The Annals of "Dunarea de Jos" University of Galati
Fascicle I – 2010. Economics and Applied Informatics. Years XVI – nº 1 - ISSN 1584-0409

The Role of Ontologies for Designing Accounting Information Systems

Adrian LUPAŞC
alupasc@ugal.ro
University "Dunărea de Jos" of Galați
Ioana LUPAŞC
Ioanalupasc22@yahoo.com
University "Dunărea de Jos" of Galați
Gheorghe NEGOESCU
Ovidius University, Constanta

Abstract.
The accounting ontologies were conceptualized as a framework for building accounting information systems in a shared data environment, within enterprises or between different enterprises. The model's base feature was an object pattern consisting of two mirror-image that represented conceptual the input and output components of a business process. The REA acronym derives from that pattern's structure, which consisted of economic resources, economic events, and economic agents. The REA model was proposed as a means for an organization to capture the signification of economic exchanges between two business partners. The REA ontology provides an alternative for modelling an enterprise's economic resources, economic events, economic agents, and their relationships. Resources are considerate organization assets that are able to generate revenue for implicated parties. Events provide a source of detailed data in this approach. Agents participate in events and can affect some resources. They can be an individual or organization inside or outside the organization that is capable of controlling economic resources and interacting with other agents. The objective of this work is to offer an understandable of this framework and to explain how this model can help us via the identification of the afferent concepts.

Keywords: *REA* ontology, accounting information systems, business process, economic exchange.

JEL CODE: D83, L86

1. Introduction

To arrive at an understanding of an enterprise and the ways it do business, a starting point could be the identifying of actors and the values changed between enterprises or changed in the same enterprise. Enterprise models are created to make explicit who are the business actors that are in a business case and to make their relations more clear. Those relations are formulated in terms of values transferred between the partners that belongs an enterprise or the actors that characterize more enterprises. The objective of this paper is to create a better understanding of enterprise models by identifying the main notation used in such models.

An enterprise model is different from a process model, because a process model captures other types of relations between actors than those of an enterprise model. For example, a process model may contain information about flow of goods changed between different actors or information about time ordering between the activities that are in progress in an enterprise.

This paper presents the use of the *REA* model as the foundation for a semantic infrastructure for knowledge-based accounting systems. Resources, events, agents, stock flows, control, and duality are the *REA* primitives. A conceptual schema that describes all aspects of economic events in the

accounting object system in accordance with the *REA* model is named full-*REA*. Full-*REA* means that events participate fully in each of the three relationships: stock-flow, control, and duality.

2. The basics and components of the rea model

The most researchers of this domain consider that ontology is an explicit, shared specification of a conceptualization and one use of the ontology is to define a universe of discourse. In the case of ontology, the universe of discourse refers at business modelling. The *REA* (*R*esource-*E*vent-*A*gent) ontology was formulated initial in *The Accounting Review* in 1982 and developed later in a number of papers. The conceptual origins can be traced back to traditional business accounting where the needs are to administrate business through a technique called double-entry bookkeeping, who records every business transaction as a double entry – a credit and a debit – in a balanced ledger. *REA* has proven to be a faithful representation of the objects and relations between those objects that exist in an enterprise accounting context.

The *REA* ontology was conceptualized as a framework for building accounting systems in a shared data environment, within enterprises and between enterprises. The model's core is an object pattern consisting of two mirror image that represents, from semantically view, the output and input components of a business. The *REA* acronym derives from that pattern's structure, which consists from economic *resources*, economic *events* and economic *agents*. The framework was extended to include abstract specification of future resource commitments along supply and value chains. The *REA* ontology as it stands in 2003 is an extended framework and it is in present a candidate model for more e-commerce transaction standards. Further, *REA* modelling is used in a many number of *Accounting Information Systems* courses and featured in a different of *Accounting Information Systems* textbooks, anywhere in world. In a semantic database design (and also in object-oriented design), the more difficult step is almost always the first: coming up with a list of candidate entities (classes or objects) on which to base the rest of the analysis. In general, modelling business enterprises is harder. To overcome this difficulty, the analysis patterns movement was born in the early 1990s. The basic framework of interlocking constellations of economic resources, economic events and economic agents of the *REA* accounting model was a complex aggregation of some of those patterns that surfaced in the 1990s. Figure 1 presents the basic element structure of *REA* model. The left to right configuration of economic resources, economic events and economic agents in a business collaboration pattern is the source of the model's *REA* name.

