An ontological analysis of the economic primitives of the extended-REA enterprise information architecture

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Abstract

The Resource-Event-Agent (REA) model for enterprise economic phenomena was first published in *The Accounting Review* in 1982. Since that time its concepts and use have been extended far beyond its original accountability infrastructure to a framework for enterprise information architectures. The granularity of the model has been extended both up (to enterprise value chains) and down (to workflow or task specification) in the aggregation plane, and additional conceptual type-images and commitment-images have been proposed as well. The REA model actually fits the notion of domain ontology well, a notion that is becoming increasingly important in the era of e-commerce and virtual companies. However, its present and future components have never been analyzed formally from an ontological perspective. This paper intends to do just that, relying primarily on the conceptual terminology of John Sowa. The economic primitives of the original REA model (economic resources, economic events, economic agents, duality relationships, stock-flow relationships, control relationships and responsibility relationships) plus some newer components (commitments, types, custody, reciprocal, etc.) will be analyzed individually and collectively as a specific domain ontology. Such a review can be used to guide further conceptual development of REA extensions.

Keywords: Domain ontology; Enterprise information architectures; Ontological categories; REA accounting model

1. Introduction

According to John Sowa, "A choice of ontological categories is the first step in designing a database, a knowledge base, or an object-oriented system." (1999, p.51). For a business corporation, those **categories** must reflect the business concepts and rules, the entrepreneurial logic, and the accounting conventions of both the enterprise itself and those interconnected organizations that deal with that corporation. Such ontological categorization and examination is the purpose of this paper wherein we analyze and develop the REA model of McCarthy (1982) as a *domain ontology* (Guarino, 1998) for business enterprises. Since its initial conceptualization as a very specific and well developed theory of representation for enterprise economic phenomena, the REA model has been extended multiple ways for both industrial and educational use, and many scholars consider it a more solid foundation for the enterprise information systems of the future than the traditional double-entry framework it attempts to supplant (Walker and Denna, 1997; Andros et al., 1992; Cherrington et al., 1993). After REA components are introduced and explained here, they will be subjected to ontological analysis using the recently developed classification ideas and concepts of John Sowa (1999). Results of this analysis will then be used to speculate on future research work needed with the refinement of REA components into a more complete enterprise ontology.

The remainder of this paper is organized as follows. The second section summarizes the components of the basic REA model and some of its extensions, both within its original accountability infrastructure and from the perspective of a policy infrastructure. The third section of the paper is devoted initially to an enumeration of the ontological categories of John Sowa. This exposition is followed by an ontological analysis of REA components within the Sowa conceptualizations. The paper concludes with summary analysis and a listing of future directions.

2. The REA model: an accountability and policy infrastructure for business enterprises

2.1. The basic REA model

The REA accounting model was first published in 1982 by McCarthy. During the 1990s, its basic structural features have been expanded a number of times, primarily in work performed by Geerts and McCarthy (1992; 1994; 1997a; 1997b; 1999; 2000a; 2000b). The generalized REA model was actually built on more specific earlier work done by McCarthy on adapting accounting systems to more semantically-oriented environments (McCarthy, 1979; 1982).

The basic REA framework is shown in Entity-Relationship format (Chen, 1976; Batini et al., 1992) in Figure 1. A strongly-typed narrative description of this model's underlying contentions would be couched as follows.

> The core of an enterprise's activities over the course of its life is constituted by its history of economic exchanges or economic conversions with parties inside and outside of the firm's boundaries. These exchanges or conversions all follow a particular object pattern:
>
> > *There is a transaction (an economic event) where an internal agent (an economic unit or agent) gives something of value (an economic resource) to an outside person (an economic agent); this decrement event is always paired with a mirror-image increment event where the internal agent receives in kind another type of economic resource which has more value to the enterprise in its pursuit of its entrepreneurial goals.*
>
> Simple examples of these paired transactions would be *Sale—CashReceipt* or *CashDisbursement—Purchase*. When both halves of this economic exchange are viewed at a more aggregate level, they constitute a business process wherein an input

resource (or set of resources) is exchanged or converted to an output resource of more value. For example, the paired transactions listed above would aggregate to a *RevenueProcess* and an *AcquisitionsProcess*. These economic processes can themselves be then aggregated into an enterprise-wide value chain (Porter, 1985), which captures the full entrepreneurial intent of the business owners as they endeavor to acquire and deploy resources to sustain profitability.

The object pattern illustrated in Figure 1 has three primitive entity components – **R**esources, **E**vents, and **A**gents – hence the REA acronym (economic units were designated as a subset of economic agents). The model also has four types of relationships defined: *stockflow, duality, control*, and *responsibility*. The last of these is a recognition of the static hierarchical reporting and assignment structures within business enterprises, and it is often omitted from detailed specification in complex REA models of dynamic firm behavior. Additionally, for simplicity sake, the three-way control relationship is often reconfigured as two binary relationships between an event and its participants.

For ontological purposes, the basic REA model has some strong features, two of which merit particular mention. First of all, the model arose from the same philosophical traditions of semantic representation that underlie most ontological work today. McCarthy developed his primitives from narrative and transactional analysis of accounting system requirements via the repeated use of abstraction mechanisms like classification, aggregation, and generalization (Batini, et al., 1992). The extended work with Geerts has followed the same path. As a consequence, the REA model already resembles an *ontology* where that term is taken to mean "a specification of a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them" (Gruber, 1993; Genesereth and Nilsson, 1987). Second – and this is a point that needs to be stressed repeatedly – the REA model is a semantic definition of a field's standard set of objects and relationships that has undergone (and continues to undergo) peer review in multiple disciplines. The original paper and its predecessor work were published in the leading worldwide journal in the field of accounting, and the follow-on work of the 1990s is targeted to similar audiences. The original REA paper used accounting theories of the 1960s and 1970s to explain the conceptual foundations of some of its abstracted primitives, and those theories in turn relied heavily on classical microeconomic analysis (Dunn and McCarthy, 1997). Additionally, the REA extensions explored below are similarly being explained with a heavy reliance on normative accounting theories and microeconomics (Geerts and McCarthy, 1994; 2000b). This is a standard that all ontologies should be held to, but few seldom are. Perhaps, it should become a requirement for any domain ontology that its basic conceptual definitions be subject to peer review not only in the computer science or knowledge representation fields, but additionally in the applied discipline as well.

