Reference Ontology for Business Models

Towards Interoperability between Business Modelling Ontologies

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Licentiate of Philosophy Thesis in
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Abstract

The emergence of the internet paved the way for companies to search for new ways of doing their business electronically. These new technological advancements mark the beginning of a new class of business information systems: e-commerce systems. Today there is a growing demand for interoperability of such systems to make it possible for companies to operate together to offer their services to the customers without boundaries and to increase their profits. As a step towards this, we propose the Reference Ontology based on three well-established business-modelling ontologies: BMO, REA and *e^3-value*. The Reference Ontology represents the synthesis of concepts used in these three ontologies. Furthermore, to strengthen its position as a business modelling ontology, we introduced a number of new concepts, primarily related to transfer of resources between various business stakeholders. Our principal goal in this research is to pave a way to develop a common understanding between different business modelling ontologies. This will enable interoperability between different types of business models created based on them.

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Contents

1 Introduction

Enabled by new technological advancements in the modern world, there is an increasing interest for searching for new avenues of doing business using the information and communication technology. In that respect, there is a growing demand within the business community for e-business solutions to make it easier for them to execute their business processes more efficiently and smoothly. An important aspect of such an e-commerce information system is that they should be capable of reflecting a business well. As Gordijn and colleagues [Gordijn00] explain, development of an e-commerce system is not a straight forward derivation from a company's business process but reflects the new ways of doing business. They argue that the development of e-business solutions and the supporting information systems should not be separated from eachother but should be an integrated process. To facilitate this kind of integration, the design of the e-business model that provides the much needed solutions should be broadly understandable by the stakeholders of the business as well as technical experts.

The first step towards e-commerce information systems' development is the designing of a business model that shows the essential business activities of a business case. Therefore it is imperative to identify *who* is doing *what* and *who* is offering *what* in this step, meaning that it should identify *who* are the actors involved in a business case and *what* business activities they carry out and *what* resources they offer to their customers. The process model developed based on such business models, on the other hand, explains *how* these resources are produced, *how* they are negotiated with the customers, *how* they are contracted, etc., which are more technical descriptions showing the ordering between these activities.

The scope in our research is limited to addressing the issues related to the business modelling. In the following sections, we discuss business models in more detail.

1.1 Business Models

As explained in the previous section, a business model provides a basis for e-commerce systems' development. It describes the value a company offers to its environment and what it expects in return.

To help in articulating vague business ideas, a business model bears the responsibility of clearly identifying actors involved in a business and the things of value transferred between them. That is, the main goals in a business model include answering the following questions:

- Who are the actors involved in a business?
- What do they offer to eachother and why these offerings are found to be valuable by the receiving party?
- What activities are there to create the things of value and who performs them?

We can drill deeper down into these questions to find more details about the value creation process and the value transfers with customers and trading partners of a company. This decomposition results in many concepts and therefore the question "*what should be in a business model?*" is very important to determine the fundamental concepts to start developing a business model. Unfortunately, there is no definite answer for this question.

However we can identify a certain number of concepts that commonly appear in the literature, for example in: [Gordijin00]; [UMM06]; [Geerts02]; and [Osterwalder04]. Basically, these concepts represent actors and things offered by them. An actor is a fundamental concept in a business model and it can play different roles like supplier and customer. Economic Resources also appear in all business models. Furthermore, these resources are transferred between the actors, and different business model languages use different terminologies for this, like value transfer and economic event. These value transfers are typically related to eachother in reciprocal relationships meaning that if one agent transfers a resource to another agent, he/she expects another resource in return, as compensation.

There are also many other concepts, and different business model languages include different concepts. In the other sections of this thesis we will go into three specific business model languages and see how they explain and relate to the above concepts.

1.2 Ontologies for Business Modelling

1.2.1 What is Ontology?

The term ontology has its roots in philosophy where it means the state of being exists [Wikipedia07a]. Later it has been used in information science, for knowledge engineering purposes to define models specifying reusable components and the relationships among them. The term ontology in this thesis is used in relation to Information Science and therefore we follow the definition provided by Thomas Gruber [Gruber93].

As defined by Gruber [Gruber93], ontology is an explicit specification of a conceptualisation. He further clarifies the conceptualisation as an abstract simplified model of the world that we intend to represent [Gruber93]. The aim of using ontology in Information Science is therefore to make a common understanding of the given subject by describing different objects of it and the relationships between them. In the following section, we briefly introduce the types of ontologies in the domain of business modelling.

1.2.2 Business Modelling Ontologies

The ontologies related to business developed in two branches: one is called enterprise ontologies and focuses on describing concepts related to organisational activities, structure, etc., of an enterprise (e.g. TOVE [Fox92]). The other describes the concepts related to business transactions among several actors meaning that it mainly aims at describing the activities network of business partners (e.g. BMO, *e^3-value*). The focus on this research falls into the second category that we, in this thesis, present an ontology that describes the activities related to value transfer between several actors and also activities related to the production of the resources.

In the domain of e-business there exist a number of ontologies that identify and classify a number of business concepts. Among them the three leading ontologies are:

- Business Model Ontology (BMO)
- *e^3-value* Ontology
- Resource Events Agents (REA) Ontology

Though they share similarities in the concepts used in eachother, they are expressed in different terminologies and from different perspectives. Among them the BMO [Osterwalder04] is wider in scope than the other two. It focuses on resource exchanges between actors as well as internal capabilities and relationships of an actor. The REA [McCarthy82], on the other hand, was developed originally as a basis for accounting information systems and focuses on increment and decrement of an actor's resources. The *e^3-value* [Gordijin99] aims at modelling value webs of cooperating trading partners and also helps the profitability analysis of the modelled business scenarios. We discuss these three ontologies and their concepts further in Chapter 2.

1.3 Related Research

With the introduction of Information and Communication Technology, there have been many efforts to support companies to deliver their products and services to the customers using the internet. These efforts include defining business models and introducing various methods for creating them. One of the first attempts to define a business model includes the work done by Paul Timmers [Timmers98]. In his work, he views a business model in different angles. On the one hand he identifies it as architecture for the products, services and information flows including the actors and their specific roles; on the other hand it is identified as a model describing the potential benefits to the stakeholders of the business and source of revenues. Furthermore, in his work he identifies eleven e-business models: e-shops; e-procurement; e-mails; e-auctions; virtual communities; collaboration platforms; third-party marketplaces; value-chain integrators; value-chain service providers; information brokerage and trust; and other third-party services, and then classifies them according to their degree of innovation and functional integration. The degree of innovation ranges from simple electronic ways of doing the traditional business to externalising the value-chain activities over the internet and these activities may or may not have been performed by the company previously. The functional integration dimension describes the number of functions performed by a company, for example an e-shop only provides the marketing function of a shop and therefore with less functional integration while a collaborative platform provides an environment for collaboration between trading partners and has high functional integration.

Similar to Timmers, Weil and Vitale [Weil01] define eight atomic business models where each model describes different ways of doing a business electronically. These models can be combined in multiple ways to represent different kinds of business models. The atomic business models are: Content Provider; Direct to Customer; Full Service Provider; Intermediary; Shared Infrastructure; Value-net Integrator; Virtual Community; and Whole of Enterprise.

Michael Rappa in 2001 [Rappa01] presented a more comprehensive list of business models comprising thirty models organised into nine categories: Brokerage; Advertising; Infomediary; Merchant; Manufacturer; Affiliate; Community; Subscription; and Utility. These generic models classify businesses based on the products/services they offer to their environment.

The business model frameworks presented above have a more descriptive nature and propose different kinds of models that one can use to represent different kinds of businesses. They are in a way exploring various kinds of business models existing in the modern world. Other than these, there is another approach to define a business model in a more precise way by identifying different constituent components of it. These latter approaches aim at defining business concepts and the relationships between them. Among them Gordijin [Gordijin02] provides a conceptual framework which he calls *e^3-value* ontology that identifies and classifies business terms based on a value-oriented approach. The approach centers between the trade of objects of value among the various business actors. On the one hand the *e^3-value* ontology aims at providing a simple value-oriented approach to enhance the ways of doing business and capturing business decisions, for example who is doing what and who is offering what to whom. On the other hand it facilitates profitability analysis of the created business models.

Business Model Ontology (BMO) by Osterwalder [Osterwalder04] provides a more comprehensive way for modelling businesses. It identifies various business concepts classified around four pillars: Product; Customer Interface; Infrastructure Management; and Financial Aspects. Altogether, these pillars aim at defining a company's business, their customers, how they carry out delivering their value proposition, who are their business partners and how they generate revenue. Among the business-modelling approaches we analysed in our research, BMO has a wider scope than other approaches and has a strategic focus.

The Resource Events Agents (REA) ontology proposed by Bill McCarthy [McCarthy82] has its origins in accounting and micro-economics and has a strong theoretical background in basic accounting principles. It centers around the concept of economic reciprocity, meaning that every economic event that increments a business's resources is linked with a decrement economic event. In Chapter 2 we will discuss concepts in REA as well as BMO and *e^3-value* in depth.

There have also been efforts, for example Unified Modelling Methodology (UMM) [UMM07], for developing a more comprehensive methodology for business and process modelling. UMM is based on REA concepts and has the goals of providing a set of reusable process and information descriptions, comprehensive process and information Meta models and to support capturing business-process knowledge regardless of the underlying implementation technology [UMM07]. Compared to other work described above, the main focus of UMM is aligned with the business process area.

So far we have been discussing developments in the business modelling area in general. In the paragraphs below, we are going into more specific detail about recent work that has been done by us, and also by others, that is related to the analysis of business models' concepts, as well as efforts to facilitate a common understanding between different business modelling ontologies.

An important step towards developing common concepts to use in business modelling is analysing the things of value transferred between business stakeholders. Our previous research on this question has drawn attention to what a buyer actually gets in a value transfer [Weigand06a] and the properties of these value transfers or more precisely, the way these resources are offered [Weigand06b]. The point of departure in both these research areas are the business models created based on the *e^3-value* ontology. We discuss these two research activities in detail in the related publications' section later in this chapter.

Apart from this line of analysis about the objects of value (or resources in general), transferred between agents and the value transfers, there are other research focuses on cross analysis between different ontologies to see how eachother contributes to the design of e-business models [Gordijin05]. On the one hand this helps to find the similarities and the differences between ontologies. On the other hand it helps any integrating efforts of different ontologies to improve the representation, design and analysis of business models. In their research [Gordijin05] they analyse two business modelling ontologies: the BMO and the *e^3-value* ontology. They argue that both these ontologies share a certain number of similarities in the areas of inter-company interoperability to improve the way companies work together as a network to offer their products to the customers. BMO does this by means of the concepts related to partnerships whereas *e^3-value* aims at developing and describing inter-company business models. Yet, they differ in their scope in designing the business models. In that respect, BMO follows a firm centered approach taking a single company and describing its customers, products, infrastructure and the relationships with both customers and the business partners while *e^3-value* adopts an approach of modelling value constellations. The conclusion of the research is that in the area of value constellation they complement eachother while in the area of customer-related concepts BMO provides more information. Furthermore, they also conclude that in the area of value-exchange-related concepts *e^3-value* ontology plays a more dominant role.

The latest developments in REA [Hruby06], [Geerts05] go into more detailed analysis of value transfers as well as activities related to the production of resources. We will discuss them in more detail in the relevant sections in the following chapters describing the concepts of the Reference Ontology.

1.4 Research Question

During recent times, interoperability has emerged as an important issue for the future development of e-commerce. Interoperability in this context is about setting up a common set of standards that enables communication between different business systems both at a technical level and also at a business level. From a technical perspective, interoperability is important to create a global and an open e-commerce market place, while from a business perspective it is important to create a better understanding between different conceptual models used to represent similar business knowledge. A starting point for creating an e-commerce system lies on the level of developing a conceptual model that describes the business entities and the relationships among them. Therefore interoperability at this level could help interoperability immensely at the technical level. In this research we limit our scope of the Interoperability to the business perspective.

Today, a number of approaches exist to create business models. However, no concrete consensus exists between different communities of users in defining a business model and its constituent components. However, a common ground for all these approaches is that a business model should depict the business of a company in relation to its network of business relationships and how it generates revenues.

To find a common ground between them, first we need to focus our attention to the more general question about what they try to address. That is the first step towards building a common set of concepts to support modelling businesses, we start with the question:

- What is the function of a business model?