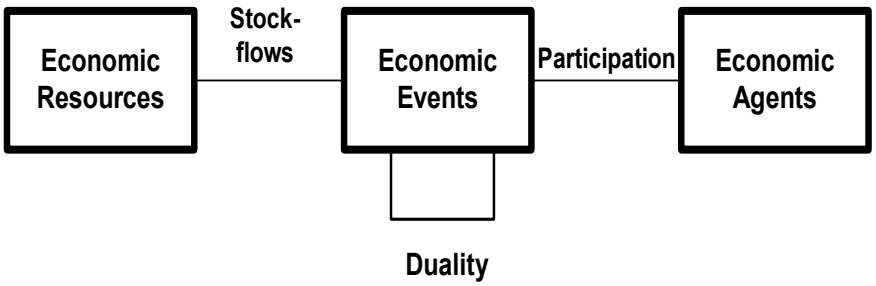

Figure 1. Basic *REA* ontology

The fundamental concepts in the *REA* ontology are *Resources*, *Events*, and *Agents* and the intuition behind the ontology is that every business transaction can be described as an event where two actors exchange resources. To get a resource an agent has to give up some other resource. For instance, in a purchase a buying partner has to give up cash to receive some goods. The amount of cash available to the partner is decreased, while the amount of goods is increased. There are two events taking place here: one where the amount of goods is increased and another where the amount of cash is decreased. The repetition of these events is named *duality*. A corresponding change of availability of resources takes place at the seller's side. Here the amount of goods is decreased while the amount of cash is increased.

The *REA* framework is a representation of an exchange. The *REA* template captures three main aspects of exchanges: the requited events, the resources that are subject of the exchanges, and the participating agents.

Figure 2 shows the model in its basic forms [McCarthy, 1982] as it exists from perspective of a business entrepreneur. *REA* model is a pattern for an arm's length collaboration (or an inside transformation) between the entrepreneur and a trading partner wherein he or she gives up control of some resource of value (the *give* part of the exchange above the dotted line) in exchange for another resource of perceived great value (the *take* part of the exchange below the dotted line). The entity types of figure 2 (the economic Resource, the economic Event and the economic Agents) are very important, but the structuring effects of the relationships are nearly as paramount. *Stock flow* relationships associate the flows in and out of a resource category while the *duality* links keep the economic rationale for the exchange boldly in the forefront.