2.2 The extended REA model

The basic REA framework of Figure 1 accounts for the semantic components of a business process, something that can be used to model exchanges with agents outside the firm and conversions with agents within the firm. Extensions to this basic framework are illustrated in Figure 2 and explained below.

On the middle left of Figure 2 is illustrated the REA process specification level, something portrayed in more detail in Figure 1. We have added the additional concept of commitment here, an important ontological extension (Geerts and McCarthy, 2000b). Above this middle part is the value-chain specification level wherein individual processes (also called cycles) are aggregated to a purposeful chain of acquire-convert-market activities designed to produce both a firmwide profit and an increase in value for the firm's customers. The specifications of these additional components to REA are given in a series of papers by Geerts and McCarthy (1994; 1997a; 2000a; 2000b). The most detailed of these papers is Geerts and McCarthy (2000b) wherein the microeconomic rationale for the concept of full-REA modeling is explained and analyzed.

On the bottom left of Figure 2, the process level of REA is decomposed down to the task or workflow level, an extension explained in Geerts and McCarthy (1997b). This task level is of more practical than conceptual significance at the present stage of REA development. Essentially, tasks are REA compromises where some occurrences in time are important enough to be specified but not important enough to be represented individually and tracked. Tasks in component form are excluded from the ontological analysis that follows later in the paper, because a *full-REA* representation (Geerts and McCarthy, 2000a, p. 132) would not need them. This is perhaps a point that needs to be debated in future ontological analysis of this model. Such a revision could go either way. Tasks at the component level could remain excluded, and a home in the ontology could be found for their type-level specifications (this is the proposal in Geerts and McCarthy, 2000b). Or alternatively, their inability to be specified at both the physical and abstract levels of an ontology might cause them to be dropped from an REA specification entirely.

When all three levels on the left of Figure 2 are taken collectively, they specify a full accountability infrastructure for a firm. This is what might be termed the "traditional accounting view of the enterprise," although it should be noted that its REA semantic primitives are certainly not ones that most traditional accountants would recognize as being its bare essentials because they differ substantially from traditional account-based models. The accountability infrastructure of a firm conceptualizes its full history of obtaining initial financing, of using that financing to acquire and deploy the factors of production, and finally of using the results of that production to satisfy customers and to become profitable. As displayed on the bottom left, this conceptualization of *Actual Business Events* tells us "what has occurred or has been committed to."

At the right, Figure 2 illustrates extensions to REA modeling that have not yet been fully operationalized. These are the addition of *type images* (Geerts and McCarthy, 1994) to the basic entities of Figure 1 (and their extensions and aggregations). In a very general sense, the REA accountability infrastructure conceptualizes what "is or has been" in the firm with an emphasis on resource tracking. The policy infrastructure on the other hand conceptualizes what "could be" or "should be" within the context of a defined portfolio of firm resources and capabilities.

Even though they differ starkly in the extent of conceptual development, both the accountability infrastructure and the policy infrastructure components of REA will be subjected to categorization within Sowa's framework during a later part of the paper. Such analysis can certainly strengthen both components; however, it should be especially helpful in identifying gaps, overlaps, or inconsistencies in the policy infrastructure of REA. Work with REA extensions such as type-images and commitment-images is in its infancy, and guidance is needed here the most.

3. The ontological analysis of John Sowa

The path-breaking work of John Sowa with conceptual structures is well known in the fields of artificial intelligence and database design. His most famous work *Conceptual Structures: Information Processing in Mind and Machine* (1984) explored the field of knowledge representation from a number of perspectives including computer science, linguistics, psychology, and philosophy. His most recent work has taken an even stronger philosophical bent, and it is summarized in a book published in August 1999 as *Knowledge Representation: Logical, Philosophical, and Computational Foundations* (Sowa, 1999).[1] Sowa's category scheme is our primary organizational rationale.

As cited at the beginning of this paper, Sowa believes that the success of knowledge representation schemes hinges primarily on the selection of the proper ontological *categories*. However, most modeling methods begin with an even more fundamental analysis of how symbolic representation mirrors actual phenomena in the real world. This is a matter that Sowa (1999, chap.3) explains in detail in his "meaning triangle," a device that explores the connections between *reality*, *symbols*, and *concepts*. This triangle was adapted for use most recently in the accounting literature by David et al. (1999). In Figure 3, one component of that device – the mapping from reality to primitive symbols of that reality and then the abstraction (classification) of those symbols to the category level and category type level – is explored with a simple example. This brief introduction will clear the way for the more difficult categorical analysis that follows.

At the left of Figure 3, we have portrayed four instances of customers – a piece of reality.[2] Each of these four stick figures is an ***occurrence*** or in common representation terms a ***token.*** The individual tokens can be referenced by pointing at them or perhaps by describing them in relative terms (i.e., "the occurrence at the top of the group"), but most commonly, they are specified by words (symbols) that carry their meaning to a reader. The individual words (*Carol, Dick*, etc.) are symbols that represent reality at the occurrence (token) level. These symbolic tokens can then be ***classified*** (Batini et al., 1992) to the symbolic category level of *Customer.* It is at the category level where both

[1] Some of his newer ideas about ontology were excerpted from that book and presented as lecture notes (Sowa, 1997) in Balzano, Italy during September 1997 at *The 1997 Bolzano International School in Cognitive Analysis -- Categories: Ontological Perspectives in Knowledge Representation* organized by Roberto Poli. The Sowa ideas on ontological categories referenced in the remaining parts of this paper are taken from the extended analysis of the 1999 book (Sowa, 1999), as influenced by his workshop.

