influence in a later computer-oriented age. Some Grundrechnung implementations are described by Back-Hock (1995).

McCarthy (1978,1980b) used a relational database model to implement his E-R system for a small retail enterprise. Later implementations reflect the advances of  REA structuring over simple semantic representation, and they are thus discussed in the REA accounting sub-section below. Reuber (1990) proposed a semantic representational scheme for manufacturing that accounted for REA modeling of activities, but which also added a layer of non-structured semantics for cost management.

**REA Accounting**

Gal and McCarthy (1983, 1986) defined a compromised retail REA implementation, first with a CODASYL database management system and then with a Query-By-Example (QBE) database system. Denna and McCarthy (1987) did the same for a manufacturing enterprise with an SQL system, as did Armitage (1985) with QBE. Kandelin and Lin (1992) followed these implementations with object-oriented work in the ACTOR language. Research prototypes such as REACH (McCarthy and Rockwell 1989) and CREASY (Geerts and McCarthy 1992) combined the REA model with artificial intelligence and object oriented programming, implementing their systems using Goldworks and Prolog respectively. Finally, constructs of the REA model have been used in production accounting system implementations such as the Price Waterhouse GENEVA Data Architectures and the IBM-Japan Financial Data Warehouse Project (Cherrington et al. 1993).

Weber (1986) is an attempt to empirically assess the validity of the REA model. Weber approached the question by observing what was being done in practice, noting that real-world accounting implementations provide a rich source of data against which to test accounting models proposed by researchers. Weber found that the major elements of the REA model are incorporated into software at the infological or high semantic level. Thus, the model is at least partially validated. At the datalogical or low semantic level, the software packages differed from one another in areas that are not specifically defined by REA. He suggested that the REA model be refined to lower levels of abstraction, even if that means making it domain specific. One recommendation was to build contracts and commitments into the REA model, two types of transactions that McCarthy (1982) specifically mentioned as possible extensions. McCarthy (1982) claimed that existing accounting convention allows less than full specification of schema elements, and he demonstrated that procedural implementations and modifications could be made to the generalized framework to model such instances. Different situations may call for different use of procedural representations or declarative modifications. These implementation characteristics perhaps accounted for some of the lower level variance in the software studied by Weber.

**Section Summary**

In  this section we reviewed the various categories of accounting models identified in section II, assessing the extent to which working systems based on the models have been implemented and the extent to which aspects of the models have been subject to empirical tests. This analysis revealed that the REA accounting model has been the most widely implemented, refined, and empirically tested of the four model categories. Perhaps more striking is the fact that very few of the studies discussed in this section were empirical validations.

## IV.  PROSPECTS FOR PROGRESS

In this section, we discuss March and Smith's (forthcoming) framework for information technology (IT) research to help identify potentially productive extensions and validations of REA accounting.

Figure 5 about here

**March and Smith Framework for Information Technology Research**

As portrayed in figure 5, March and Smith (forthcoming) propose a two dimensional framework for planning and evaluating IT research. The components of each dimension are below.

1. The horizontal dimension of the framework distinguishes between design science and natural science. March and Smith note that natural science typically consists of two stages--theorize and justify--and they also propose that design science consists of two stages--build and evaluate--which actually parallel the two stages of natural science. **Build** is defined as the construction of an artifact, proving feasibility (i.e., that it can be constructed). **Evaluate** is defined as the development of specific metrics for assessing the performance of an artifact and then measuring the artifact according to that criteria. **Theorize** in IT research involves explaining why and how an artifact works (or doesn't work), while **justify** performs empirical and/or theoretical research to test the proposed theories.

2. The vertical dimension of the IT research framework consists of the broad categories of outputs produced by design research: constructs, models, methods, and instantiations. The exact delineation of these categories is somewhat imprecise, but the four in concert certainly cover most design science endeavors.

March and Smith (forthcoming) say natural science aims to understand and explain phenomena, whereas design science aims to develop ways to achieve human goals. They further argue that IT research should be concerned both with utility, as a design science, and with theory, as a natural science. In discussing the evaluation of IT research, March and Smith argue that building the first (never done before within the discipline) of virtually any kind of construct, model, method, or instantiation has research contribution provided the artifact has utility for an important task. Building subsequent constructs, models, methods, and instantiations addressing the same task must demonstrate significant improvement in order to provide research contribution. Thus, per March and Smith, evaluation is the key activity for assessing such research.