Should a business model describe the organisation of internal activities of an enterprise or should it focus on external relationships and transfer of values between other entities or should it deal with both? Ideally it may be very attractive if a business model deals with both these aspects. However, it depends on which questions one tries to answer by using a business model. On the bottom line, a business model should answer certain basic questions. They could be:

- What things of value do we offer to our customer and why should they find them important?
- What activities do we have to create these values?
- What differentiates us from our competitors?
- Who are the other business partners involved with our business and how do we cooperate with them?

To answer the above questions we analyse three well-established ontologies: BMO; REA; and *e^3-value* and propose ontology that includes concepts that answer the above questions and are most widely agreeable to the above three ontologies in our analysis.

1.5 Goal and Expected Results

The goal of this research is twofold: 1) to find a conceptualisation agreeable to the three well-established business modelling ontologies: BMO; REA; and *e^3-value*, by analysing transfer of value between various business stakeholders. 2) Use this conceptualisation to facilitate interoperability between different types of business models created based on different business modelling ontologies.

We expect to achieve the above goals by means of proposing an ontology and then proposing a set of mappings between each of these ontologies and the proposed ontology and vice versa. In brief, at the first step we propose an ontology comprising the most important concepts related to transfer of value between various business stakeholders. Then we propose a set of mappings between BMO, *e^3-value* and REA and the proposed ontology. These mappings have to be proposed in both directions between the original ontologies and the proposed Reference Ontology in order to facilitate interoperability between them.

1.6 Research Contributions

As stated in the above section, our goals include proposing a conceptualisation agreeable to three well-established ontologies: BMO; REA; and *e^3-value* and a way of facilitating a common understanding between them. The Reference Ontology proposed in this research addresses the first goal. In this respect, apart from the existing knowledge, the Reference Ontology also contains additional concepts that do not exist in the original ontologies. The latter goal is addressed by means of proposing a set of mappings between the similar concepts in these original ontologies and the Reference Ontology. Hence both these are main contributions in this research. Furthermore, the proposed set of mappings between the *e^3-value* ontology and the Reference Ontology are realised by using XML Query Language – XQuery and Extensible Stylesheet Language Transformations (XSLT). This is another important contribution in the thesis.

1.7 Research Approach

Our research approach that answers the above mentioned questions consists of three main steps:

1. Define the scope of a business model and analyse three leading business ontologies to identify a set of concepts to be represented in the proposed ontology.
2. Proposing high level mappings from the concepts in the original ontologies to the proposed Reference ontology.
3. Evaluating the results by using a case study.

That is, firstly, we fix our scope of a business model and its perspective. Then based on the analysis of the BMO, *e^3-value* and REA ontologies, we propose a set of concepts that goes in line with the results above. Secondly, we establish a set of mappings between each ontology in our analysis and the proposed Reference Ontology and vice versa. Finally we formalise one set of mappings between one of the three ontologies and the Reference Ontology.

1.8 Research Methodology

1.8.1 Research as a Design Science in Information Systems Research

Hevner and colleagues [Hevner04] present a conceptual framework that should be used to evaluate the design science research for its usefulness, applicability and the effectiveness in the problem domain. It consists of seven guidelines that should be satisfied by effective design science research. In the following we analyse our work according to these guidelines. More information about these guidelines can be obtained from [Hevner04].

Guideline 1: Design as an Artefact

> *"Design-Science research must produce a viable artefact in the form of a construct, a model, or an instantiation"* [Hevner04, pp. 83].

An ontology in the domain of information science can be described as a model that describes a set of constructs and their relationships to eachother [Wikipedia07a]. In this research, we propose a set of conceptualisations that is agreeable to three well-established business modelling ontologies. However, the proposed Reference Ontology is not confined to the concepts in the original ontologies and contains additional concepts that have a bearing on the transfer of value between actors. Furthermore, as a step towards facilitating communication between the original ontologies, we propose a set of high-level mappings between the concepts in the original ontologies and the concepts in the Reference Ontology. In addition to that, we have also formalised the proposed high-level mappings between the *e^3-value* and the reference ontologies using the XQuery as the mapping language. The results are stored in an RDF/OWL format that can be imported into an ontology-processing tool Protégé.
Based on the above facts, we can identify two clear artefacts produced in this research: one is the Reference Ontology and the other is the formalisation of mappings between *e^3-value* and the related concepts in the Reference Ontology, i.e. a way to derive one business model from another.

Guideline 2: Problem Relevance

> *"The objective of design-science research is to develop technology-based solutions to important and relevant business problems"* [Hevner04, pp. 83].

One of the basic requirements for an ontology is to be a generic description shared by the community of users [Osterwalder06]. As they explain, there is no definite consensus existing between different communities of users on what elements should be in a business model. With inter-organisational e-commerce growing rapidly, there is an increased interest in Information Systems (IS) integration in cross-enterprise environments. To integrate systems across enterprises, we need to find ways to facilitate communication between different kinds of IS and the point of departure could be at the very first steps of developing such systems, for example, creation of business models that describe a company's business.

"The problem that we face today is that the computer systems to support enterprise functions were independently created, consequently they do not share the same representations. This has led to different representations of the same enterprise knowledge and as a consequence, the inability of these functions to share knowledge" [Fox92, pp. 1].

In this context, there have been some research efforts such as TOVE [Fox92], and Enterprise Ontology [Uschold98] for the development of a shared representation of enterprise knowledge to address the problem of sharing knowledge. Further to this, there have also been certain other efforts to analyse different representations against eachother to find the similarities and the differences and ways of integrating them (e.g. [Gordijin05]).

The formation of a reference model that facilitates communication between different kinds of business models provides a foundation for new methods to integrate different systems across companies and also facilitates the creation of computer-based tools. Therefore this is a very relevant problem in the domain of business modelling to support interoperability between different e-commerce systems.

Guideline 3: Design Evaluation

"The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods" [Hevner04, pp. 83].

As explained in [Hevner04], evaluation is a crucial component in a research process. It proves whether or not a developed artefact is actually useful to solve the problem that it intended to solve. However we could not carry out an evaluation of the proposed Reference Ontology in this dissertation in a real-life business situation due to time and resource limitations. Further to that, the formalisation of mappings related to BMO and REA and the mappings between the Reference Ontology and the original ontologies that are essential for transforming from one business model to another is not yet finalised. Nevertheless, we show the applicability of the proposed Reference Ontology through a case study similar to one used in [Gordijin05]. Apart from that, we also implemented a set of mappings from *e^3-value* to Reference Ontology. Our experience with this implementation suggests that the mappings work well and can derive the Reference Ontology version of the same business model after several steps. However this needs to be tested for the mappings related to the other two ontologies as well. Also we have to test the applicability of the Reference Ontology by applying it in a real business situation to see the richness of its concepts and relationships between them as well as its usefulness in such situations.

Guideline 4: Research Contributions

> *"Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies"* [Hevner04, pp. 83].

The main contributions of this research are the proposed Reference Ontology and the mappings from each of the three ontologies, REA, BMO and *e^3-value* to the Reference Ontology. One of our goals in this research is to propose a shared representation of knowledge related to a business modelling that is agreeable to three well-established ontologies: BMO; REA; and *e^3-value.* In this respect, apart from the existing knowledge, the Reference Ontology also contains additional concepts that do not exist in the original ontologies. We believe that these contributions will enhance the efforts to facilitate the communication between different representations of similar knowledge in these ontologies interpreted by means of different scopes and perspectives. It will also lead to a better understanding of the relationships of these concepts with eachother.

Guideline 5: Research Rigour

> *"Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact"* [Hevner04, pp. 83].

The proposed Reference Ontology is based on three well-established ontologies: REA; BMO; and *e^3-value.* Among them, REA has its origins in accounting theory where every transaction is seen as either an increasing or decreasing resource of an organisation. The BMO has its roots in the Balance Score card approach [Kaplan92] and business management literature [Markides 99] and provides nine basic elements grouped around four pillars. The approach was initially tested by using a prototyped computer-based tool which uses Business Modelling Language: BM^2L as the modelling language and also applied to real-life business cases. The *e^3-value* ontology is based on the value-based requirements' engineering and basically looks upon the transfer of value between networks of actors. It has also been applied in real-life business cases and has been proven to work efficiently within its scope: value-based e-business modelling. Other than the above sources of literature, the Reference Ontology refers to certain other well-established business management frameworks such as the Porter value chain [Porter85].

In addition to above, we used XML Query Language (XQuery), a W3C standard for querying XML documents for the formalisation of the proposed mappings between *e³-value* and the Reference Ontology. The output of the mapping process is presented in RDF/OWL format: a format used for knowledge representation which is also a W3C standard for defining Web ontologies.

Guideline 6: Design as a Search Process

> *"The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment"* [Hevner04, pp. 83].

In our research, we analysed three well-established ontologies in the domain of business modelling. They all have different scopes and support modelling business cases in different perspectives. As we have stated before, one of our goals is to propose a set of shared representation to cover all three ontologies: BMO; REA; and *e³-value*. However we have no intention to include each and every concept in them in the proposed Reference Ontology. Furthermore, we have also examined the constituent components of objects of value, transferred between agents and also economic events within and outside actors and how to group them [Weigand06a], [Weigand06b]. The formalisation of mappings presented in this thesis is related to *e³-value* and Reference Ontology and is an iterative process with two steps. In step one, the concepts that are possible to directly map from *e³-value* to the Reference Ontology is realised, where as in the second step, the missing information related to the concepts that could not be directly derived from the *e³-value* business model is appended. In the first step XQuery is used to search and map the available information from *e³-value* concepts to Reference Ontology concepts and in the second step XSLT is used to append any missing information into mapped Reference Ontology concepts. However, to fully test the effectiveness of the proposed mappings of all three ontologies, we have to formalise the mappings related to the other two ontologies: REA and BMO, as well as propose and implement mappings between the Reference Ontology and the original ontologies. In particular the mappings related to BMO would be more interesting to implement and test. This is due to the fact that among these three ontologies, the BMO has a wider scope and once the mappings are implemented, it will show whether the proposed Reference Ontology suits in its context of modelling too and what further improvements need to be done.

Guideline 7: Communication of Research

> *"Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences"* [Hevner04, pp. 83].

This guideline describes that the designed artefact must be presented so that both technical experts as well as business users can understand how it could be used. The important concepts in the Reference Ontology are explained in detail. In particular, we have described the concepts that do not exist in REA, BMO and *e^3-value* and also their relationships to eachother. Further to that, the mappings proposed in section four also contain justifications wherever it is appropriate to make it easily understandable. This information can be understandable to both the business audience and the technical audience. The proposed mappings are in a high-level language (except for the *e^3-value* which we have formalised the mappings) which could be understandable but they do not give sufficient details about how they would work on the instance level. This, we think is a drawback, but addressing these issues is left for future research. The proposed Reference Ontology is also presented in an UML class diagramme which shows the concepts and their relationships to eachother with cardinalities. This will be understandable to the technical audience.

1.9 Related Publications

The work presented in this thesis contains references to our previous research publications in various scientific conferences. The details of the Reference Ontology in Chapters 3 and 4 in the thesis is mainly based on publications in two scientific conferences: *3rd Open Interop Workshop on Enterprise Modelling and Ontologies for Interoperability (EMOI'06)* [Andersson06b] and in the *25th International Conference on Conceptual Modelling (ER-2006)* [Andersson06a]. Furthermore, the version of the Reference Ontology proposed above has been amended and extended based on various other research activities within our research group and also with other collaborative partners and has a bearing on work presented in Weigand and colleagues' publications [Weigand06a] and [Weigand06b]. In these two research papers, we analysed the objects of value transferred between various business stakeholders. The Reference Ontology captures this information by introducing concepts such as conversion events, transfer events and second-order values. Precisely speaking, in the work presented in [Weigand06a], we identified different aspects of a value object defined in *e^3-value* based on what a customer actually gets as a result of a value transfer. On one hand, we argue that one acquires a certain right over something when he buys it. The right he acquires describes the things he is entitled to do with the resource that he bought, for example borrowing a book and buying a book transfers two different rights over the same type of resource: a book. On the other hand services like hairdressing or transportation behave in a different way that in such cases some action is performed on an object that has an interest to the buyer. In both these cases, there is a certain right transferred but differs in the sense that in the former case a buyer gets the resource as a result of a value transfer but in the latter case he gets some form of a transformation on something belonging to him as a result of a value transfer.