[2] Actually, as readers are undoubtedly aware, the first column of Figure 3 shows not a piece of reality (i.e., actual customers), but illustrative symbols (stick figures of customers). Readers are asked to visualize real customers.

our main ontological analysis and that of Sowa initiates. In the fourth column of Figure 3, we abstract further with **typification** (Sakai, 1981) to type-images or groupings of customers (such as “high credit risk,” “low credit risk,” etc.).

Sowa’s (1999, chap. 2) ontological categorization scheme relies on foundations established by a number of philosophers including Plato, Aristotle, Kant, Hegel, Husserl, Whitehead, Heidegger, and (especially) Peirce. Throughout the history of philosophy, all of these theorists have dealt in different ways with the fundamental question of representation*: What are the categories into which components of reality can be classified?* Sowa’s answer to this question is derived from extensive fundamental analysis, and his twelve main categories for classification can be seen as the result of 2x2x3 factoring of the following ontological facets:

a. ***Physical*** vs. ***Abstract*** which “is a two-way split between the category Physical for anything consisting of matter or energy and the category Abstract for pure information structures” (Sowa, 1999, p.68).
b. ***Continuant*** vs. ***Occurrent*** where a continuant is an enduring object that “has stable attributes that enable its various appearances at different times to be recognized as the same individual” while an occurrent is a process or event that “is in a state of flux” and that “can only be identified by its location in some region of time-space” (Sowa, 1999, p.71).
c. ***Firstness*** vs. ***Secondness*** vs. ***Thirdness*** which are facets adapted most prominently from Peirce and explained thusly by Sowa (1999, pp.61-2):

    1. An individual can be recognized as a human being or as a subtype, such as man or woman, by sensory impressions (Firstness), independent of any external relationships. The type label Woman characterizes an individual by properties that can be recognized without regard to any relationships to other entities.
    2. The same individual could be classified relative to many other things, as in the concept types Mother, Attorney, Wife, Pilot, Employee, or Pedestrian. A classification by any of those types depends upon an external relationship (Secondness) to some other entity, such as child, client, husband, airplane, employer, or traffic.
    3. Thirdness focuses on the mediation that brings the first and second into relation. Motherhood, which comprises the act of giving birth and the subsequent period of nurturing, relates the mother and the child. The legal system gives rise to the role of attorney and client. Marriage relates the wife and the husband. Aviation relates the pilot to the airplane. The business enterprise relates the employee to the employer. And the activity of walking on a street that is dominated by vehicles relates the pedestrian to the ongoing traffic.

    Sowa (and Peirce) expect that higher orders of this facet (like Fourthness, etc.) are unnecessary because they can be defined recursively in terms of triads (Thirdness).

Derived from this factoring are his twelve central categories. These are illustrated in the Figure 4 matrix as cells with large underlined letters. In left-to-right, up-to-down order, these categories are: *object, process, schema, script, juncture, participation, description, history, structure, situation, reason,* and *purpose*. Explanations of each are given by Sowa (1999, pp. 73-4) who also constructed a matrix from which Figure 4 is derived (1999, fig. 2.7).

For a proposed representation scheme like the REA ontology (Geerts and McCarthy, 2000b), the Sowa categorization matrix (and the accumulated wisdom behind it) presents an opportune vehicle for analysis of completeness and reasoning consistency. For that purpose, we have filled in the cells of Figure 4 with the various REA primitives, and we embark upon that analysis below.

4. Specification of REA ontological categories

In each cell of the matrix in Figure 4 the Sowa central categories are portrayed in large underlined type while the corresponding REA primitives are given in smaller italicized type. We analyze each of the REA ontological categories below. We structure our discussion along Sowa's categories of firstness or Independent, secondness or Relative, and thirdness or Mediating.

4.1. Firstness

Firstness requires us to define the independent building blocks of an enterprise information architecture. Sowa's classification of objects as Continuants (C) and Occurrents (O) fits well with REA's categorization of stable objects, ***Economic Agents*** (A) and ***Economic Resources*** (R), and dynamic objects, ***Economic Events*** (E). An important aspect of ***Economic Events*** is their location in some region of space-time. We extend the original REA categories as defined in McCarthy (1982) in two ways, both of which are explained in more detail in Geerts and McCarthy (2000b). First, we declare ***Commitment*** as an REA ontological category. ***Commitments*** are different from ***Economic Events*** since they represent obligations (of various degrees of enforceability) to trading or production partners instead of actual consumption or acquisition transactions. An example of a ***Commitment*** is a reservation for an airline flight or a reservation for a hotel stay. Second, we extend the existing REA categories with type images that support the definition of a policy infrastructure (the right side of Figure 2). The abstract categories (the two rightmost columns in Figure 4) represent structural information about the physical categories (to the left in Figure 4). An example of a Continuant type image or Schema was illustrated in Figure 3 as customer type (***AgentType***). Instances of customer type could be "high credit risk," or "low credit risk," and these instances would share class-level characteristics such as "maximum allowable monthly purchase amount." An example of an Occurrent type image or Script is payment type (***EventType***). Instances of payment type could be cash payment or credit card payment. Each instance of payment type represents a different Script with its own intrinsic properties such as the different operations needed to effect it and the total expected time of the operation.