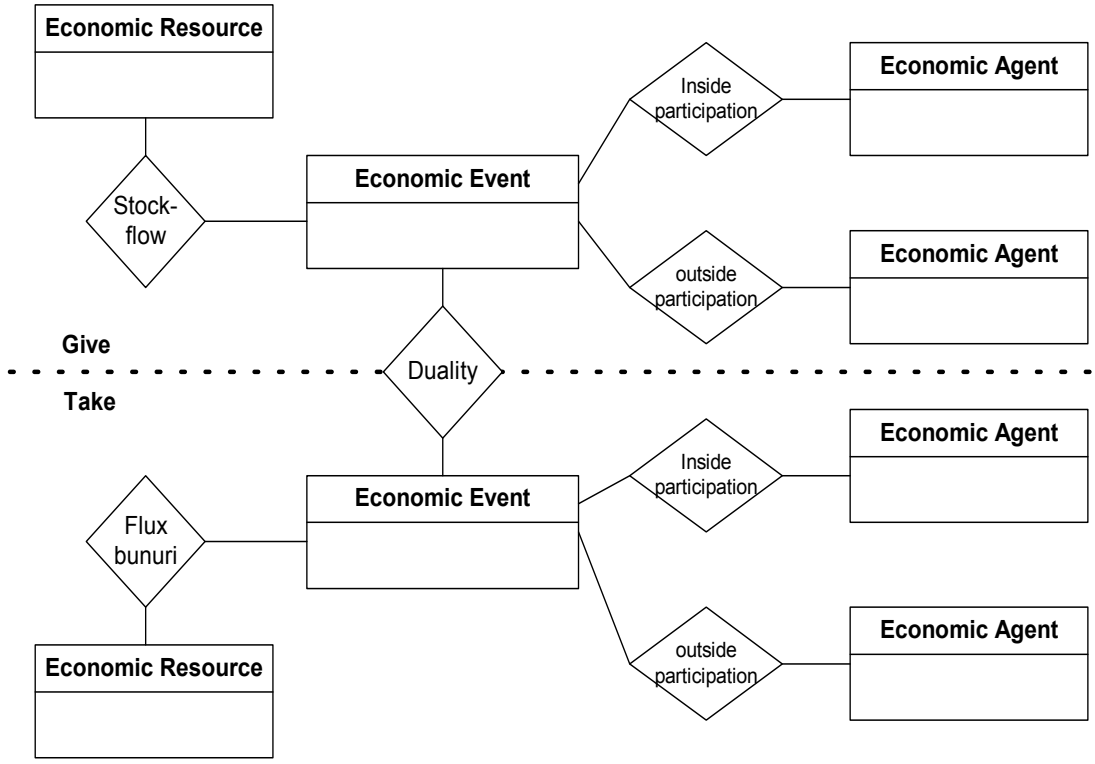

Figure 2. The *REA* ontology from entrepreneur perspective

The mirror-image of exchanges is given by the *duality* relation between an inflow economic event and an outflow economic event. We differentiate between two types of exchanges: transfers and transformations which lead to two types of duality relationships: transfer duality and transformation duality. Transformations create value through changes in form or substance. For transfers, value is created in a market transaction with outside partners.

Stock flows describe the connection between economic resources and economic events. An economic event results in either an inflow or an outflow of resources. Inflows and outflows are further specialized depending on the nature of the duality relation. For an exchange relationship we *give* up a resource to *take* another resource. During a transformation we either use or consume a resource to produce another resource. When resources are used, they often completely disappear in the transformation process and lose their form so as to be unrecognizable. When resources are consumed, they are decremented in chunks that leave the original form discernible. It is important to note that the same resource can participate in many different types of stock flow relations.

The *participation* relation describes the agents involved in an economic event. Inside and outside are two different subtypes of this relation representing the two roles of agents in the participation relation. The same agent can be an inside agent for one event and an outside agent for another event. We consider accountability as a specific subtype of the inside relation. An accountability relation records the agent responsible for the event.

Two of the information technology advances of the 1990s were the advent of *ERP* (Enterprise Resource Planning) systems and the initiation of business process reengineering. In many cases, these technologies accelerated the use of *REA* modelling because its fundamental pattern had the same microeconomic foundation and rationale.

Figure 3 shows how the *REA* maps to the frameworks for these two technologies by defining an enterprise value chain and a business process. An enterprise value chain represent a network of business processes aimed at assembling the individual components of a final product of value to the customer. Business processes represent a group of activities that takes one or more types of input and creates an output that is of more value to the customer. All business process illustrated has a group of inputs (economic resources consumed or given) and a group of outputs (economic resources acquired or taken). The main aim of this network of business processes is to assemble the cookie's bundle of value-adding attributes for the customer.

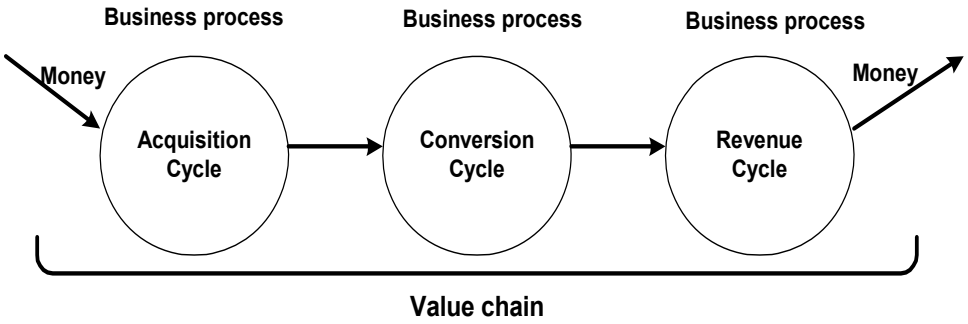

Figure 3. Defining a business process and an enterprise value chain

The *REA* ontology is a semantic data model for the integration and development of conceptual schemas for accounting information systems. Although in the Accounting Information Systems literature the *REA* is proposed as a benchmark against which to evaluate newly accounting data models, only few studies have been undertaken to empirically validate the benefits of *REA* modelling.