These two aspects together provides a basis for capturing information about the relationship between transfer and conversion events where different rights over resources are transferred between actors and the use of these resources to create value for them through different conversion events.

In [Weigand06b], we focused on extending the *e^3-value* ontology to support strategic analysis on three dimensions: competition analysis; customer analysis; and capability analysis. This work emphasises the importance of highlighting the objects of value with *second order* which are defined as a way of providing a value object, for example, *convenient* one click shopping method provided by amazon.com or complementary objects offered together with core or primary value objects, like for example, a toy with a Mac Happy Meal. These second-order values play an important role in distinguishing ones business from his competitors, and also have a bearing on modelling the business processes. These concepts are introduced in Chapter 3 describing the Reference Ontology.

In addition to the above publications, we also investigated methods for going from business models to process models in structured ways. The complete list of publications can be found at the end of this chapter.

1.10 Structure of the Thesis

This thesis is structured as follows. Chapter 1 presents a background to the business models, synthesis of related literature review, the research problem that we intend to address and our research goals. It also presents the research methodology and set of published papers that have a relationship with this work. Chapter 2 of the thesis explains three well-established business model ontologies: BMO, REA and *e^3-value* which form the corner stones of the proposed Reference Ontology. In Chapter 3, we present the Reference Ontology and its concepts in detail. Chapter 4 presents the proposed high-level mappings between each of the ontologies: BMO; REA; *e^3-value*; and the Reference Ontology. Formalisation of mappings between *e^3-value* and the Reference Ontology is presented in Chapter 5 and finally we conclude by briefing the work presented in this dissertation and by giving the directions for future research in Chapter 6.

1.11 List of Publications

1. Andersson, B., Bergholtz, M., Edirisuriya, A., Ilayperuma, T. and Johannesson, P. (2005): "*A Declarative Foundation of Process Models,*" Proceedings of Advanced Information Systems Engineering: 18th International Conference (CAiSE05), Porto. Springer-Verlag, LNCS, pp. 233-247.
2. Weigand H., Johannesson P., Andersson B., Bergholtz M., Edirisuriya A. and Ilayperuma T. (2006): "*On the Notion of Value Object,*" Proceedings of Advanced Information Systems Engineering: 18th International Conference (CAiSE06), Luxembourg, pp. 321-335.
3. Weigand H., Johannesson P., Andersson B., Bergholtz M., Edirisuriya A. and Ilayperuma T. (2007): "*Strategic Analysis Using Value Modeling: The c^3-value Approach,*" 40th Hawaii International Conference on Systems Science (HICSS-40 2007). Waikoloa, Big Island, HI, USA. IEEE Computer Society. CD-ROM/Abstracts Proceedings, 175.
4. Weigand, H., Johannesson, P., Andersson, B., Bergholtz, M., Edirisuriya, A. and Ilayperuma, T. (2006): *"Value object analysis and the transformation from value model to process model,"* Proceedings of INTEROP-ESA'06, Bordeaux, France, pp. 55-65.
5. Ilayperuma T.(2006): *"A Declarative Approach of Process Model,"* Proceedings of the Workshops and Doctoral Symposium of the Second IFAC/IFIP I-ESA International Conference: EI2N, WSI, IS-TSPQ 2006, Bordeaux, France, pp. 315-319.
6. Andersson, B., Bergholtz, M., Edirisuriya, A., Ilayperuma, T., Johannesson, P., Bertrand G., Michael S., Dubois E., Abels S., Hahn A., Gordijn J., Weigand H. and Wangler B. (2006): "*Towards a Common Business Ontology,*" Proceedings of the 3rd Open Interop Workshop on Enterprise Modelling and Ontologies for Interoperability (Interop-EMOI'06). Luxembourg, pp. 643-654.
7. Andersson B., Bergholtz M., Edirisuriya A., Ilayperuma T., Johannesson P., Gordijn J., Grégoire B., Schmitt M., Dubois E., Abels S., Hahn A., Wangler B. and Weigand H. (2006b): "*Towards a*

Reference Ontology for Business Models," Proceedings of the 25th International Conference on Conceptual Modeling (ER-2006). Arizona, USA, pp. 482-496.

8. Andersson B., Bergholtz M., Edirisuriya A., Ilayperuma T., Johannesson P. and Zdravkovic J.(2007): "*On the Alignment of Goal Models and Business Models*," REA 25:A Celebration of the REA Enterprise Ontology. June, 2007, Newark, Delaware, USA.
9. Andersson B., Bergholtz M., Edirisuriya A., Ilayperuma T., Johannesson P. and Zdravkovic J. (2007): "*Using Strategic Goal Analysis for Understanding and Enhancing Value-based Business Models,"* In proceedings of *BUSITAL* (a workshop on Business/IT Alignment and Interoperability), co-located with CAISE'07*,* Trondheim, Norway, June, 2007, pp. 413-420.

2 Introduction to Business Modelling Ontologies

As explained in Chapter 1, an ontology that describes the concepts in e-business modelling provides an important foundation for creating a business model. It not only describes the concepts but also highlights the relationships between them. In this chapter, we go into the details of three leading business modelling approaches: the Business Model Ontology (BMO); the Resource Events Agents (REA) ontology; and the *e^3-value* ontology that make foundation stones for the proposed Reference Ontology.

2.1 The Business Model Ontology (BMO)

The Business Model Ontology (BMO), proposed by Alexander Osterwalder [Osterwalder04] aims at providing an approach to build business models by applying more rigorous, accurate and detailed analysis of business activities for an enterprise. Influenced by the Balanced Scorecard approach of Kaplan and Norton [Kaplan92] and Markides [Markides99], it proposes nine interrelated concepts grouped around four pillars.

The Balanced Scorecard approach [Kaplan92] gives a set of measures that enables top managers to get a comprehensive view to lead their business efficiently. It identifies four perspectives of the business: customer perspective; internal perspective; innovation and learning perspectives; and financial perspective. The customer perspective deals with answering the question: how is a company seen by its customers? In the internal perspective, the company tries to identify what must be done in order to meet the expectations of its customers. The innovation and learning perspective aims at continued improvement of their existing processes, as well as abilities to expand them, to introduce new products. Finally, the financial perspective asks the company itself about how it is viewed by its shareholders.

Markides [Markides99] describes that a company should focus on whom they target as customers, what they should offer to their customers and how they should go about doing that. As also explained by Ostwerwalder, what is missing in this proposal is the financial aspect of a business.

In the following table Osterwalder compares the four pillars of its BMO with a Balanced Scorecard approach and Markides' work.

Business Model Ontology	**Balanced Scorecard (Kaplan and Norton 1992)**	**Markides (Markides 1999)**
Product	Innovation and Learning Perspective	What?
Customer Interface	Customer Perspective	Who?
Infrastructure Management	Internal Business Perspective	How?
Financial Aspects	Financial Perspective	

Table 1: Four pillars of BMO with two other approaches adapted from [Osterwalder04].

Based on an extensive survey of existing business model literature, Osterwalder proposes a new approach by identifying and analysing various business model building blocks proposed by others. The nine elements, which fall into the four categories mentioned above, interrelated with eachother and cover most of the concepts proposed by others in his literature survey. The following table adapted from [Osterwalder04] summarises the Synthesis of his literature review by grouping them into his four pillars.

Pillar	Building Block of Business Model	Description
Product	**Value Proposition**	A Value Proposition is an overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	**Target Customer**	The Target Customer is a segment of customers a company wants to offer value to.
	Distribution Channel	A Distribution Channel is a means of getting in touch with the customer.
	Relationship	The Relationship describes the kind of link a company establishes between itself and the customer.
Infrastructure Management	**Value Configuration**	The Value Configuration describes the arrangement of activities and resources that are necessary to create value for the customer.
	Capability	A capability is the ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.
	Partnership	A Partnership is a voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.
Financial Aspects	**Cost Structure**	The Cost Structure is the representation in money of all the means employed in the business model.
	Revenue Model	The Revenue Model describes the way a company makes money through a variety of revenue flows.

Table 2: Business model concepts adapted from [Osterwalder04].

The above table not only summarises the most commonly appearing building blocks from various other researches in the area of business modelling but also shows the nine core concepts of the BMO divided into four categories similar to a Balanced Scorecard approach and also to Markides' work. In the following section we briefly explain the concepts of BMO. We limit our focus to the first three pillars and the financial aspects pillar is not discussed as we do not consider the concepts relate to financial aspects in our Reference Ontology.

2.1.1 Elements of the Business Model Ontology

Product

The PRODUCT pillar gives a high-level view of a company's business including a bundle of products or services offered to its customers and how it differentiates from its competitors. Basically it is comprised of two components: the Value proposition and the Offering. In the following we explain these concepts in detail.

Value Proposition and Offering

Value proposition in BMO describes the value offered by a company to its customer segments. It specifies a set of products and services offered and how they are bundled together. In addition to that, it also specifies why customers should buy their products and how a company differentiates from its competitors by pinpointing different features of their products and services and the way they are offered.

The Offering sub-element decomposes the aggregated view of the company's Value Proposition, into a set of elementary components by illustrating certain characteristics of specific products or services that describe their position in a competitive market. The BMO uses several attributes: Reasoning; Value Level; Price level; and Life Cycle to describe why customers should be interested in their products by specifying various aspects of having them and using them, for example, how much effort is needed in order to obtain these products and the costs related to their maintenance, etc. These attributes further specify how an enterprise differentiates its products and services from its competitors by means of explaining whether they are unique for the enterprise, or they are an improvement over the same competitive products/services offered by others or just the same as the products offered by others. Furthermore these attributes illustrate the position of the prices of the products over their competitors.

Customer Interface

The Customer Interface is the second pillar of the BMO. It describes the customers of a company and primarily aims at answering questions of type *who*, *how* and *what* of the customers. These questions collectively describe the type of customers targeted by a company, how a company reaches them to deliver its products and what a company does to attract new customers and retain existing customers.

Target Customer

The Target Customer element in the customer interface represents the customers that a company targets to sell their products. Segmentation of customers and identification of groups to sell products is important as to maximally utilise resources and increase profits, a company needs to be more specific about to whom they plan to sell their products. The BMO uses a Criterion sub-element to decompose a company's customers into different segments using a set of characteristics it has, for example, of being a geographical or socio-demographic nature.

Distribution Channel

The third element of BMO, the *Distribution Channel*, describes how a company delivers its value proposition to the Target Customers, whether it is directly by itself (e.g. through sales force or over the internet) or indirectly, for example, through intermediaries. As explained by Osterwalder [Osterwalder04], its purpose is to deliver the right amount of products/services to the right people at the right time. He further breaks down distribution channels into a sub-element *Link* that illustrates specific marketing tasks employed by a company to deliver its value proposition to its customers. The *Link* sub-element potentially describes the parts of a distribution channel by looking at them from different aspects, for example, how the usage of web impacts on reaching their customers or what specific functions at various stages of the customer buying cycle are fulfilled by channel links? Moreover, the *Link* sub-element inherits attributes from the *Offering* sub-element of the Value Proposition.

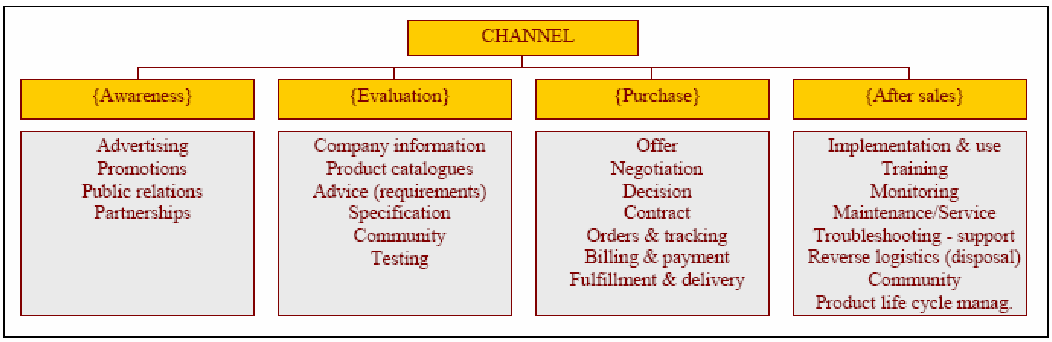

Figure 1: Channel functions and Customer Buying Cycle adapted from [Osterwalder04].