4.2. Secondness

Secondness requires us to describe how the REA Firstness categories are related, and by and large, the secondness primitives relate to the concept of relationship types in traditional database modeling (Batini et al., 1992). We have defined three different stable relationships between Continuants as REA categories that fit Sowa's definition of a Juncture: ***Association*** (an agent-agent or A-A relationship), ***Custody*** (A-R), and ***Linkage*** (R-R). Under this scheme, the original REA ***Responsibility*** relationship of Figure 1 would become a subtype of ***Association*** as would explicit static relationships between internal and external economic agents such as salesperson and customer and between different external agents such as two of the company's trading partners. This omission analysis has allowed us to identify these last two primitives as ***Assignment*** and ***Alliance*** in Geerts and McCarthy (2000b). An example of a ***Custody*** juncture would be the explicit relationship between a warehouse clerk and the inventory that he or she is responsible for, and an example of a ***Linkage*** juncture would be the connection between an actual component and its aggregate in a finished product.

To the existing Participation categories of ***StockFlow*** (E-R), and ***Duality*** (E-E), we add ***Accountability*** to the extended REA ontology (Geerts and McCarthy, 2000b) as a binary substitution for the original ternary Control relationship of McCarthy (1982). ***Accountability*** will have itself two subcategories, one for the relationship between an external agent and an economic event and one for the relationship between an internal agent and an economic event. By including ***Commitment*** as a Firstness primitive, we increase the number of REA categories that fit Sowa's description of Participation from three to seven with these new ones: ***Executes*** (C-E), ***Involvement*** (C-A), ***Reserved*** (C-R), and ***Reciprocal*** (C-C). Examples of the four new categories are ***Executes***: order-sale; ***Involvement***: order-vendor; ***Reserved***: reservation-room; and ***Reciprocal***: raw-material-requisition—job-order.

Description and History are further extensions to the original REA categories which we explain with examples in Figure 5 and Figure 6. A Description is an application of a Schema (type definition) to describe some Continuant, either Physical (***Typification***) or Abstract (***Characterization***). We use a different ***Typification*** category for each of the different Schema categories: ***Resource-ResourceType*** and ***Agent–AgentType***. Figure 5 expresses both ***Typification*** and ***Characterization***. Here ***Typification*** establishes membership of a physical object into an abstract information structure. ***Typification*** allows us to declare a specific customer as a small or a medium or a large company. Customer instances automatically inherit the characteristics of the type, such as the range for the number of employees. The upper part of the diagram illustrates a ***Characterization*** where two different type definitions are related to each other. ***Characterizations*** are an excellent tool to represent corporate policies or control procedures. The policy expressed in diagram 5 is that inexperienced salespeople are used for small companies while experienced salespeople are used for medium and large companies. Fowler (1996) names the explicit representation of policies as *knowledge level representations* while he names the relation between the actual objects as *operational level representations*. Policies can be used to monitor the actual links between physical objects. Here the policy specification can be used to insure that an employee with the right qualifications is assigned to a customer. We have a ***Characterization*** for three Juncture categories: ***AgentType-AgentType***, ***AgentType-ResourceType***, and ***ResourceType-ResourceType***.

A History is an application of a Sowa Script (type definition) to describe some Occurrent, either Physical (***Typification***) or Abstract (***Scenario***). ***Typification*** allows a collection of Physical objects to share the same script. Figure 6 illustrates an example of an ***Event-EventType Typification***. In the Figure 6 example, we assume a small restaurant where all food is prepared following one of the three generic preparation types or recipes (Scripts): diet, spicy, or regular. Figure 6 also shows how an ***EventType*** can be related to a ***ResourceType*** to express some of the restaurant's cooking strategies or policies: neither spicy fish nor diet meat is prepared in the restaurant. The ***Scenario*** represents general strategies for preparing certain food types.

4.3. Thirdness

Sowa's Thirdness category is both an extension to and an integration of the components of the original REA model. Thirdness or Mediating purpose requires definition of the rationale for the related primitives in the Secondness categories, and the entries we have given for the four cells on the bottom of Figure 4 are the results of preliminary analysis which must be extended much further in future REA ontology work (Geerts and McCarthy, 2000b). An example from the Structure cell would be the explanation of the relevance for the relationships between ***Agent*** and ***Agent*** and between ***Agent*** and ***EconomicResource***. We believe that the ***Responsibility*** rationale inherent in the common notion of responsibility accounting assists here. For example, the manager of a certain internal department is responsible for both the assets and the people assigned to him or her. In a like manner, the notion of strategic ***Partnering*** would explain some of the reasons why two parties external to a firm might form an association. And finally, the engineering rationale of ***Configuration*** would explain at least some of the reasoning behind the insertion of a certain resource as a component in another.

Figure 4 has REA-related mediating purposes for Sowa's three other Thirdness categories: Situation, Reason, and Purpose. As we mention above, our entries here are decidedly tentative and future REA ontology work is bound to excise some and add others. However, for completeness purposes, we give some general explanations of what our entries mean, and we also speculate how more extensive analysis of these rationale entries will move the ontology toward further stages of completion.

- <u>Situation</u>: The general reasons why two mirror-image Resource-Event-Agent constellations are aggregated together with stock-flow, accountability, and duality are twofold in nature: either to effect a market ***Exchange*** between independent agents or to complete a ***Conversion*** process within the confines of one agent. This same rationale gets extended in a parallel manner when commitments are added to the relationship mix: ***Contracting*** between parties involves bundling commitments for full economic exchanges, while

Scheduling involves bundling commitments for the components of a conversion process. Both of these Situations are explored in much greater detail by Geerts and McCarthy (2000b).

- Reason: ***Segmentation*** provides the rationale for grouping resources and agents into abstract categories like "high margin products" or "slow-paying customers," while ***Policies*** (as illustrated in Figure 5) provide the rationale for tying these abstract categories together at the knowledge level. And finally, notions like ***Substitutability***, ***Complementarity***, and ***Configuration*** provide at least some of the reasons why enterprises would link resource types with each other.