The *REA* ontology provides a framework for modelling an enterprise's economic resources, economic events, economic agents, and their relationships. This model is used to capture the essence of economic exchanges between parties. Economic resources are enterprise assets that are able to generate other assets. These resources can be intangible or tangible, but must be under the control of the enterprise. Here, it is important to say that economic resources do not include artefacts that can be obtained from other primary data. Economic events can be some phenomena that cause changes in economic resources. Also, economic events can provide a source of detailed data in this modelling approach.

There are three categories of events: information events, operating events and decision events. The first category is associated with recording, maintaining and reporting information. Operating events are considerate activities that are associated with producing of goods or with providing services. Decision events or management events are activities that lead to decisions being taken. In the case of *REA* model, only operating events are addresses.

Finally, economic agents can affect economic resources and participate in events. These events have power to use or dispose of economic resources. Economic agents (economic partners) are

capable of controlling resources and interacting with other agents. Also, economic agents can be an individual or enterprise outside or inside the enterprise.

An alternative of *REA* model adds location as a modelling element, known as the *REAL* (Resource–Event–Agent–Location). In this case, location refers to the location of an event or resource [David et al. 2002]. A location is an object that is sometimes needed to fill out the specification for a full economic transfer. Locations simply identify the place where economic events take place.
The *REA* models relations between resources, events and agents. The *REA* is grounded in economic and accounting theory and designed to provide information in order to answer five questions about economic exchanges. These questions are: When did the exchange appear? Who can play roles and what roles are played? How resources are used and what kind of resources? Where did the exchange appear? What happened when an exchange occur?

Focusing on an event as a key business occurrence, McCarthy researcher [McCarthy, 1982] shows that the nature of an event is that an agent (economic partner) gives up a resource in receipt for another resource. For example, a customer (external actor) enters a retail establishment and shops for more goods (economic resource). Afterwards, the customer choices these goods and pays for them (an economic event) at a checkout stand (internal actor). The customer has exchanged currency for the goods. Then, the retailer receives said currency and gives up said goods.

This perspective offers a starting point for investigating enterprise events at a general level. In the preceding example, a modification in scenario from a brick and mortar retail establishment to the *WWW* (World Wide Web) does little to modify the essence of the economic event. An entire-*REA* designed information system would emphasize the impact of recording the important characteristics of events and makes the information available to information stakeholders both external and internal to an organization.

The present trading phase of an exchange is adjusted well by the object structure presented above in Figure 1. But, trading partners in long term relations need more predictable and trusted structures where parties contract for their exchange behaviour in advance. The *REA* model adjusts this extension with the addition of the classes presented as economic commitments, economic contract and economic agreement in Fig. 4.

Commitments are promises by a partner to initiate an event latter. A commitment should be reciprocated by the other partner who commits to initiate another kind of economic event in return.

A contract represents a bundle of reciprocating commitments between partners who bind themselves to one ore more exchanges in the future. Contracts are a subtype of the general object class named agreement. Agreements can determine other agreements.

An exchange is when an agent receives resources from another and gives resources back to the agent, and vice versa. A conversion is when an agent consumes resources to produce other resources [Hruby, 2006]. Events perform the commitments of agents. A commitment is defined as being an agreement to execute an event in future that will result in either an increase or a decrease of resources available to an agent. Thus, events happen because exist commitments between agents, and the duality relation between events exists because of a relation named reciprocity between commitments. Which commitment is related to which is established through an agreement.

Materialization of claims is needed when some partners insist on documentation of partially completed exchanges (for example, when a customer takes possession of an good before paying for it in full). Likewise, claims can be instantiated by documents like invoices or by accounting artefacts like accounts receivable. Their inclusion is more a matter of business custom than ontological completeness.