**The Build and Evaluate Categories**

Most of the work discussed in this paper fits into the **Build** category of March and Smith's framework, and more research can be done in this category. However, as March and Smith emphasize, future **Build** work must meet certain criteria if it is to be considered useful. March and Smith emphasize repeatedly that any new models, methods, or constructs proposed must be **Evaluated** against existing ones before their research efficacy can be established. We contend that any new constructs, methods, models, or implementations in events or database accounting that ignore the semantic and structuring orientations of the REA model would not be justifiable as advances in the field. For example, a proposed system that contains a database orientation but which declaratively models accounting artifacts (debits, credits, accounts) as primitives must prove its superiority over a pure semantic database that directly models real-world economic phenomena.

We believe that semantic accounting models must also have a structuring orientation if they are to serve as a foundation for enterprise-wide models; however, there could certainly be alternatives to REA's methods of structuring. March and Smith's framework firmly places the burden of proof on researchers proposing such alternatives to demonstrate that they **Evaluate** well against REA's methods on some definitive metrics. Thus, for example, it is not acceptable to simply say object oriented systems are perceived to be an advance over more declarative semantic formalisms (such as entity-relationship modeling, data abstraction, or Nijssen's Information Analyses Methodology (NIAM)), therefore any object-oriented accounting system is better than the accounting systems

already built which used those prior frameworks. One must define specific metrics for evaluating the two models and demonstrate where the previous work falls short on those metrics. In the case of object-orientation, we believe that such efforts would find many of the advantages to be already present in existing REA work (McCarthy and Rockwell 1989; Geerts and McCarthy 1992). In other words, every new software idea is not automatically research when it is applied for the first time to an accounting domain.

Potentially productive extensions in REA accounting research could include (1) use of REA to explicate better methods, constructs, or instantiations or (2) building better instantiations of accounting systems than the ones reviewed here.

An example of research fitting the first category is development of the construct of *epistemological adequacy* (McCarthy and Hayes 1969) for accounting systems (Geerts and McCarthy 1992). The definition of this construct stems from the idea that a system consists of repeated occurrences of the structured REA template. Other examples would include the use of REA as a foundation for manufacturing systems, as proposed by Denna et al. (1994) and by Grabski and Marsh (1994). For the second category, March and Smith point out that instantiations offer proof of feasibility of constructs, models, and methods; these resulting artifacts then become the objects of study. Since REA has been instantiated both in prototype systems and in corporate implementations (Cherrington et al. 1993), research in category 2 could include instantiation of other proposed accounting models and evaluation of those instantiations compared to existing prototypes and implementations.

**The Theorize and Justify Categories**

The greatest need for REA accounting research appears to be in the **Theorize** and **Justify** columns, i.e., the empirical realm. The only two empirical studies reviewed in section II were Benbasat and Dexter (1979) and Weber (1986). Benbasat and Dexter studied individual behavior; Weber examined organizational level phenomena. Potentially productive validations of the REA model could likewise include studies at either the individual level or at the organization level.

***Individual User Validation Studies***

The study of individual users' behavior as a means of validating accounting systems and models is an area that has been largely untouched in accounting systems research and thus provides a vast array of research possibilities. Existing instantiations of REA accounting constructs, models, and methods can be tested with user performance as a validation criteria. Theories can be generated as to why performance with one instantiation would be expected to surpass that with the other; tests can be conducted to justify the theories.

Studies in this category could be laboratory experiments, field tests where users are questioned directly, or survey research. Measures of user performance included in other IS studies (e.g. Jih et al. 1989) have included decision quality, decision completion time, and user satisfaction.  Decision quality has been measured as accuracy (in studies where there are correct answers), as best result (such as highest profit where decisions affected profit or lowest cost where decisions affected costs), or as consensus (in studies where there was no correct answer or best result possible, it was determined that the extent to which experts agreed with the decision indicated how good it was). Decision completion time may be measured as amount of time to make a decision. Alternatively it may be measured more finely, for example, through process traces indicating how much time a subject spent looking at particular computer screens within a system. Suggestions for measuring user satisfaction are presented by Seddon and Kiew (1994).