- Purpose: ***Standardization*** provides the rationale for typing economic events like raw material issues and commitments like raw material requisitions, because it allows predictability in terms of what resource amounts and agent types are needed for these planned occurrences. This predictability in turn enables ***Policies*** and ***Strategies*** to be determined within and between different types of linked business processes as managers try to determine best practices for the optimal deployment of the resources and people under their control.

Finally, we should note that Sowa states that the Firstness, Secondness and Thirdness categories suffice for ontological declarative purposes since relations of a higher order can be expressed in terms of these categories. Other ontological constructs of paramount importance in the specification of an enterprise information architecture – such as *value chains* and *supply chains* – can be expressed in terms of the basic ontological categories shown in Figure 4. See for example Geerts and McCarthy (1997b; 1999) for a definition of value chains in terms of REA-structured business processes.

5. Summary and future directions

There can be little doubt that the components of the original REA model fit the realm of ontology very well. Gruber says that "An ontology is a specification of a conceptualization" (1993), and the 1982 REA paper fits that definition almost perfectly. As enumerated earlier, the reasons for this match might include its being published in the literature of the home discipline with a notation and abstraction methodology that has much in common with the primary body of ontology work in both computer science and philosophy. We certainly believe here that as shared communication and its accompanying need for increased ontological commitment become stronger in enterprise information systems, REA should have some natural implementation advantages over more traditional kinds of accounting conceptualizations. This goodness-of-fit judgement for the basic REA model applies also to its extensions up into the value chain level and its decomposition down into the task or workflow level (although this latter extension was not analyzed here).

With regard to the extension of REA concepts into the non-accountability or policy areas of enterprise information systems conceptualization (i.e., its knowledge level), we cannot make as definitive a set of judgments. This is simply because those models haven't been implemented or researched extensively, and the analysis done here was decidedly preliminary. The results of this present work can be used as a platform on which to conduct integrated research into these newer specifications.

There are also other ontological directions of both a procedural and a declarative nature for REA researchers to take. For procedures, the set of logical axioms that define valid conclusions to be derived from the ontological primitives (Guarino,1998) needs considerable development. Geerts and McCarthy (1992; 2000a) have made some progress here, but much more work is needed to take the REA ontology to the level where a significant percentage of the derivable "accounting conclusions" (like revenue or profit) are specified. On the declarative side, there certainly needs to be some attempts at integrating this small domain ontology into more general frameworks such as CYC (Lenat and Guha, 1990) and into more specific enterprise frameworks such as those enumerated in Bernus et al. (1998) and in Vernadat (1996). Additionally, there are other domain-specific conceptualizations of enterprise value chains that need to be analyzed and integrated with REA. Two especially promising candidates here are the libraries of "best practices" for business process reengineering purposes and the reference models for supply chain management. And finally, "along a very different path" as noted by Mylopoulos (1998, p. 30), Wand and Weber (1990) "study the adequacy of information systems to describe applications based on a general ontology, such as that proposed in Bunge (1977)." Weber (1997) continues this exploration into different representational and philosophical assumptions of ontological research, and the limited (but extremely useful) computational and representation frameworks we are proposing here need to be considered in the light of his much more encompassing and general analysis.

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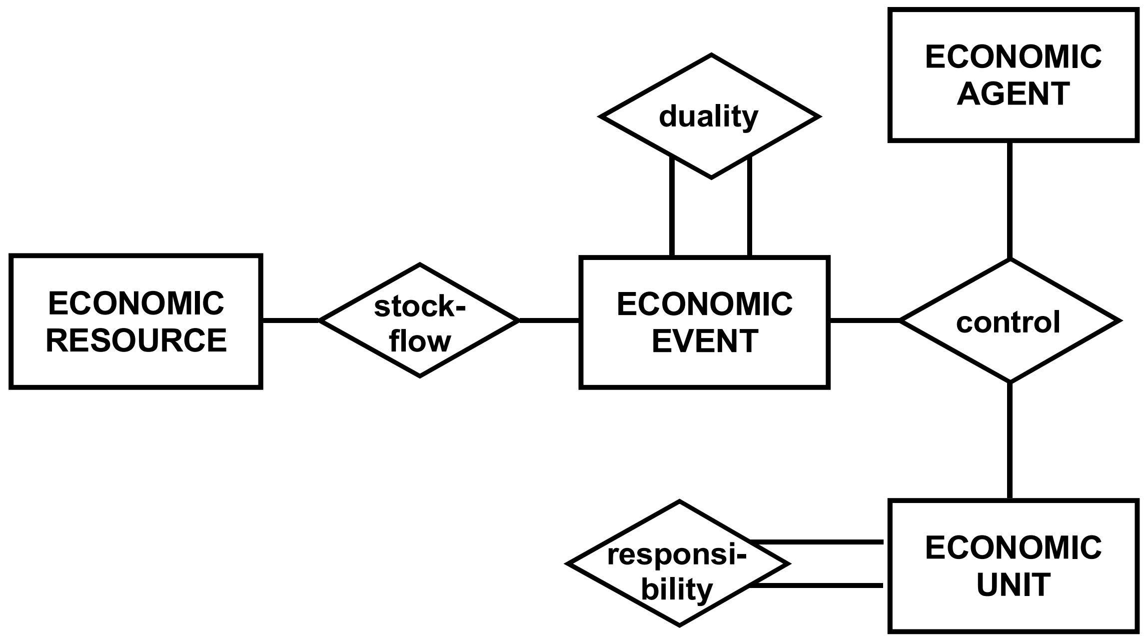

Figure 1 – The Basic REA Model
Source: McCarthy (1982, p. 564)