Relationship

The Relationship element refers to a relationship that a company builds with its customers. It is most important for a company to have a strong customer base in order to be able to survive in a competitive market. For that, managing existing relationships and building new relationships is essential. The relationship building comes at a high cost and therefore a company must carefully define the ways to do it. The BMO classifies customer relationship based on customer equity goals of a company: i.e., acquiring, retention and add-on selling. The idea behind this classification is to treat the customer as a company's asset and to emphasise that they have to be maximally utilised like any other asset. As he describes, this analysis would help companies to optimise the acquisition, retention and selling additional products to their customers and to increase its value for the company throughout its lifetime. To attract and keep customers, a company must highlight the different features it has over its competitors, both of products and of delivering these products or services to the customers.

Osterwalder [Osterwalder04] decomposes the Relationship element to a sub-element Mechanism to describe the specific actions that a company takes to build a relationship with its customers. These actions include personalisation of actions, establishing trust, and strategies of promoting the brand name.

The personalisation represents building a one-to-one relationship with customers. This can be done in several ways like tailoring the marketing activities to a specific customer or to customer segments, for example, personalised product recommendations.

The trust issue deals with the establishment of trust between a buyer and a seller. For example, a company could use a third party to establish the trust between them and the customers, they could also use customer comments to increase the trust upon them.

Furthermore, as Osterwalder explains, the brand could also play a pivotal role to attract customers. A popular and trustworthy brand name would be an excellent way to attract and retain customers.

Infrastructure Management

This is the third pillar of the BMO. It is concerned with how a company creates value and what abilities they should have in order to create and deliver value for customers. It consists of three main concepts: Capability; Value Configuration; and Partnership, which are discussed in detail below.

Capability

Capability represents the ability for a repeatable use of a company's assets to create and offer their products and services to the market [Osterwalder04]. The Capability in BMO is defined based on the resources and the partnerships that a company has. Since the resources are scarce, frequently capabilities are outsourced to partners. As Osterwalder explains, the use of e-business technologies enables a firm to have a tight integration between outsourced capabilities for them to function properly.

BMO decomposes the capability element down to Resource and Actor sub- elements. A Resource is an input to the value creation process of a company. As previously stated, the resources act as a source of a company's capabilities. They can be tangible like equipment, intangible like brand names of a company, or human resources like a skilled labour force.

An Actor in BMO is an outside organisation. More precisely, it is meant for company's trading partners and is not equivalent to the Target Customers. The company, together with its partners, offers products or services to the target customers.

Value Configuration

The sixth element of the BMO, the Value Configuration, shows all the activities necessary for the creation of value and the relationships among them. It represents all the activities, both inside and outside. The value configuration in BMO extends the Porter value chain [Porter85] by two other types: value shop and value network, based on some other researches in the area. The value chain describes the activities of a company that aims at providing low-cost or differentiated products [Osterwader04]. It includes the main activities: inbound logistics; operations; outbound logistics; marketing and sales; and service in the value-chain framework of Porter [Porter85]. Osterwalder [Osterwalder04] states that service provisioning has a different value creation logic as service providers aiming at providing new solutions rather than reproducing a fixed solution. The value network aims at linking customers rather than concentrating transfer of logistics between them. It represents the configurations related to a company's role as an intermediary.

In relation with the Value Configuration element, the BMO also defines the Activity sub-element. An Activity in BMO is defined as actions that a company performs to carry out its business tasks [Osterwalder04]. It distinguishes primary and supportive activities based on the value-chain framework by Porter [Porter85]. Further to that, it describes several types of primary activities belonging to configuration types: value chain; value shop; and value network.

The primary activities of the value chain include primary activities: Inbound logistics; Operations; Outbound logistics; Marketing and sales; and Service, proposed by Porter [Porter85]. The primary activities of a value shop are Problem finding and acquisition, Problem solving, Choice, Execution, and Control and evaluation. These activities describe the activities ranging from understanding a problem to be solved, finding alterative solutions, evaluating them and choosing among them up to implementing a solution and measuring its successfulness to solve the problem [Osterwalder04]. The primary activities of the value network are Network promotion and contract management, service provisioning and Network infrastructure operations. They describe the activities associated with selecting and inviting customers to join the business network, managing contracts related to a mediation, establishing, marinating and terminating links between them and keeping the network on alert to serve customer requests.

The Activity sub-element further shows how it relates to one or more Resource elements using fit, flow and shared relationships. These relationships are defined based on how many activities and resources are related to eachother.

Partnership

Partnership is defined as a voluntarily initiated cooperative agreement between several companies to jointly create value for the customers by coordinating their core competencies [Osterwalder04]. It describes the configuration of activities between a company and its partners and the distribution of resources between them.

In order to work partnerships properly, the terms and conditions for working together must be clearly defined. For that, BMO defines an Agreement sub-element which aims at explaining the motivation behind a partnership and the conditions under which the parties will cooperate with eachother [Osterwalder04].

It explains the motivation from several aspects: establishing partnerships to get access to infrastructure facilities, to expand the business operations, to reduce risks and to get access to resources like knowledge, data, etc. Furthermore, an agreement describes the importance of partnering with another, the degree of competition between them and how close they are linked together [Osterwalder04].

2.1.2 Example

Figure 2 below presents the running example modelled using BMO from Gordijin [Gordijin05]. However we limit ourselves to show the concepts related to the three pillars: Infrastructure management; Product; and Customer Interface in BMO. The reason behind this is that in our analysis of BMO, we have limited it only to these three pillars.

In the following figure, the value proposition represents what SENA offers to its customers. It delivers these offerings through the distribution channels: artists' acquisition department and rights clearing department. SENA reaches its target customers through specific relationship mechanisms as shown in the figure. Partnerships show SENA's business partnerships that support carrying out its business activities whereas the Value Configuration shows what activities are there to support providing the Value Proposition. In the figure below, the Value Configuration shows two activities representing the collection and redistribution of rights and collection and redistribution of fees. To provide its Value Proposition SENA uses its ability to connect right owners and right users

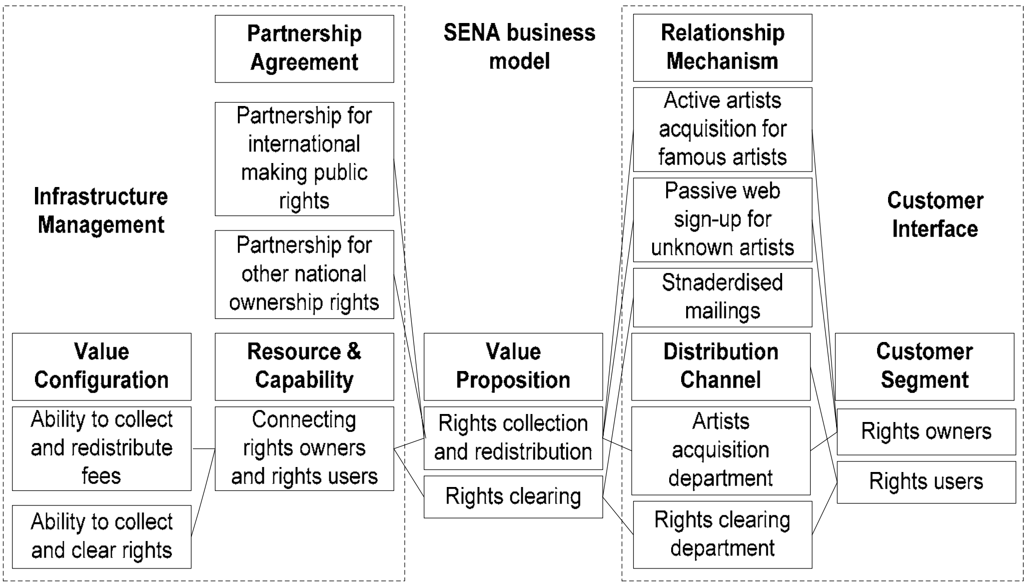

Figure 2: BMO model for the clearing rights case [Gordijin05].

2.2 The *e^3-value* Ontology

The *e^3-value* Ontology proposed by Gordijin [Gordijin02] focuses on describing the things of value created, transferred and consumed between networks of business actors. The author argues that the main goal of the business modelling is to answer the question "*who* is offering *what* to *whom* and expects *what* in return." Moreover, he states that the central notion of any business model should be the concept of value and the main design decisions to be represented in a business model are:

- Who are the business actors?
- What offerings are there and who are the actors involved in these offerings?
- What are the elements of these offerings?
- What are the value-creating or value-adding activities to produce and consume these offerings?
- Who performs them?

To address the above concerns, Gordijin found a lack of support in the existing approaches such as the Value-chain approach proposed by Porter and Miller [Porter85] and also the Tapscott value-maps [Tapscott00]. The former approach focuses on showing the strategic relevant activities of an enterprise. It consists of a set of primary activities and a set of supporting activities through which firms can create value and have competitive advantage [Porter85]. The latter shows actors and exchange of goods, services, revenues, knowledge, and intangible benefits. Among these two approaches, the Tapscott value-webs are closer to the graphical representation of *e^3-value* business models. However it lacks a showing of economic reciprocity, one of the most important economic phenomena. Furthermore Gordijin [Gordijin02] explains that the Tapscott value-webs cannot express the value adding or creating activities performed by the actors, bundle of value objects and partnerships with other actors.

Motivated by these drawbacks in the approaches mentioned above, Gordijin [Gordijin02] proposes an ontology which he argues as satisfying the requirements of e-business modelling. It consists of three sub-view points: the global actor view; the detailed actor view; and the value activity view. The global actor view shows the value objects created by actors and the value objects consumed by them in the value creation process. It also shows what value objects actors exchange with eachother and what they expect in return. Figure 3 shows the concepts and their relationships of *e^3-value* ontology in the global actor view.

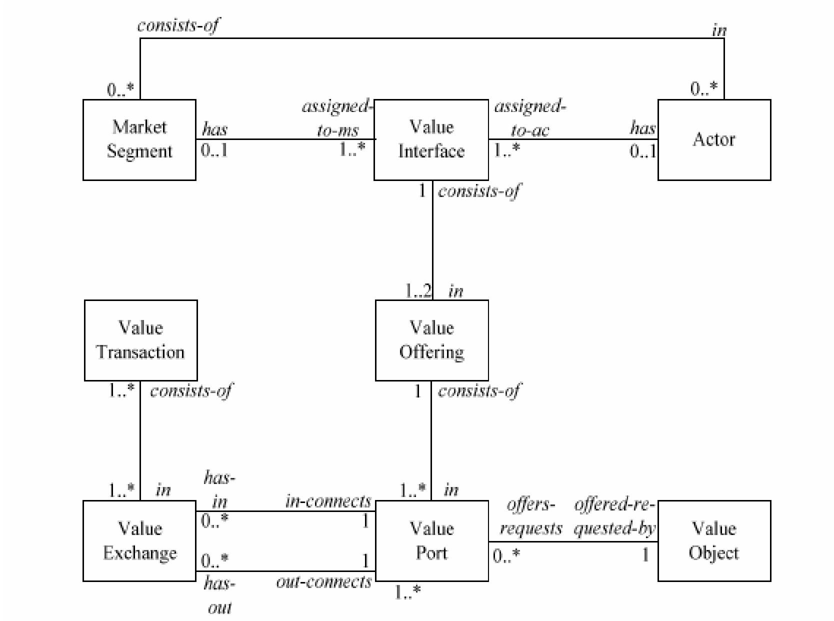

Figure 3: The global actor view adapted from [Gordijin02].

The detailed actor view provides the information such as value constellation and partnerships. It breaks down an actor identified in the global-actor view into more actors where ever it is applicable and shows the value that is offered by eachother. This means that in the global-actor view, one can represent a complex situation of having many actors unite together to provide a certain value object to its environment. In the detailed-actor view this composite actor is decomposed down to a set of actors showing the partnerships among them and what value objects are created and offered by them. To support this, they introduce two additional concepts: a composite actor and an elementary actor, both are related to an actor via a relationship. It should be noted that in the case of a composite actor, it is not the actors which are grouped but the value interfaces belonging to them. This is due to the fact that the customer may not see who provides what, in the case of a value object it is a bundled product and one may only see this bundled product. Figure 4 below shows the concepts and their relationships in this detailed actor view.