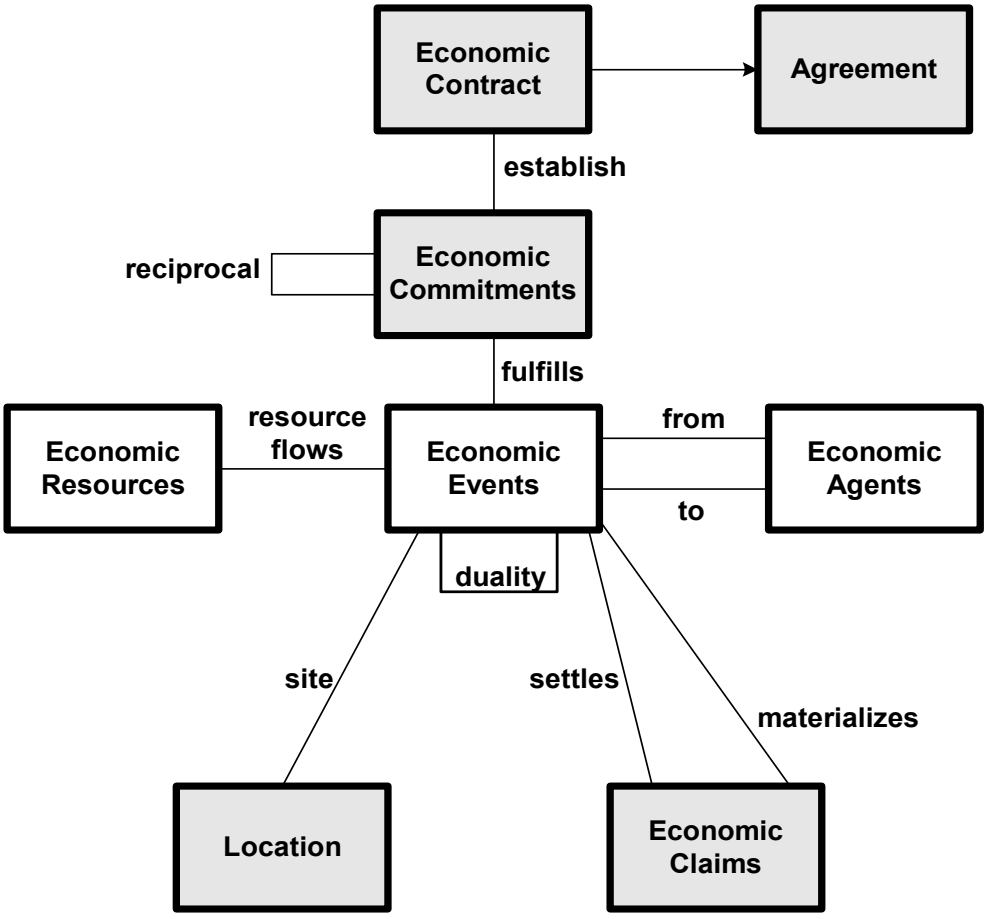

Figure 4. The *REA* ontology with commitments, contracts and agreements

A resource can be an object that is regarded as valuable by some agents. An agent views a resource as valuable because this resource can use it for producing other resources, for trading it with other agents or for deriving some consumer experience. It is important to mention that any object can be a resource. However, it is possible to identify some typical kinds of resources like information, goods and services, and a resource may have properties and associations to other objects.

Also, resources are furthermore related to rights. A right on a resource means that an agent can use that resource in some way. An example is the ownership of a book, which means that an actor can read the book, give it to someone else, or even destroy it. Another example of a right is borrowing a book, which gives the agent the right to read it, but not to give it away or destroy it or use it in any other way.

An event changes a right or a characteristic of any resource. An event is associated to exactly one agent representing the perspective from which the event is viewed. This means that each event can be seen as either an increment or decrement event from the agent's perspective. An increment event changes a particularity or a right of a resource in such a way that the resource becomes more important for the agent, while a decrement event causes a change that decreases the value of the resource.

3. Conclusions and future research

The use of ontologies improves communication between organizations and people, create interoperability between enterprise systems, and improve the reusability and reliability of the systems engineering process. Over the years, a number of ontologies have been developed (*TOVE*, Enterprise Ontology, e^3-value ontology, *REA* ontology, *BMO* - Business Model Ontology). The main difference between these ontologies is the lens through which they look at enterprise and

business reality and that determines their conceptualization of an enterprise (the enterprise concepts they consider relevant).

A limitation of many accounting systems is the lack of knowledge reuse and knowledge sharing, which makes the implementation and design of new accounting systems expensive time and consuming. An important requirement for knowledge reuse and sharing is the existence of a common semantic infrastructure. In this paper I used McCarthy's (1982) Resource-Event-Agent model as a common semantic infrastructure in an accounting context.

It is accepted that when modelling organizations and the way they do business, a starting point could be to identify the actors and the values exchanged between them. This can be accomplished in terms of enterprise models. Business or enterprise models are created to make clear who the enterprise actors are in a business case and to make their interrelations explicit. Interrelations in a business model are formulated in terms of values exchanged between two or more actors.