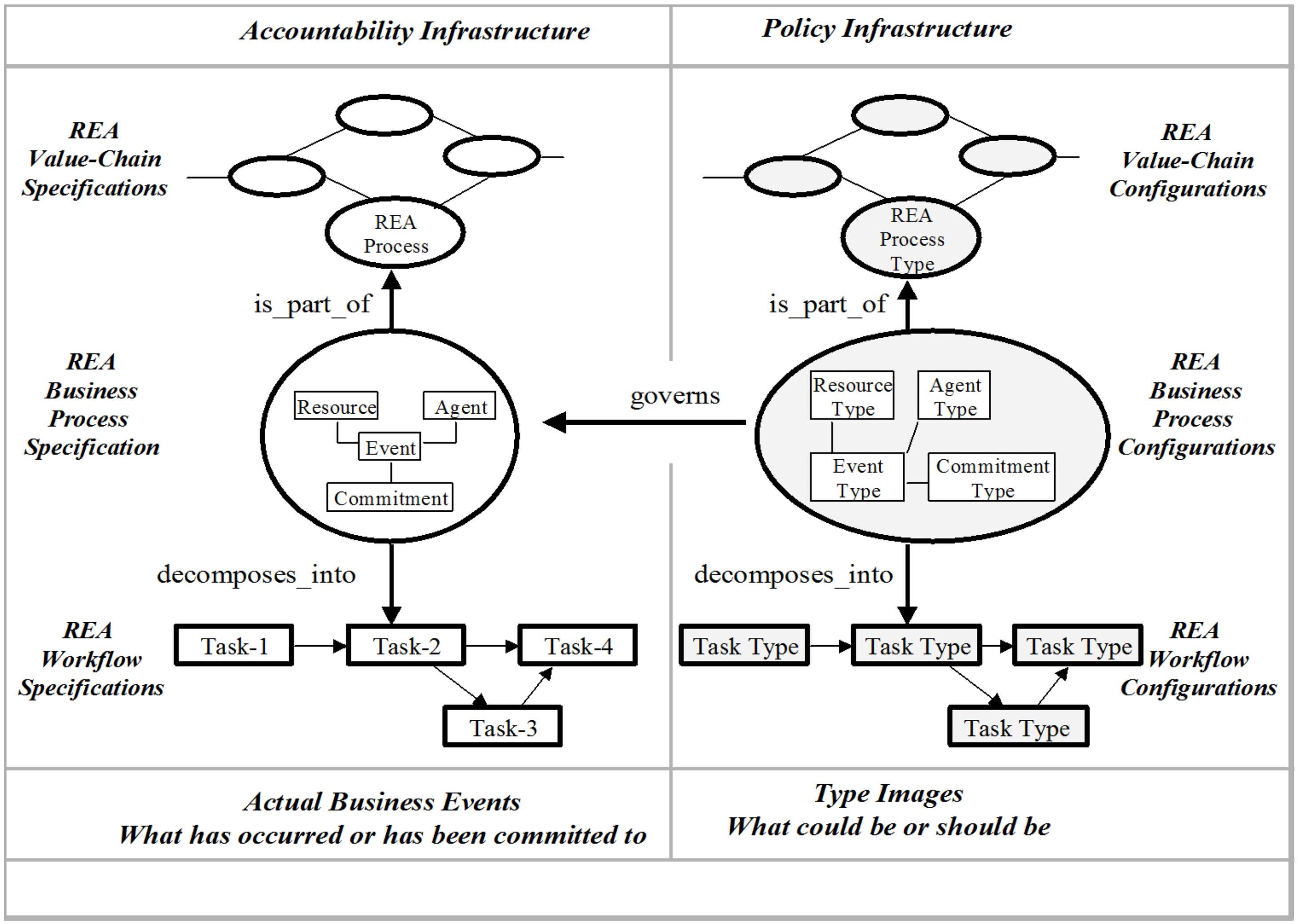

Figure 2 – Accountability & Policy Infrastructures

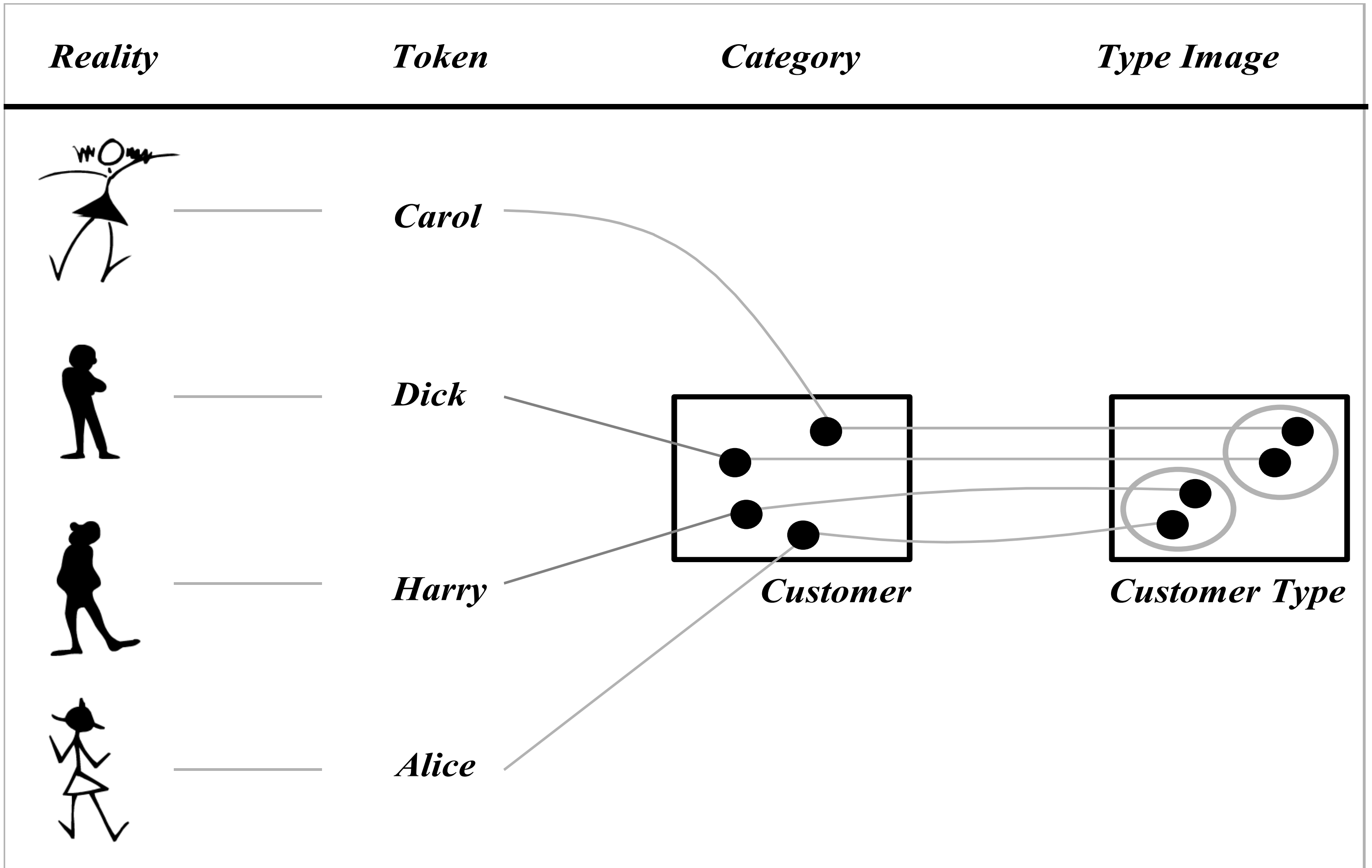

Figure 3 -- Reality to Category Mapping

	Physical Categories		Abstract Categories	
	Continuant	***Occurrent***	***Continuant***	***Occurrent***
1st ***(Independent)***	<u>Object</u> ***EconomicAgent (A)*** ***EconomicResource (R)***	<u>Process</u> ***EconomicEvent (E)*** ***Commitment (C)***	<u>Schema</u> ***AgentType (AT)*** ***ResourceType (RT)***	<u>Script</u> ***EventType (ET)*** ***CommitmentType (CT)***
2nd ***(Relative)***	<u>Juncture</u> ***Association (A-A)*** ***Custody (A-R)*** ***Linkage (R-R)***	<u>Participation</u> ***StockFlow (E-R)*** ***Duality (E-E)*** ***Accountability (E-A)*** ***Executes (C-E)*** ***Involvement (C-A)*** ***Reserved (C-R)*** ***Reciprocal (C-C)***	<u>Description</u> ***Typification*** ***(A-AT)*** ***(R-RT)*** ***Characterization*** ***(AT-AT)*** ***(AT-RT)*** ***(RT-RT)***	<u>History</u> ***Typification*** ***(E-ET)*** ***(C-CT)*** ***Scenario*** ***(ET-RT)*** ***(ET-ET)*** ***(ET-AT)*** ***(CT-ET)*** ***(CT-AT)*** ***(CT-RT)*** ***(CT-CT)***
3rd ***(Mediating)***	<u>Structure</u> ***Responsibility*** ***Partnering*** ***Configuration***	<u>Situation</u> ***Exchange*** ***Conversion*** ***Contracting*** ***Scheduling***	<u>Reason</u> ***Segmentation*** ***Policy*** ***Substitutability*** ***Complementarity*** ***Configuration***	<u>Purpose</u> ***Standardization*** ***Policy*** ***Strategy***

Figure 4. REA components in Sowa categorical form.