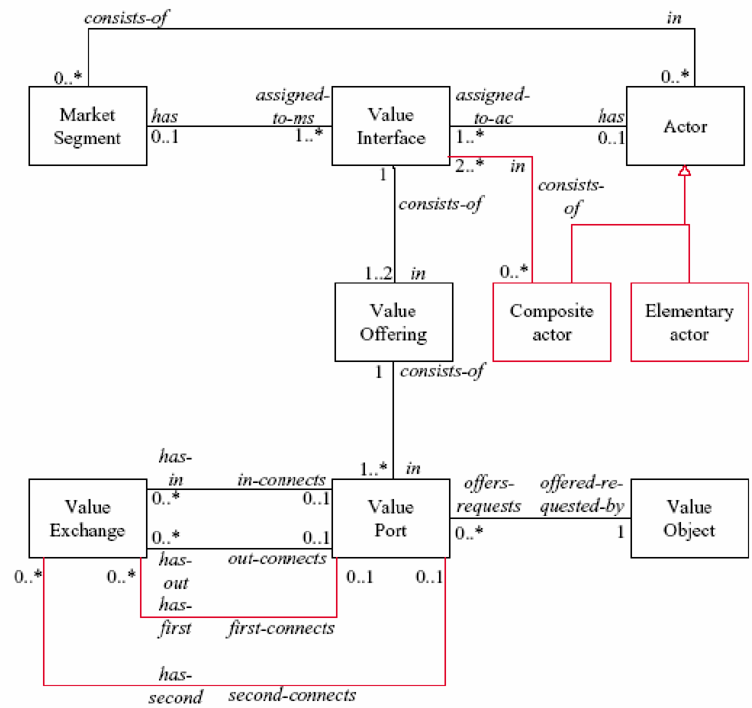

Figure 4: The detailed actor view adapted from [Gordijin02].

The value activity view represents the assignment of value activities of actors. The figure below shows the extension of e^3*-value* ontology to show the concepts and the relationships of this view.

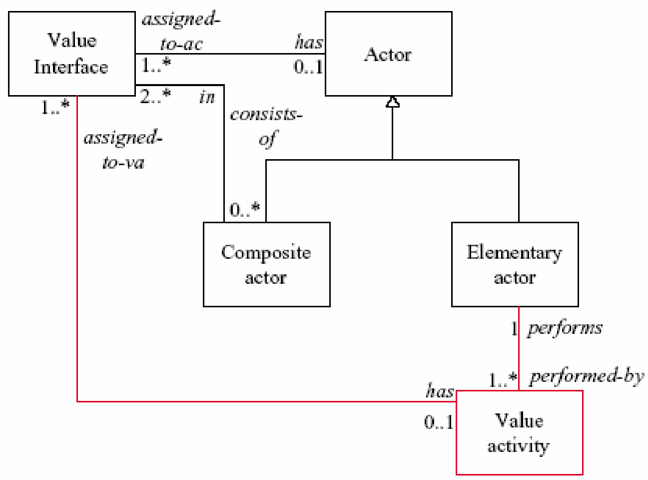

Figure 5: The value activity view and its relationships adapted from [Gordijin02].

The e^3*-value* ontology facilitates carrying out a profitability analysis of the business model created based on it and can be seen as an advantage of the approach. However it lacks a marketing perspective [Osterwalder04].

In the following section we will briefly explain principal concepts in the *e^3-value* ontology.

2.2.1 The Principal Concepts in the *e^3-value* Ontology

The *e^3-value* ontology uses various constructs, relations and constraints related to the three view points discussed in the above paragraphs to describe the transfer of value objects between actors and the value adding and creating activities carried out by them.

Actor

An actor in *e^3-value* represents an independent economic entity. Enterprises and customers are examples of actors.

Value Object

Value objects are the things of value transferred between the actors. They could be goods, services or even consumer experiences which are of value to at least one of the actors in a business model. Actors may value them according to their preferences.

Value port

The value ports facilitate the exchange of value objects between the actors. They indicate the preferences and the willingness of an actor to receive or provide a value object. A value port has a direction *in* or *out* which indicates inflow or outflow of a value object.

Value Interface

A value interface is used to group value ports. It shows the objects of value an actor is willing to exchange as compensation for another object through one of its value ports. A value interface must contain at least one value port but can have many ports. However, if one port of an interface is activated, then all other ports in it must also be activated in order to be able to exchange value objects through that interface. This means that all ports must exchange value objects or none at all. Furthermore a value interface has a valuation function which defines the valuation properties of value objects transferred via all its in and out value ports. An actor can have many value interfaces meaning that he/she offers many products/services to the environment. A value interface is attached to exactly one value activity.

Value Exchange

Value exchange represents the trade of value objects between the actors. Value exchanges occur between value ports of opposite directions. That is, from an out-port to an in-port, and therefore there should be at least one in-port and one out-port present in an exchange.

Value Offering

A value offering in *e^3-value* groups set of value ports in an interface having the same directions. A value interface contains at least one value offering.

Market Segment

A market segment in *e^3-value* is defined as a set of actors sharing the same valuation properties. Accordingly, the actors in a market segment shares at least one similar value interface since the valuation function is bound to a value interface. The value exchanges and offerings shown in a value interface of a market segment are the abstraction of real instances of exchanges and offerings of each individual actor in that market segment from/to other actors.

Value Activity

Value activity represents a collection of internal value creating the activities of an actor. The value activities of an actor should be able to perform economically independent from eachother and cannot be decomposed further down to smaller activities that can be assigned to different actors. An actor can have multiple value activities and a value activity is assigned to exactly one actor who can either be an atomic or composite one. It can have one or more value interfaces. The notion of value activity in *e^3-value* does not aim at describing the internal sequencing of activities. Rather, it focuses on abstracting the operational aspects and giving the overall picture of externally visible outcome of the created value through that activity.

2.2.2 Example

In this section we will illustrate *e^3-value* concepts described above using an example which is an abbreviated version of a music rights case presented in [Gordijin05].

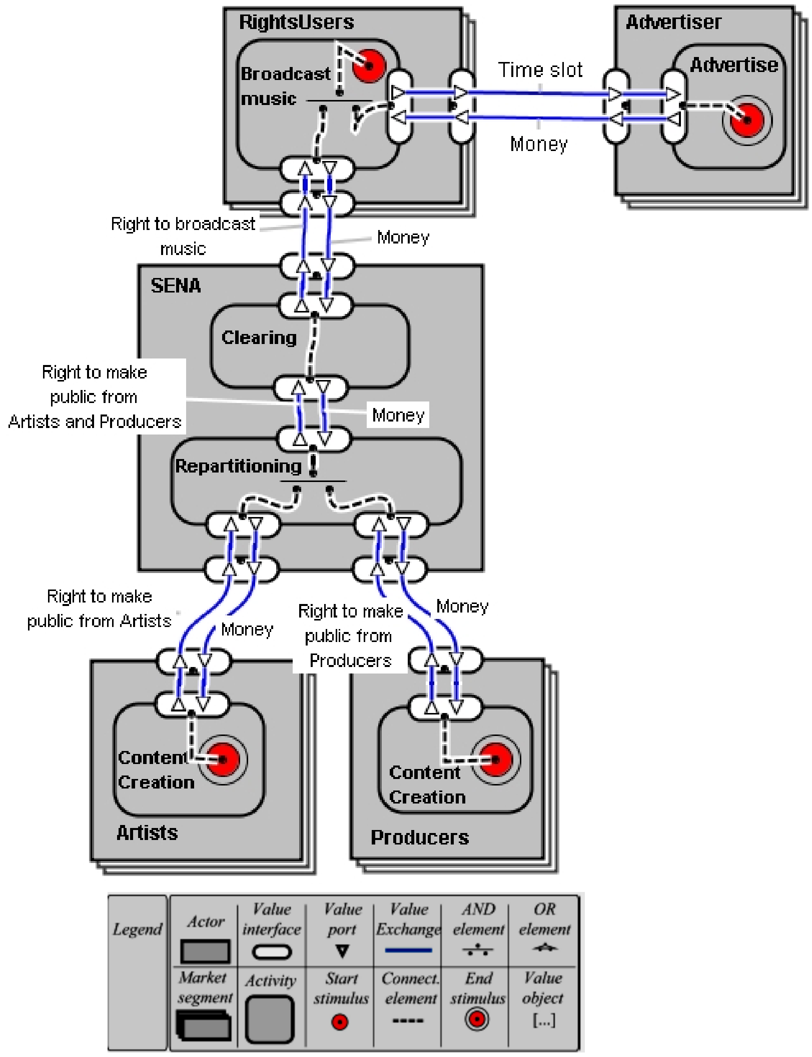

Figure 6: *e^3-value* model for a Music rights case adapted from [Gordijin05].

The above figure shows a shortened version *e^3-value* business model described in [Gordijin05]. We have omitted certain other actors in the clearing rights case described in [Gordijin05] for the simplicity of the model. The *Artists* and the *Producers* are rights owners who have rights on certain music tracks. The *RightsUsers* need to obtain rights to make a music track public in order to be able to broadcast it. The rights society which is called *SENA* clears the rights on a music track on behalf of *Artists* and

Producers. To do that they perform two value activities *Clearing* which represents collecting money from the *RightsUsers* and *Repartitioning* which represents paying the collected money to the *Artists* and *Producers*. The *RightsUsers* have the value activity *BroadcastMusic* to create the profit and by doing so they sell time slots to *Advertisers* to advertise their products and get money from them.

2.3 The Resource Events Agents (REA) Ontology

The Resource Events Agents (REA) ontology proposed by McCarthy in 1982 [McCarthy82] has its roots in accounting where every transaction is seen as either incrementing or decrementing resources. For example in a purchase, the buyer gives up money in order to receive goods. In this case while the amount of money that the buyer has is decreased, the amount of goods he has is increased. In recent years, REA ontology has been further developed to extend its usability e.g. [UMM02], [Geerts99] as a business modelling ontology.

The basic REA ontology model is depicted in Figure 7:

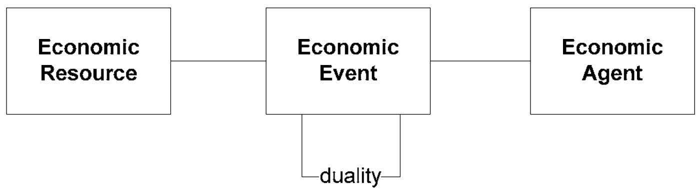

Figure 7: The basic REA Ontology.

REA classifies business activities around three main aspects of an exchange: the resources that are the subject of the exchange; the economic activities that transfer these resources; and the participating agents. To facilitate binding the main components of the ontology together, REA defines three rules [Geerts05]:

1. Axiom 1 – at least one inflow event and one outflow event exist for each economic resource;
2. Axiom 2 – all events effecting an outflow must be eventually paired in duality relationships with events effecting an inflow and vice-versa;
3. Axiom 3 – each exchange needs an instance of both the inside and the outside subsets.

These axioms aim at defining how to model the exchange of resources, how to couple reciprocal economic events and what agents should participate in an exchange of resources.

2.3.1 Principal Concepts in REA Ontology

The economic resources in REA are the things exchanged between the agents. They are scarce and are under control of an enterprise. Products, service, and labour are examples of resources.

Economic events facilitate the exchange of these resources between actors. REA defines two types of economic events: increment and decrement events. They mean that in order to receive a resource an agent must give up another resource where receiving a resource represents an increment event and giving up another resource as compensation represents a decrement event. For example, to receive products, a customer should give up the money he has. The connection between these two reciprocal economic events is an important economic primitive in REA and is defined as the *Duality* relationship.

Recent developments of REA [Geerts05] distinguish two types of events: transfers and transformations. The transfer events are related to transactions with external actors while transformations are the events related to value creation of an actor. Stock-flow relationships in REA describe the connection between the economic events and the economic resources. It differentiates among sets of stock-flow relationships related to transfer and transformation events. In case of transfer events, the stock-flow relationship takes values: *give* and *take*. For example the customers *give* up cash to *take* products. Possible stock-flow relationships between transformation events and the resources are: *use, consume and produce.* As McCarthy [Geerts05] describes, when a resource is used, it either ceases to exist or leaves its original form so as to be unrecognisable. Consuming a resource will make it gradually decrease its original form. In a transformation process a resource is either used or consumed to *produce* a resource.