Enterprise ontologies provides important opportunities for facilitating communication between partners in business, for improving the organization system engineering processes and for creating interoperability between enterprise systems. However despite these opportunities, their use in practice is still harder. This can be partly attributed to the lack of formal representation of these ontologies. This work proposed a structured approach which uses conceptual models as intermediary representation for formalizing business domain ontologies. The proposed methodology is used for the process level specification of the *REA* ontology.

Today, *REA* began to be used as a framework for teaching accounting systems. In its extended form, the *REA* model integrates the teaching of accounting transaction structures, business process engineering, commitment and business policy specification, and enterprise value chain construction. As of 2004, *REA* modelling is used in a variety of Accounting Systems courses and featured in a variety of Accounting Systems textbooks, anywhere in the world.

References

1. *[Andone, Tabără, 2006] Andone, I., Tabără, N., (Coord.), Contabilitate, tehnologie şi competitivitate, Editura Academiei Române, Bucureşti, 2006.*
2. *[Andersson et al., 2006] Andersson, B., Bergholtz, M., Edirisuriya, A., Ilayperuma, I., Johannesson, P., Grégoire, B., Schmitt, M., Dubois, E., Abels, S., Hahn, A., Gordijn, J., Weigand, H., Wangler, B., Towards a Reference Ontology for Business Models, submitted to the 25th International Conference on Conceptual Modeling (ER2006), 2006.*
3. *[David et al. 2002] David, J.,S., Gerard, G.,J., şi McCarthy, W.,E., Design science: An REA perspective on the future of AIS, In V. Arnold & S. Sutton (Eds.), Research Accounting as an Information Systems Discipline, pp. 35-63, Sarasota, FL: American Accounting Association, 2002.*
4. *[Denna, McCarthy, 1987] Denna, E.,L., şi McCarthy, W.,E. An events accounting foundation for DSS implementation, In C.W. Holsapple & A.B. Whinston (Eds.), Decision support systems: Theory and application. Berlin: Springer-Verlag, 1987.*
5. *[Dunn et al., 2005] Dunn, C., Cherrington, A.,O., şi Hollander, A.,S., Enterprise information systems: A pattern-based approach, (3rd ed.), Boston, McGraw-Hill/Irwin, 2005.*
6. *[Dunn, McCarthy, 1997] Dunn, C. şi McCarthy, W.,E., The REA accounting model: Intellectual heritage and prospects for progress, Journal of Information Systems, (Spring), pp. 31-51, 1997.*
7. *[Geerts, McCarthy, 2001] Geerts, G.,L., McCarthy, W.,E., Using object templates from the REA accounting model to engineer business processes and tasks, The Review of Business Information Systems, 5 (4), pp. 89-108, 2001.*
8. *[Geerts, McCarthy, 2002] Geerts, G., şi McCarthy, W., E., An ontological analysis of the primitives of the extended-REA enterprise information architecture. The International Journal of Accounting Information Systems, pp. 1-16, 2002.*
9. *[Hruby, 2006] Hruby, P., Model-Driven Design Using Business Patterns. Forthcoming book, Springer Verlag, 2006.*
10. *[McCarthy, 1982] McCarthy, W., E., The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment, the Accounting Review, pp. 554-578, July, 1982.*
11. *[McCarthy, 2003] McCarthy, W.,E., The REA modeling approach to teaching accounting information systems, Issues in Accounting Education, (November), pp. 427-441, 2003.*
12. *[Osterwalder, 2004] Osterwalder, A., The Business Model Ontology. A Proposition in a Design Science Approach, PhD-Thesis, University of Lausanne, 2004.*

13. *[Osterwalder, 2005] Osterwalder, A., Pigneur, Yves şi Tucci, C., Clarifying Business Models: Origins, present and Future of the Concept, CAIS, Vol. 15, p. 751-775, 2005.*

WEB REFERENCES

http://jeffsutherland.com/oopsla2000/mccarthy/mccarthy.htm, 15.08.2006.
http://ontoweb.org/About/Deliverables/Deliverable111.pdf, 24.07.2006.
http://www.ladseb.pd.cnr.it/infor/Ontology/Papers/vanHeijst.pdf, 24.07.2006.
http://www.msu.edu/user/mccarth4/Alabama.doc, 15.07.2006.
http://www.msu.edu/user/mccarth4/McCarthy.pdf, 15.08.2006.