Dunn (1995) is an example in this category that encompasses all four columns of the March and Smith framework. McCarthy (1982, 1987) and Gal and McCarthy (1995) suggested the use of abstraction hierarchies as developed by Smith and Smith (1977) in conjunction with the REA model. They proposed a seven level abstraction hierarchy which could be used to control complexity in accounting systems. Dunn built an instantiation of this REA abstraction hierarchy as an interface to an REA database, and she also built an instantiation of a non-abstraction interface. Based on prior behavioral accounting and computer science studies, Dunn developed hypotheses as to why the abstraction hierarchy interface should assist users with various cognitive processes involved in preparation of financial statements from a database, thereby enhancing their performance of that task. She conducted a laboratory experiment to evaluate the two instantiations and to justify her proposed hypotheses. The hypotheses were not supported, opening up a research avenue to develop alternative hypotheses as to why the instantiation did not work as predicted.

### *Organization Level Validation Studies*
The study of organization level phenomena as a means of validating accounting systems or models has likewise been given little attention in accounting systems research with the exception of Weber (1986). Studies in this category would have as their primary intent a determination of whether database, semantically-modeled, or REA systems prove their alleged advantages. By nature, studies in this category could be either field studies or econometric analyses such as are found in the financial accounting markets literature.
One approach that can be taken in organizational studies is that used by Weber (1986). Termed Economic Darwinism by Zimmerman (1995), this approach suggests that an activity engaged in by surviving and presumedly economically-rational organizations over extended periods of time must be yielding benefits in excess of its cost (though it may not be necessarily optimal). This suggests, for example, if existing firms are using the REA model or its constructs in some conceptual or compromised fashion, such implementations must have benefits that exceed their costs. A second approach to organization level studies is to observe implementations of events, database, semantically-modeled, or REA accounting systems and to measure specific indicators of IS success, such as economic performance, productivity, competitive advantage, etc. David (1995) takes such an approach. She conducted a field study in which she evaluated companies' accounting information systems as to the extent they incorporate REA semantics and structure. She also measured various IS success indicators. She then compared each system's degree of REA correspondence to its success indicators to gain evidence as to the specific benefits the REA model can produce.

### Section Summary
In this section, we proposed a framework  based on March and Smith (forthcoming) for evaluating future research projects in the domain of accounting information systems.  It is certainly our opinion that a substantial amount of both empirical and non-empirical work remains to be done. **Design science** emphasizes computer science traditions; potential new projects should concentrate on building new constructs, models, and methods and then evaluating them with specific metrics against the database, semantic, or structuring orientations of existing accounting models. **Natural science** emphasizes traditional social science research methods; potential new projects should concentrate on developing theories about existing constructs, models, methods, and instantiations, and then justifying the theories through empirical tests. We believe that there is considerably more potential for

natural science work in accounting systems research than there is for design science work. There has been far less natural science research done in accounting systems, and the social science research methods are much more familiar to a wider spectrum of accounting researchers.

## V. Conclusion

This paper has concentrated on past research work in accounting information systems; however, its most important implications are clearly for the future. A half-century ago, Goetz (1939) and Schmalenbach (1948) foresaw the need for accounting systems to adapt as competitive business environments themselves change. To a large extent, their suggestions lay fallow for many years until the enabling effect of information technology, especially with regard to the possibilities for database implementations, began to affect AIS research and practice. The *events* ideas of Sorter (1969) were not themselves the blueprint for modern semantic models of enterprise economic phenomena, but their public airing was interpreted by 1970s researchers like Colantoni et al. (1971) as a call for research into more disaggregate transaction processing systems using database technology. These database accounting systems eventually led to the introduction of semantic modeling by McCarthy (1979), an innovation that produced accounting systems whose structures and philosophies for use were congruent with the earlier ideas of researchers like Goetz (1939, 1949). McCarthy's REA work (1982) extended semantic work further and resulted in an object template of economic resources, events, and agents that was proposed to model enterprise economic activities when such phenomena were patterned in a repetitive and integrated fashion. The primitive entity and relationship types of the REA framework were derived with semantic abstraction methods, but their definitions and use were partially explained with terms and ideas derived from the work of Ijiri (1975) and Mattessich (1964). Weber (1986) examined the validity of the REA model empirically and found that its major elements were incorporated into software packages at the infological or high semantic level.

Future work on semantically-modeled accounting systems should proceed on two fronts. Within the *design science* arena, REA ideas should be expanded with new constructs, methods, and instantiations, while simultaneously being challenged with extended or alternative new models. An example of research doing the former is Geerts and McCarthy (1992), while research doing the latter is Geerts and McCarthy (1994). In the arena of *natural science* research, the new accounting information system artifacts being proposed by REA theorists and other modelers need abundant doses of empirical examination, such as that done by Dunn (1995) and David (1995). For progress in this field to occur at a faster pace, both design science work and natural science work are important. At present, however, we believe that the relative paucity of empirical results and the relative abundance (and acceptability) of academic AIS researchers with skills and interest in pursuing natural science research projects warrant concentration in the AIS community on work of that type.