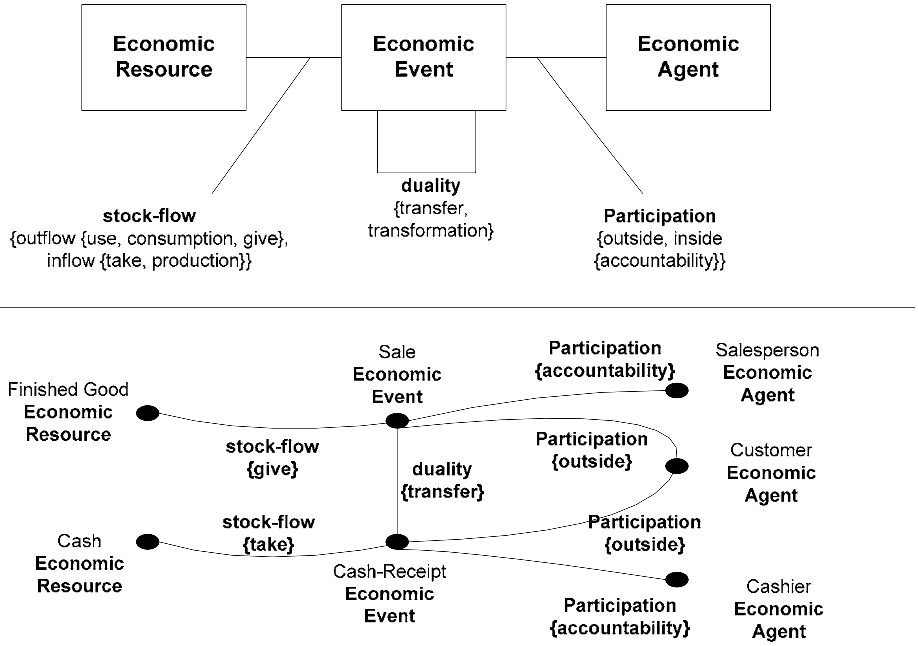

Figure 8: Economic event types and their respective relationships adapted from [Geerts05].

The economic commitments in REA represent the planned and scheduled events for a well-defined future. The actual economic events and their respective commitments are connected by *executes* relationship. Similar to the *duality* relationship between pair-wise actual economics events, REA also defines pair-wise requited commitments having the *reciprocal* relationship between them.

Economic agreement in REA bundles reciprocal commitments. REA [Geerts05] differentiates two types of agreements: contract and schedule based on the nature of the economic event. The transfer events execute *contracts* while the transformation events execute *schedules*.

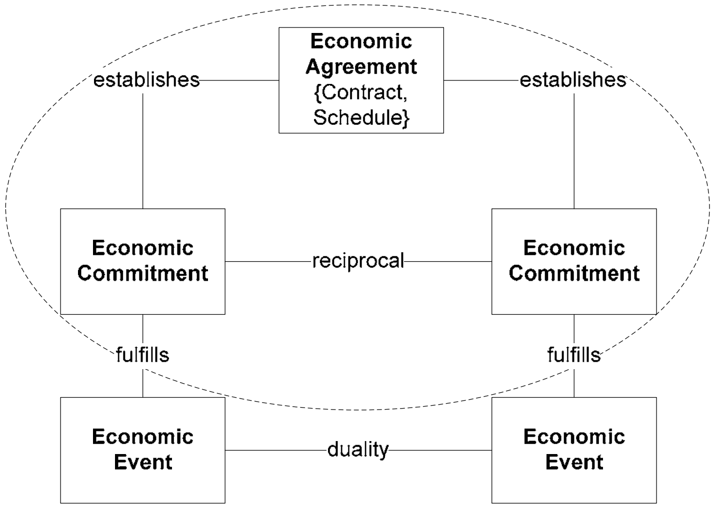

Figure 9: Economic commitment, agreement and event adapted from [Geerts05].

Typification in REA abstracts away an actual phenomenon and captures a description applicable to a group. This concept is important as if an actual phenomenon no longer exists, the abstract definition in the typification is preserved for future use. In REA these typification definitions are regarded as the components in the knowledge level while the actual phenomena are in the operational level. There are four main type images in REA. They are: Economic Resource Type; Commitment Type; Economic Event Type; and Economic Agent Type. A car is an example of a resource type which applies to a large number of actual cars at the operational level. An example for agent type is a market segment containing preferred customers. In addition to that there can also be typifications of certain other phenomena such as Economic Agreement, etc.

2.3.2 Example

The figure below shows the REA model for clearing music rights by *SENA*. *SENA* collects money from the *RightsUser* and clears music tracks for them to make it public. In the figure below, we only modelled resources, exchanges and the actors for simplicity. The model below should be viewed from *SENA*'s perspective. The economic events *Cash Receipt* and *Music Rights Sale* are increment and decrement economic events, respectively. The former event increases the resource *Cash* under the control of *SENA* whereas the latter event decreases the resource *Music Track Rights* as he gives it up in order to get *Cash*. It should be noted that the terms increment and decrement depends on the actor on focus of the model, in this case *SENA*.

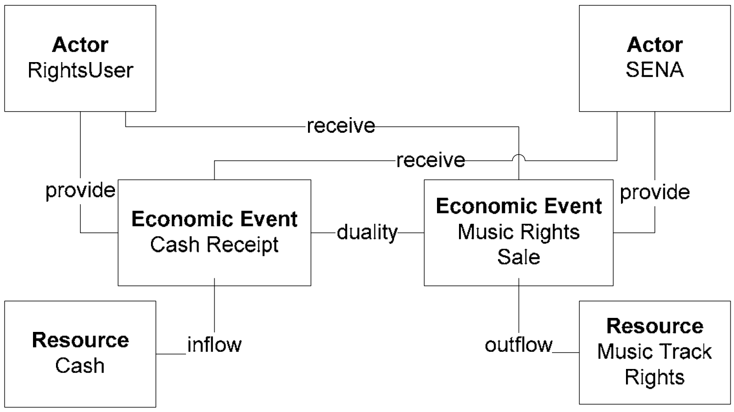

Figure 10: REA instantiation model for SENA music rights clearing process.

3 The Reference Ontology

This chapter explains the core concepts of the Reference Ontology and their relationships to eachother. As stated previously, one of the most basic requirements of ontology is the generic description shared by a community of users. However, we observe that there are different representations of the same business knowledge. This motivated us to analyse the three main business modelling ontologies and to propose an ontology consisting of a basic set of concepts that are agreeable to the three ontologies of our concern. To enhance its usability as a business-domain ontology, we also introduce additional concepts that are not part of the ontologies subject to our analysis.

Our effort in here is not to build an ontology which includes a large number of concepts in the business domain. The main goal of our research is to identify, analyse and compare basic notions of business models by constructing ontology based on three well-established business model ontologies: REA; BMO; and *e^3-value*.

3.1 The Ontological Foundation of the Reference Ontology

A prime objective of a business-modelling ontology is to conceptualise a basic economic phenomenon of what things of value are being created and offered by an enterprise to its customers. Towards this line we analysed both internal value-creating activities and external value-transferring activities of an actor to see the basic concepts needed to represent these activities in a business model. Moreover, in the proposed Reference Ontology, we pay special attention to analyse the things of value transferred between different actors.

The Reference Ontology separates its concepts to be at knowledge and operational levels. The operational level concepts represent the real-world objects, while the knowledge level describes abstract information structures used to characterise objects at the operational level. An advantage of having both levels is that it permits to hold abstract information structures even if the actual operational-level phenomena no longer exist. Also it helps constructing knowledge-level infrastructure for planning and control, a step above actual operational-level infrastructure [Geerts05].

In the proposed Reference Ontology, we introduced concepts to cover almost all the basic concepts in REA and *e^3-value* ontologies. The reason behind this is that both these ontologies focus on concepts describing activities of an enterprise related to the value creation and transfer them to its customers. However we omitted several concepts that are not directly related to transfer of value which is our prime concern in the Reference Ontology. For BMO, we left concepts: cost structure and revenue model from the financial aspects pillar as these concepts deviate analysis of transfer of values between the actors.

The Reference Ontology is created from an external perspective meaning that it shows the activities related to all the actors involved in a business model. The additional concepts introduced in the Reference Ontology have relationships to our previous and ongoing research activities.

3.2 The Reference Ontology Concepts

In the previous sections, we explained the conceptual foundation of the Reference Ontology. This section explains the concepts in the Reference Ontology. The concepts introduced and explained below have relationships to the concepts in BMO, *e^3-value* and REA. Also they have relationships to our previous research publications, mostly to [Andersson06a], [Andersson06b], [Weigand06a] and [Weigand06b].

Actor

An Actor is one who participates in economic events. An actor can be an organisation or an individual.

Resource, Feature and Right

A Resource is anything that has a value to an actor participating in an economic event. However, by resource in here we only mean the resources that are subjected to exchange between participating actors in an economic event. An actor may value a resource based on the ways he would be able to use it. For example, he may value it because it could be used to produce another resource. Typical examples of resources are goods and services. The value of a resource to an actor depends on his needs for that resource at a particular moment of time. For example when someone is thirsty and has limited access to water, he gives more value to a bottle of water than when he is not thirsty and/or has unlimited access to it.

The resources have properties and associations to other resources and we model them by means of the class *Feature* [Andersson06]. The *Weight* of a pizza, or the *mineral content* of bottled water, or *packaging* of a product, are all examples of features. A feature can also be a state of a resource like *existence* or *availability* that is changed through its production. As Hruby [Hruby06] explains, usually these features are changed as a result of some activity that may or may not be modelled at the application level. He further explains that Existence is the only feature that a resource must have. This is because the software applications do not contain real-world objects but information about real-world objects and hence keeping information about the resources that do not exist may be due to its consumption or destruction or may be for some other reason [Hruby06]. The features of a resource could carry a value itself, for example a green product that may have a value to interested parties. We will discuss these in the section describing competitive values later.

Rights serve as rules of interaction between people and hence they place constraints upon actions that can be performed on society [Wikipedia07b]. The concept of right is a much debated subject in the modern world. Nowadays we increasingly talk about rights of a variety forms: fundamental rights; human rights; intellectual rights; etc. However, in this analysis we limit ourselves to discussing the concept of rights in relation to economic resources in a business model.

In this section we describe several types of rights associated with a resource. An *Ownership* right defines a right associated with a resource owned by some actor. This means that an ownership right assures that an actor who posseses the ownership is entitled to use that resource in any way according to his will. He can determine whether to use it or not, whether to destroy the resource or not or whether to limit access to it for the others. In contrast the *Use* right does not grant an actor who posseses it to use the associated resource in any way he wishes. The owner of the resource puts constraints on things an actor who posseses that right can do with the resource. For example, when someone borrows a book from a library he is not entitled to destroy it or do anything that could damage the book. This situation is different from buying a book where the buyer gets the ownership right to the book. In that case he/she is entitled to do what ever he/she wishes to the book he bought.

Furthermore, there can be cases where more than one actor shares different ownership rights to a certain resource. For example, in the music rights case study presented in this thesis, we identify that artists and producers have different rights on the same resource: song. In such cases the right itself has a value to the actor who possesses it. However, we argue that it is meaningless to talk about the right alone as it carries a value because it is associated with some physical resource and without this associating resource we could not talk about any form of rights that they have. Therefore a right is always associated to a resource.

Based on the property rights theory, Gordijin and colleagues [Gordijin06] identify several types of rights associated with properties. As they explain, there can be other types of rights such as income rights, transfer rights or even copyrights, however it is not our intention to go into that much detail about the rights associated with a resource. It could be a topic for future research.

In some cases the rights transfer is explicit and may not be too important to specify. Having a right to a resource means the one who has the resource is entitled to use it in some way. Therefore associating rights to a resource has an advantage as one can define what things the receiving party is entitled to do with the resource after it is transferred to him.