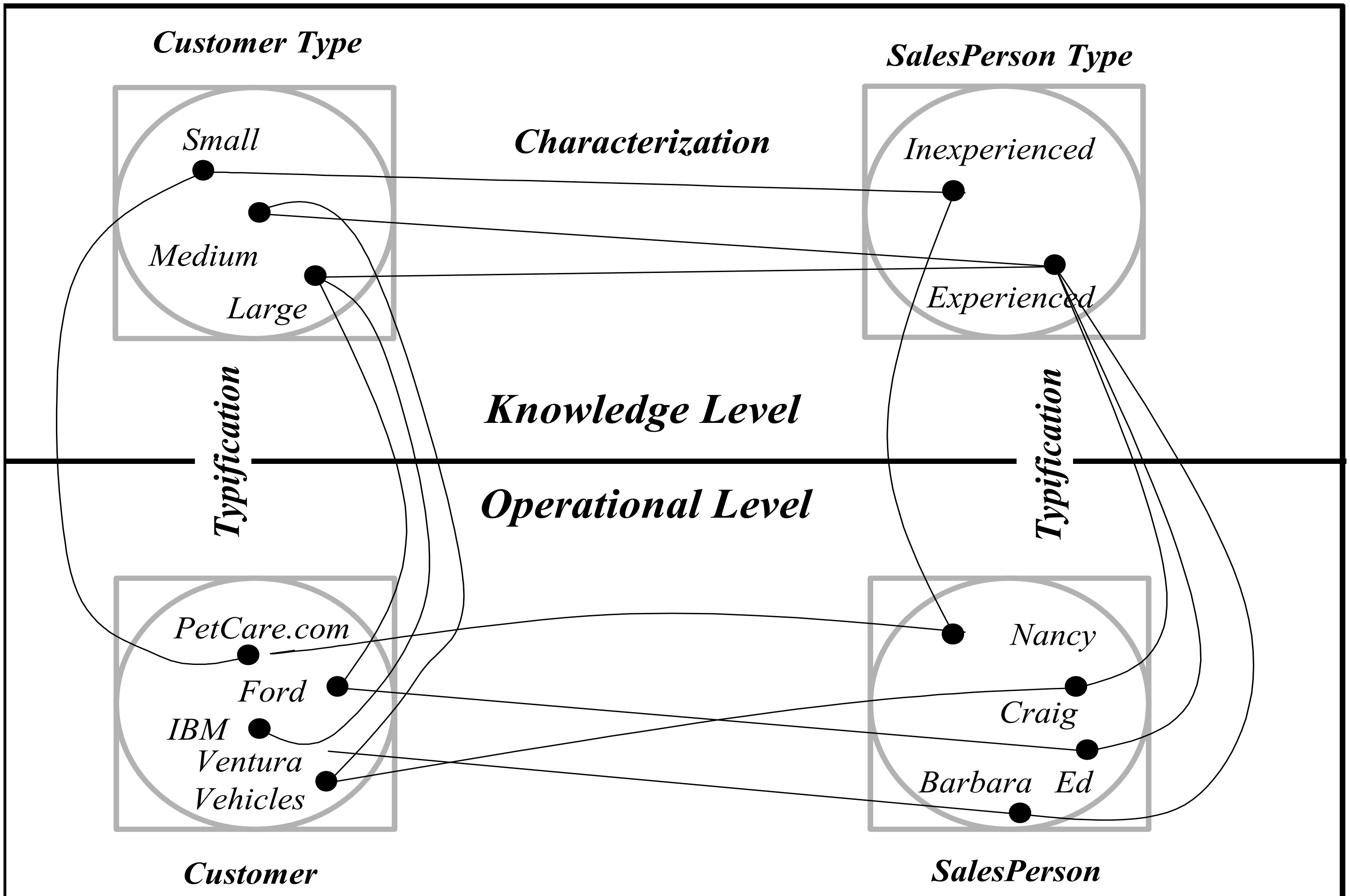

Figure 5 -- Description Representation

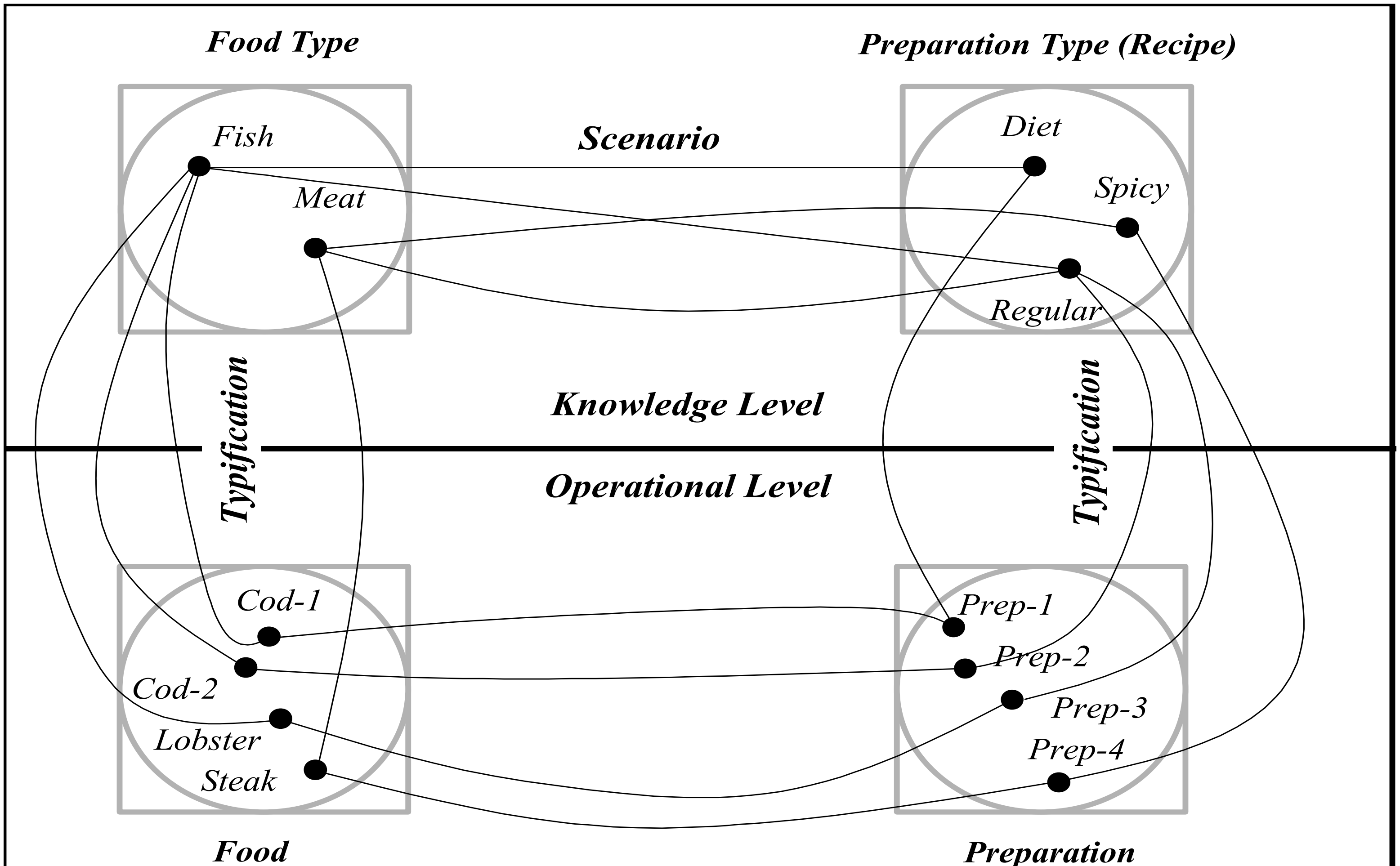

Figure 6 -- History Representation