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# TABLE 1

## Categorization of Accounting Frameworks

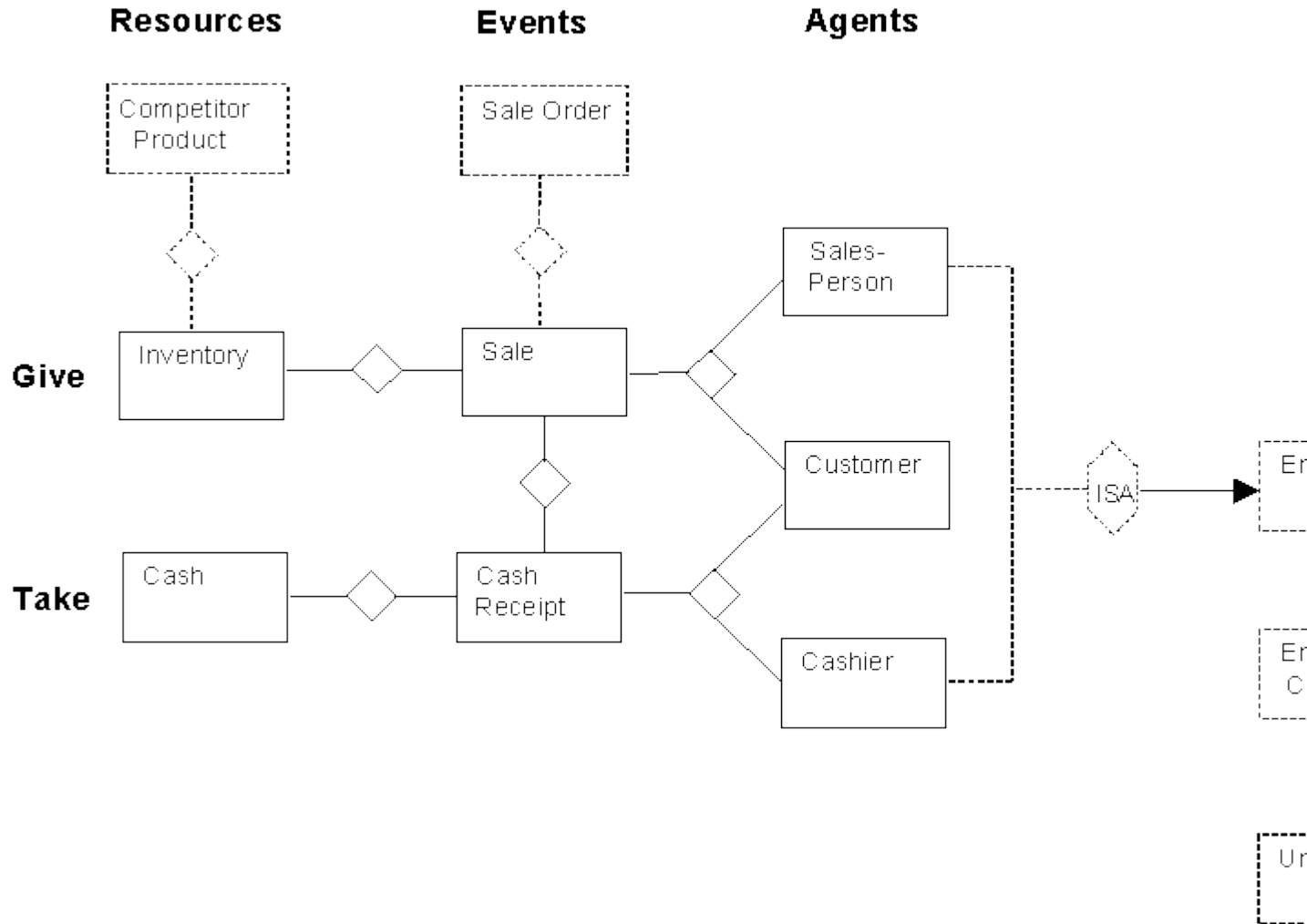| Year | Title | Author | Ideas |
|---|---|---|---|
| **Events Accounting** | | | |
| 1969 | An 'events' approach to basic accounting theory | Sorter | Events accounting<br>Disadvantages of Value theory<br>Operational rules |
| 1970 | Towards an "events" theory of accounting | Johnson | Forecast and observational verification criteria<br>Definition of permissible aggregation<br>Mathematical model |
| 1962 | An inductive approach to accounting theory | Schrader | Difference between observed data and manipulated data |
| **Database Accounting** | | | |
| 1971 | A unified approach to the theory of accounting and information systems | Colantoni, Manes and Whinston | Introduction of database concepts<br>Event coding<br>Key algebra |
| 1975 | A structuring of an events-accounting information system | Lieberman and Whinston | Three part structure<br>User-defined database characteristics<br>Self-organizing database capabilities |
| 1976 | Design of a multi-dimensional accounting system | Haseman and Whinston | Hierarchical organization of events database<br>Definition of restructuring functions |
| 1977 | A relational approach to accounting models | Everest and Weber | Data independence<br>Normalization |
| **Semantically-Modeled Accounting** | | | |
| 1939 | What's wrong with accounting? | Goetz | Maintain an unadulterated Basic Historical Record |
| 1949 | Management planning and control | Goetz | Basic Pecuniary Record plus a legal-financial supplement |
| 1948 | Pretiale Wirtschaftslenkung, Volume 2 [Pretiale Lenkung] | Schmalenbach | Develop a basic accounting system with no particular objective (a Grundrechnung) |
| 1979 | An entity-relationship view of accounting models | McCarthy | Second generation data modeling<br>Artifact-free design |
| **REA Accounting** | | | |
| 1982 | The REA accounting model: A generalized framework for accounting systems in a shared data environment | McCarthy | REA accounting model<br>Generalization hierarchies<br>Semantic expressiveness<br>Enterprise-wide conceptual schema |