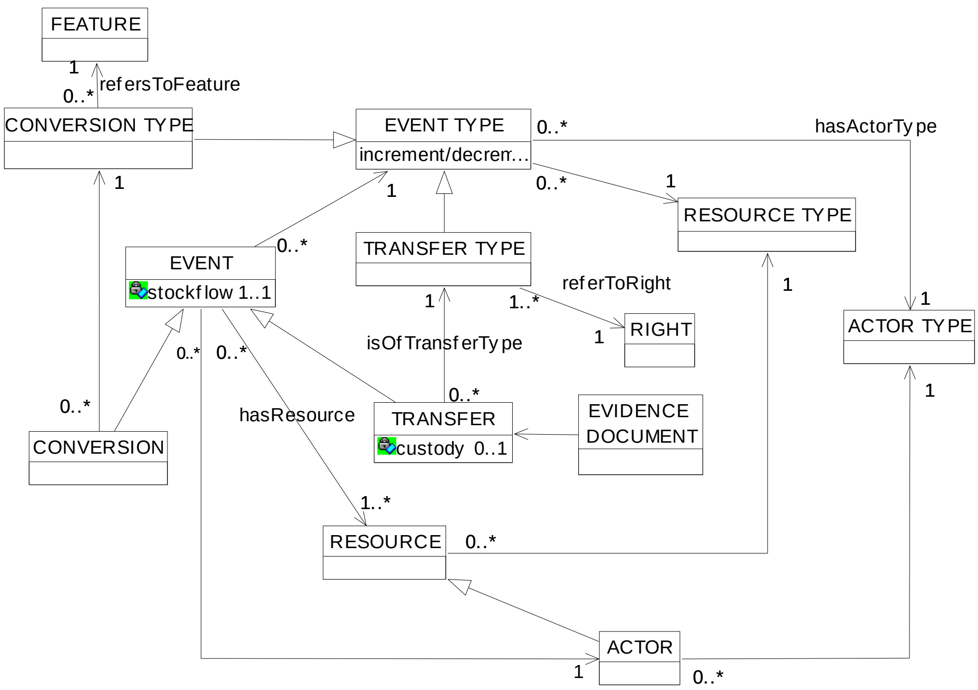

Figure 11: Resource, Feature and Right and their respective relationships.

Economic Event, Transfer and Conversion Processes

An Economic event in the Reference Ontology represents internal and external activities of an actor. They aim at producing resources and exchanging them with other business stakeholders. An economic event is either seen as an increment or decrement event depending on the perspective of the actor performing that event. In an increment event, an actor produces a more valuable resource or obtains some form of right (e.g. ownership) on a resource while a decrement event uses or consumes a resource (changes its features in a way that decreases its value to the actor involved in the decrement event) or gives away a right to a resource.

Transfer and conversion are two sub-classes of the event class. A Transfer event transfers objects of value between the trading parties. Every transfer that happens between two actors should include at least one or more of the following [Andersson06]:

1. Transfer of right;
2. Enabling access to the resource (transfer of custody);
3. Documentary evidence.

Transfer of right means that the provider gives away his right to a resource (in order to obtain the right to a different resource: e.g., money). In a resource transfer, the transfer of right is not enough and the buyer should be enabled access to the resource. Enabling access to a resource is very important as otherwise a buyer would not be able to exercise his right on it.

In a right transfer a customer may also be given documentary evidence. The documentary evidence is optional in a value transfer but could be useful in cases where there are post-actualisation activities such as damage distribution and/or cases where there is an assessment of partial fulfilment of commitments. It plays different roles in a value exchange [Gordijin06]. One is to use it as evidence of a right transfer and another is simply to use in obtaining the access to exercise the right. For example when one buys a movie ticket, the cinema transfers the right to see a movie to him/her. The movie ticket is the evidence that the buyer has the right to see a movie. Here, it plays the role of an evidence document for the right transfer. When a buyer wants to watch the movie, he hands over the ticket to the cinema and gets access to it. In this case he does not transfer anything new to the cinema but uses the ticket as an evidence document to obtain access to a movie.

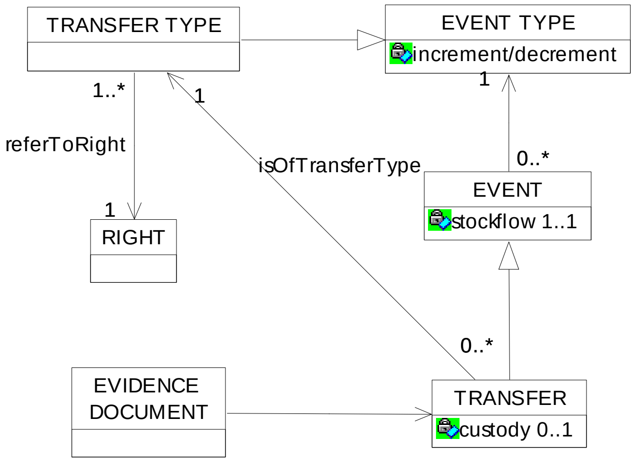

Figure 12: Transfer event and its relationships.

A conversion event in the Reference Ontology answers the following questions:

1. What are the activities carried out by an actor and with the use of what resources?
2. What resources are produced?
3. What features of the resources are changed?

Conversion events represent the activities internal to an actor. A conversion event takes one or more resources as inputs and produces a resource either by changing some features of the input resources or by consuming the input resource. If the conversion event produces a new resources or change of feature(s) of an input resource to increase its value, it is a *produce* event [Andersson06]. If the input resources cease to exist after the conversion event, it is a *consume* event and if they exist after the conversion event then it is a *use* event [Andersson06]. Among them, the produce event is an increment event and the use and consume events are decrement events. Obviously a produce event is an increment event since it produces some resource. In a use event a resource may exist even after the economic event but the value of it might be decreased during the conversion process or it may not be usable again. The consume event consumes a resource and hence it ceases to exist after the event. Therefore both use and consume events are decrement events.

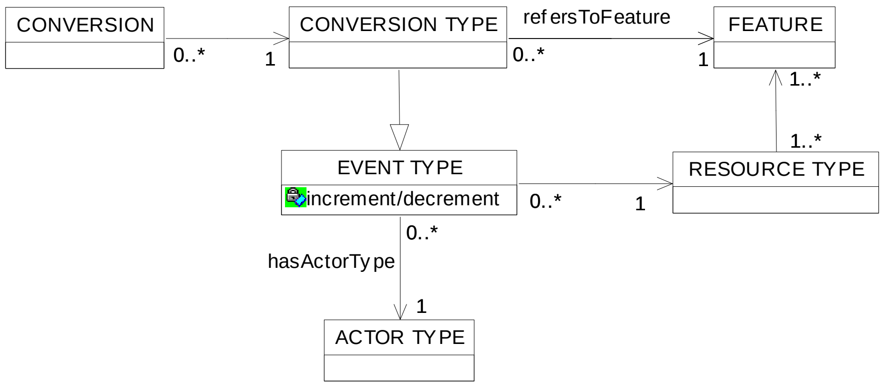

Figure 13: Conversion Event and its relations.

Process, Transformation, Interface, Exchange and Transaction

Process concept in the Reference Ontology group different increment and decrement event types related to eachother. That is, our scope of the *process* concept is limited to grouping different types of events associated with the different actors. It does not cover communication and temporal aspects as in the process modelling. The class process has several sub-classes representing groups of transfer and conversion event types, namely: Transformation; Interface; Exchange; and Transaction.

A *Transformation* process groups different conversion event types belonging to the same actor type. It groups all decrement and increment conversion event types in a certain value creation process of the same actor type. In a transformation process an actor takes a resource as an input and either uses or consumes it to produce a new resource. The goal of grouping such conversion event types is to show the set of activities related to a value creation process of an actor. Therefore in the simplest case, a transformation process should contain one decrement conversion event type and one increment conversion event type. In general it could contain several decrement event types but could only contain one increment event type that is related to the production of a resource.

An *Interface* process either shows the possible collaborations of an actor type with its environment or possible collaborations between its value creation activities. It does this by collecting increment and decrement transfer event types related to a particular resource transfer of an actor type with another actor type and a particular resource transfer between transformation processes of an actor type. An interface process shows that an actor is willing to trade with its environment according to the increment and decrement transfer event types defined in that interface. It could also show the transfer types between two transformation processes of an actor.

Furthermore, an Interface process of an actor type shows the competitive values (if any) attached to it. These competitive values show the different features of transfer types and also transfer types related to complementary resources offered together with core resources and differentiate an actor type from its competitors. We discuss competitive values later. An interface process also enables hiding complex internal activities of an actor by only showing what resources he is willing to offer in return for what and hiding how these resources are created. Finally, an actor can have several interface processes depending on how many transformation processes he has.

An *Exchange* process consists of a pair of increment and decrement transfer types associated with two different actor types. It represents exactly one value transfer between two actors. This concept has the advantage of showing which transfer types belonging to different actors are related to eachother in a value transfer between them.

Transaction process groups number related exchange processes, i.e. they consist of a set of pairs of one increment transfer type related to a give transfer event and one decrement transfer type related to a take transfer event between two actor types. More precisely, it groups different transfer types in interfaces of two actor types that are related to eachother via exchange processes. Thus, a Transaction process in the Reference Ontology represents an important concept: economic reciprocity between two actor types.

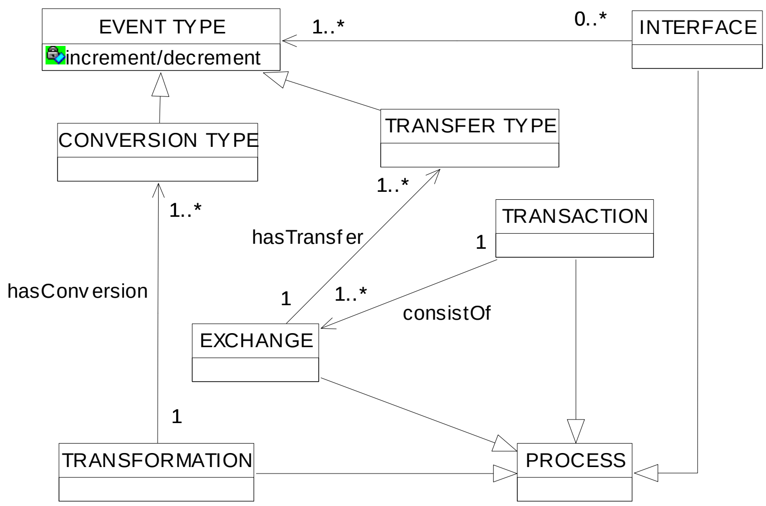

Figure 14: Transformation, Exchange, Interface, Transaction and their respective relationships.

Commitment, Contract, Agreement and Schedule

In the Reference Ontology, we define a Commitment as an obligation to carry out a give Transfer Event in the future. Hruby [Hruby06] explains the use of commitments as a way of solving promises about the future economic events. He further explains that economic events cannot be used for this purpose as they hold information about actual increments and decrements of resources and that there may be differences between what is planned for the future and what actually happens. Therefore to hold information about promises and about future transfer types and scheduled conversion types such as what a company is willing to provide and what it expects in return and what conversion activities are scheduled to take place, and what resources they might need, we use the class commitment in the Reference Ontology.

A Contract is defined as a collection of Commitments. It specifies what should happen in the case of partial fulfillment of commitments [Hruby06]. It also provides the actors with a way to agree upon the actions to take about unfulfilled commitments in advance. Hruby further argues that this information may be vital for the application developers to keep track of things that should happen in such cases of partial fulfillment of commitments.

In the Reference Ontology, we define an agreement as a concept in the knowledge level that contains information about contracts. Furthermore, an agreement in the Reference Ontology describes the motivation and functions of the agreement.

Reference Ontology uses Schedule to hold information about conversion events planned for the future. Similar to [Hruby06], it also holds information related to future conversion events that may be important to mitigate the consequences in case it fails to happen.

Value Proposition

A Value Proposition specifies a resource type, its special features and how it could be used to produce or improve another resource. That is, on the one hand it specifies the resource type offered by a firm and on the other hand it specifies why someone should be interested in buying it by highlighting how it could be used to meet customer needs. It does this by relating features of the resource, such as the freshness or nutritional content of a pizza to it or arguing how a resource could be used to produce or improve other resources, for example, with a kitchen machine it would be that it could be used to produce freshly squeezed orange juice [Andersson06].

Competitive Values

Competitive analysis plays a key role in distinguishing an actor from its competitors. In order to gain competitive advantage it is important to develop a number of techniques that helps a firm to position itself uniquely from its competitors. A firm can highlight the price or quality of its products, its brand name, services or other products offered together with the core or primary resource in concern and how these products or services are offered, etc.

In the Reference Ontology, we analyse competitive values in two directions: one in the direction of how products and services are offered and the other in the direction of extra products or services offered together with the primary resource. We call the former Second Order Values and the latter Complementary Values. In the Reference Ontology the Competitive Values are defined as a collection of Second Order Values and Competitive Values.

Second Order Values define the properties of value transfers [Weigand06b]. Examples are: convenience; friendliness; and safety. These properties highlight the special features of the transfer types of an actor type. For example, a transfer type related to a payment exchange may highlight the *safety* of each payment exchange occurring through that transfer type.