**FIGURE 1**
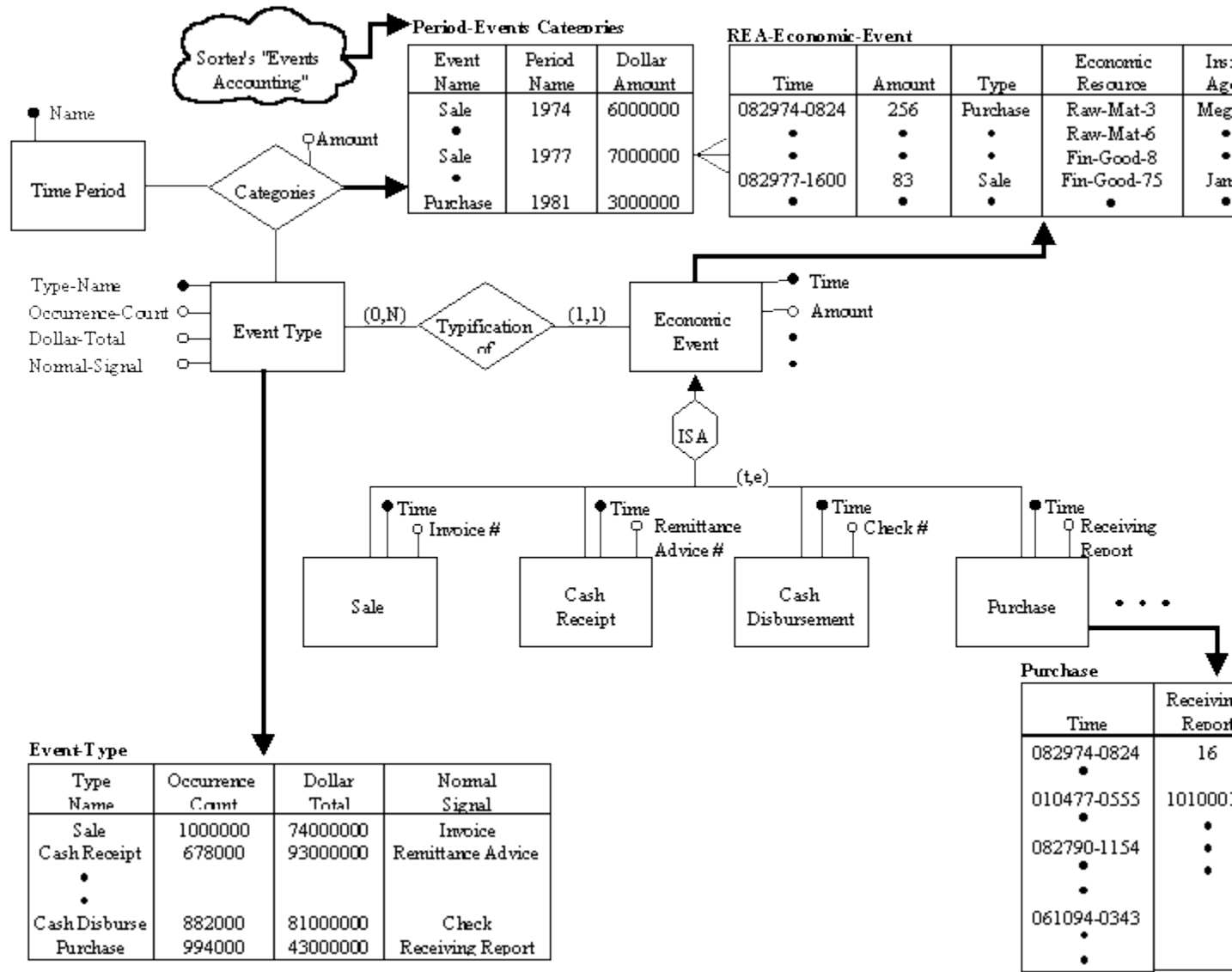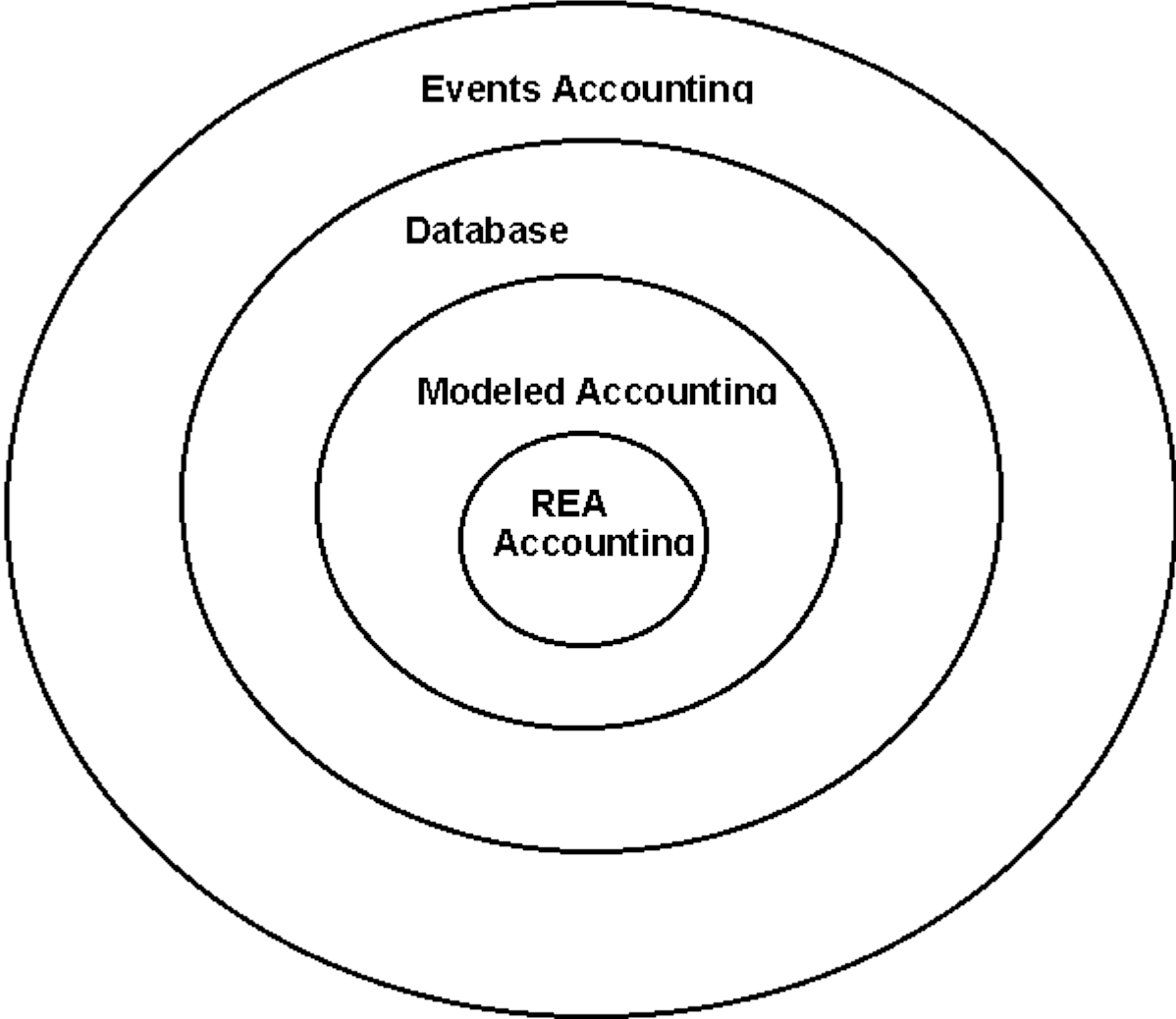**REA Template**
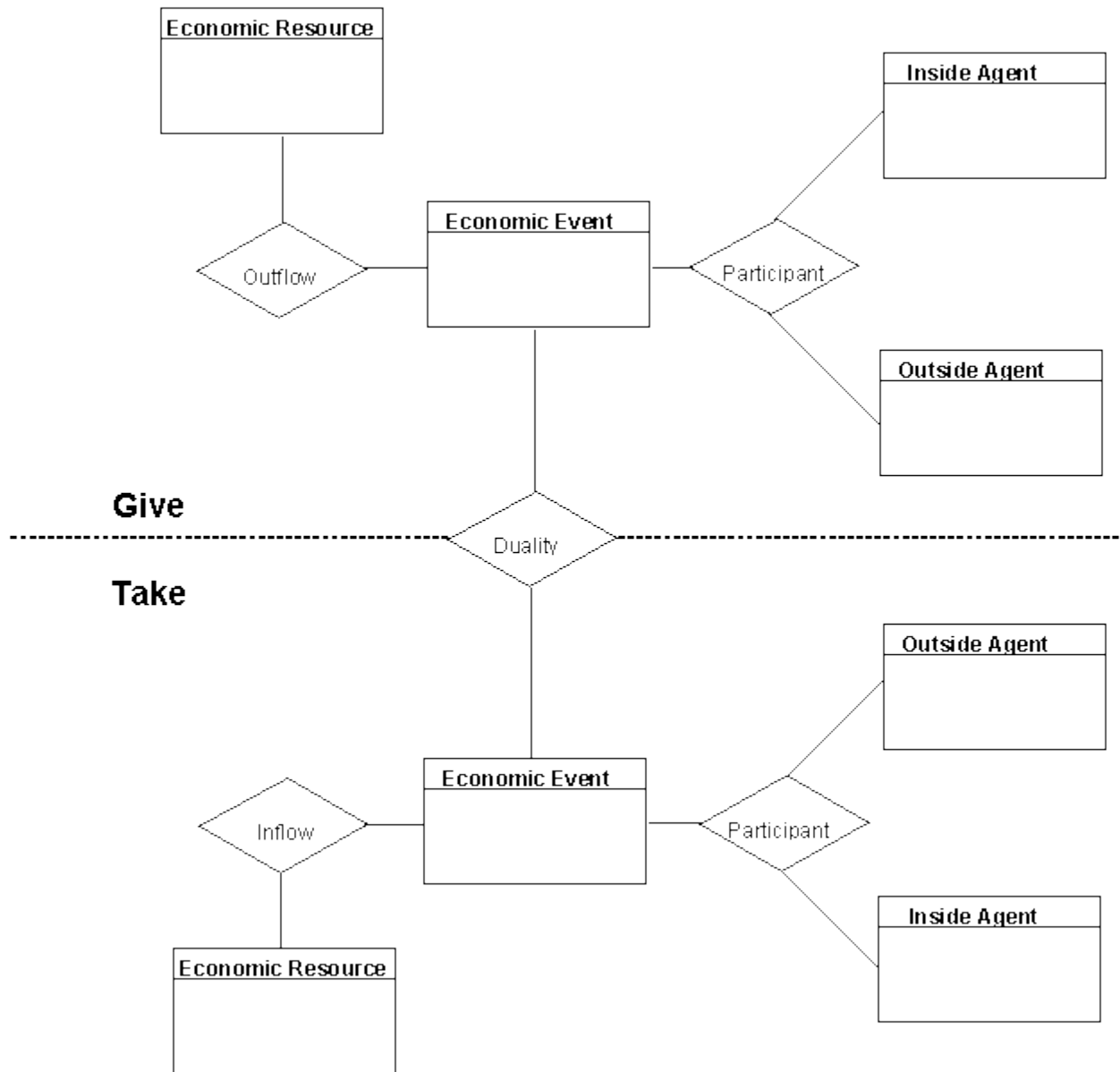
# FIGURE 2
## Revenue Process

**Resources**          **Events**          **Agents**

Competitor Product

Sale Order

Sales-Person

Customer

Cashier

**Give**    Inventory    Sale

**Take**    Cash    Cash Receipt

ISA

Er

En C

Ur

# FIGURE 3
## Events versus REA Accounting

Sorter's "Events Accounting"

**Period-Events Categories**

| Event Name | Period Name | Dollar Amount |
|---|---|---|
| Sale | 1974 | 6000000 |
| • | | |
| Sale | 1977 | 7000000 |
| • | | |
| Purchase | 1981 | 3000000 |

**REA-Economic-Event**

| Time | Amount | Type | Economic Resource | Ins[...] Ag[...] |
|---|---|---|---|---|
| 082974-0824 | 256 | Purchase | Raw-Mat-3 | Meg[...] |
| | | | Raw-Mat-6 | |
| • | • | • | Fin-Good-8 | • |
| 082977-1600 | 83 | Sale | Fin-Good-75 | Jan[...] |
| • | • | • | • | • |

Name

Time Period

○ Amount

Categories

Type-Name ●
Occurrence-Count ○
Dollar-Total ○
Normal-Signal ○

Event Type

(0,N) — Typification of — (1,1)

Economic Event

● Time
○ Amount
•
•

ISA

(t,e)

● Time
○ Invoice #

Sale

● Time
○ Remittance Advice #

Cash Receipt

● Time
○ Check #

Cash Disbursement

● Time
○ Receiving Report

Purchase

• • •

**Event-Type**

| Type Name | Occurrence Count | Dollar Total | Normal Signal |
|---|---|---|---|
| Sale | 1000000 | 74000000 | Invoice |
| Cash Receipt | 678000 | 93000000 | Remittance Advice |
| • | | | |
| • | | | |
| Cash Disburse | 882000 | 81000000 | Check |
| Purchase | 994000 | 43000000 | Receiving Report |

**Purchase**

| Time | Receivi[...] Report |
|---|---|
| 082974-0824 | 16 |
| • | |
| 010477-0555 | 101000[...] |
| | • |
| 082790-1154 | • |
| • | |
| • | |
| 061094-0343 | |
| • | |

**FIGURE 4**
**Overlap of Accounting Frameworks**

Events Accounting

Database

Modeled Accounting

REA
Accounting

# FIGURE 5

## March and Smith IT Research Framework

|  | *Build* | *Evaluate* | *Theorize* | *Justify* |
|---|---|---|---|---|
| *Constructs* |  |  |  |  |
| *Model* |  |  |  |  |
| *Method* |  |  |  |  |
| *Instantiation* |  |  |  |  |

**Column Headings = Research Activities  Row Headings = Research Outputs**
**Light Shading = Design Science**
**Dark Shading = Natural Science**

SOURCE:  Adapted from March and Smith (forthcoming)

**End Notes**

[1]   The partial set of tables in figure 3 illustrate a possible relational implementation of the specified data model under certain cardinality assumptions.  Different assumptions might necessitate more or less tables.

[2]  Today, artificial intelligence, object oriented, and perhaps other technologies could be used to achieve this purpose.  In 1971, database technology was the only practical mechanism available.

[3]  McCarthy (1979, 1980, 1982) used ideas and constructs adapted from McCarthy (1978) where the term **events-based accounting system** was used to describe explicitly semantic systems.

[4]  The semantic orientation of REA accounting systems is sometimes mistakenly tied to the exclusive use of Chen's (1976)  entity-relationship model  (e.g., see Murthy and Wiggins (1993, 109)).   Such a restriction is a mistake.  The 1982 discussion of data abstraction mechanisms and behavioral semantics by McCarthy was much more general than Chen's original work.  Additionally, both he and others have covered these questions in related work since that time.   For examples of alternative REA specifications with different semantic formalisms (such as NIAM, logic programming, and object orientation), see Geerts and McCarthy (1991), Geerts (1993), and Rockwell (1992).

[5] Part of this table has been adapted from McCarthy (1981).

[6]  Later, Whinston along with Haseman (Haseman and Whinston 1977) developed an implementation of an accounting system, but it did not follow the Colantoni et al. model.  It was simply a traditional accounting model that was modeled as a network.