Complementary Values include the things offered together with the core resource, for example, a toy with a Mac Happy meal (where the Mac Happy meal is the core resource and the toy being the complementary resource). By core resource, we mean the economic resource(s) in focus of the value proposition of an actor towards another actor. For example, in the case of the above example, the firms focus is in offering a Mac Happy meal to its customers and it uses the toy as a way to differentiate its product (Mac Happy meal) from its competitors and to attract customers. Complementary values can either be required or optional. Depending on its necessity, they can be a part of the same interface process with the core resource or a part of a separate interface process. If it is a part of the same interface process, it is required to be offered together with the core resource or else as an optional. As it is described in [Weigand06b], these complementary objects can be tangible or intangible, like for example a brand name which increases the status of the user of that object. The aim of introducing complementary values in the Reference Ontology follows the fact that it enables an actor to mark his position among his competitors by distinguishing the differences between him/her and them.

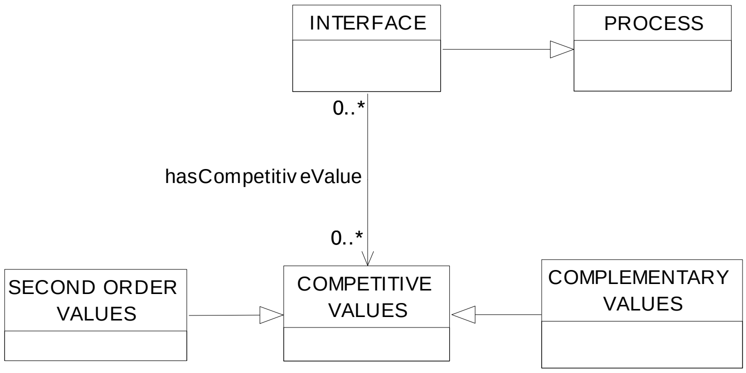

Figure 15: Competitive Values and its relationships.

3.3 Example

Figure 16 illustrates the process concept and its relation to transfer events in the Reference Ontology. It shows two transfer types of the RightsSociety related to rights and money transfers between it and artists. Also, it shows two transfer types of artists related to selling their music rights to the RightsSociety. The rectangles with dotted lines represent the interface and transaction processes of these two actors. The top most rectangle, with a dotted border, represents an interface process of the RightsSociety while the bottom most one shows an interface process of artists. The two transfer types related to selling music rights (*SellRights*) and buying music rights (*GetRights*) of artists and the RightsSociety are grouped by means of an exchange process. The other exchange process consists of two transfer types related to exchange of money between these two actor types. The rectangle with a dotted border in the middle shows the transaction process that groups these two exchange processes.

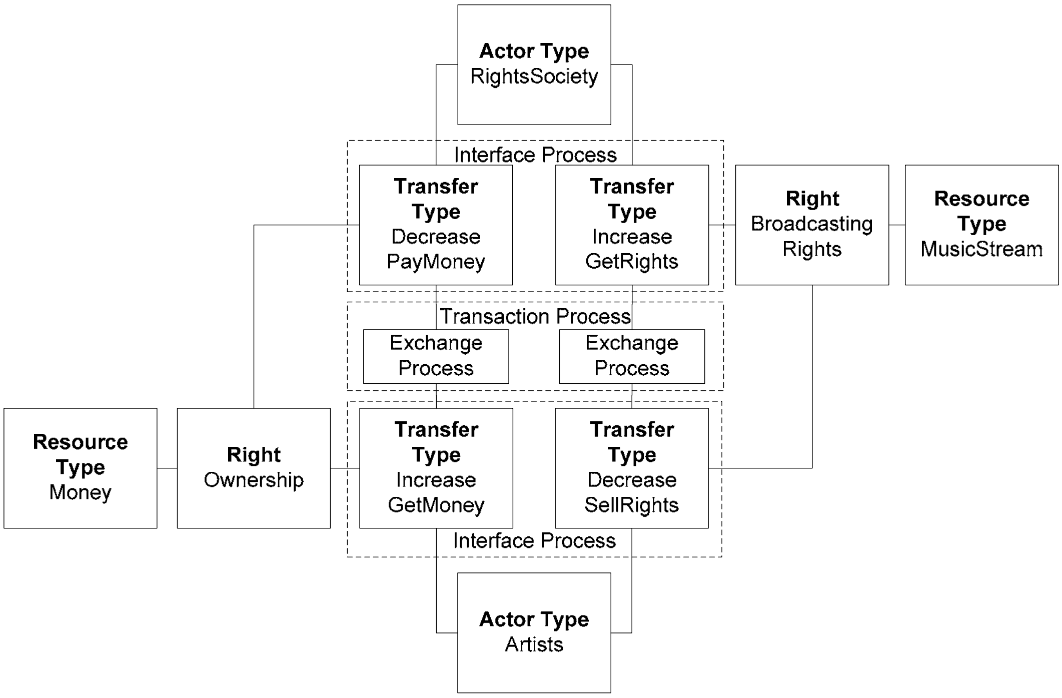

Figure 16: Interface, Transaction and Exchange Processes of Artists and RightsSociety.

As explained in the above paragraph, Figure 16 contains both value exchanges from artists to the rights society as well as from rights society to artists.

1. Rights are sold by artists. This is represented by *SellRights*, which is a decrement Transfer Type.
2. Rights are received by the RightsSociety. This is represented by *GetRights*, which is an increment Transfer Type.
3. Note that what is transferred is not money, but a right on money, in this case ownership of money.
4. The two Transfer Types here are related in one Exchange (Process).

In the figure below, we further illustrate the concept: transformation process using the music rights example. Here, we focus our attention to the transfer types and conversion types belonging to the Advertiser. The Advertiser buys a time slot from RightsUsers to advertise its products. From one point of view, the advertiser gets a time slot from RightsUsers. However, one can also argue that he gets the audience from the RightsUsers (for example, a radio station) when he advertises with them. Since both these views are reasonable, how can they be reconciled? In the Reference Ontology we make a distinction between the resource transfers between the advertiser and the RightsUsers and how these transferred resources are used.

1. The Advertiser gets a time slot. More precisely, he/she gets the right to use the timeslot by filling it with its advertising material.
2. The Advertiser uses the timeslot in order to get an audience. More precisely, he uses it to create awareness for its product(s).

There is a two-stage process here. First, the advertiser gets a right on the time slot, and then he uses it.

In the figure below, we use the Reference Ontology to model this situation.

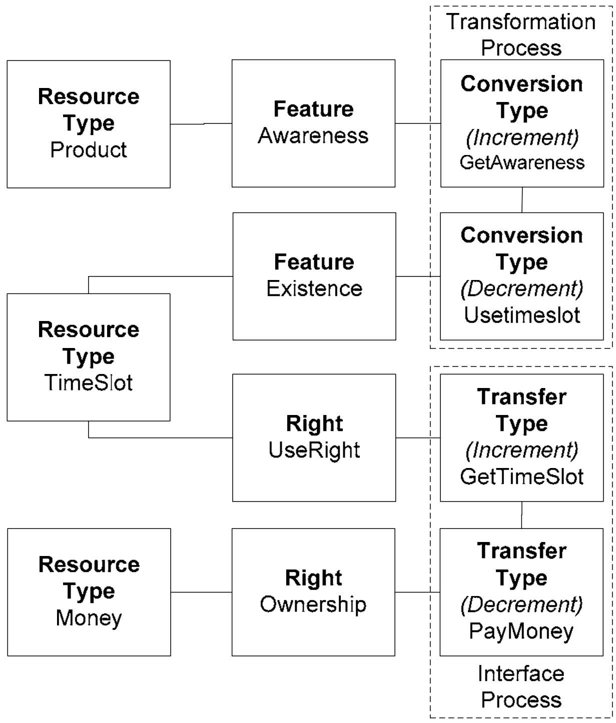

Figure 17: Conversion and Transfer types and of the Advertiser.

The bottom most boxes show the decrement transfer event type *PayMoney*, related to the payment made by the Advertiser to the RightsUser. This decrement transfer type is then related to an increment transfer type *GetTimeSlot* where the Advertiser gets the right to use the time slot. The two conversion event types shown in the figure: *UseTimeSlot* and *GetAwareness* are related to the consumption of the time slot and getting the product awareness. The decrement conversion type consumes the time slot and advertises the products. As a result, the time slot ceases to exist. Therefore it changes the feature *Existence* attached to the resource time slot. The increment conversion event followed by this decrement conversion event changes the feature *Awareness* attached to the resource product.

The two conversion events are related to eachother by means of a transformation process while the two transfer events occur within an exchange process. Both the transformation and exchange processes are shown by dotted rectangles in the figure.

4 Mapping BMO, *e^3-value*, REA Concepts to the Reference Ontology

In this chapter, we present a set of high-level mappings between the concepts in BMO, *e^3-value* and REA and the Reference Ontology. The mappings proposed in the following sections do not indicate that the concepts in two ontologies related by them are identical to eachother, but only provide a basis for a realisation of them. This means that in the level of realisation of a certain mapping in the following, there might be relationships to other concepts that are not shown below. That is, in the following mappings we have only considered which concept in ontology "x" is related to which concept in ontology "y" but not what other relationships that the concept in ontology "x" might have. For example, in the realisation of mapping between the Value Exchange in *e^3-value* and the Exchange Process in the Reference Ontology, we might need to add more details such as transfer types, actor types, etc., to the Exchange Process to complete the realisation depending on the relationships that an actual instance of Value Exchange in *e^3-value* input has.

4.1 Mapping BMO to the Reference Ontology

The table below tabulates a set of BMO concepts and their corresponding concepts in the Reference Ontology. In the following analysis, we limit our scope to the concepts in BMO related to product, customer interface, and infrastructure management and we leave the concepts related to the financial aspects.

BMO	Reference Ontology
Target Customer	Actor Type (1)
Distribution Channel	Actor and Transformation process (2)
Relationship	Combination between Interface and Competitive Value(3)
Value Proposition	Value proposition (4)
Agreement	Agreement (5)
Actor	Actor OR Actor Type (1)
Activity	Set of conversion and transfer events (6)
Value Configuration	Process (7)
Resource	Resource
Capability	Resource Type and Transformation Type(8)
Partnership	Set of Agreement and Actor Type(9)

Table 3: BMO concepts and corresponding Reference Ontology concepts.

(1) The Business Modeling Ontology (BMO) views an actor from an internal perspective meaning that it is designed from one actor's view point by making this actor implicit. Therefore an Actor in BMO represents all except the one for whom the ontology is designed. In contrast, the Reference Ontology views an actor from an external perspective by making it represent all the actors including the one from whose perspective the ontology is designed. The class Target Customer in BMO represents a group of customers that the modelling agent (implicit) intends to address and is on the knowledge level. Hence we would map it to the class Actor Type in the Reference Ontology. However, there is a difference in these two concepts. Due to the perspective differences explained at the beginning of this paragraph, the Actor Type in the Reference Ontology also includes the modelling agent, whereas the Target Customer in the BMO includes all outside customers of the modelling agent and not the modelling agent itself.

The class Actor in the BMO represents an outside organisation that is included in the firm's business model. This we understood as being a concept defined on the operational level. Hence we map it on to the class Actor in the Reference Ontology.

(2) The Distribution Channel in the BMO describes how a company delivers its products or services to Target Customers, directly by itself or through another trading partner. BMO breaks these channels further down to accommodate more technical level details about the activities,

actors and resources used to reach customers. In the Reference Ontology there is no direct candidate to map it on. However, we map it to an Actor Type and Transformation process. An Actor Type specifies the actor involved in reaching the customers and the Transformation type specifies associated resource types and activities to reach the customers.

In the music rights case, we identify two distribution channels for the RightsSociety SENA to deliver its value proposition. They are the artist acquisition department and the rights clearing department. Both these belong to the RightsSociety SENA. If we need to go further down to see what activities these departments do, we may identify them as belonging to two Transformation processes: rights collection that takes care of artist acquisition/obtaining rights and making payment and rights distribution which deals with redistribution of rights and collecting payments. The activities inside these Transformation processes such as artist acquisition/obtaining rights etc., specify the particular resources they deal with, for example, in the case of artist acquisition uses web sign-up, the *web site*, could be a resource.

(3) In BMO, the Relationship concerns the relationship that a company builds with its customers. As they describe, the interactions with customers come at a given cost and therefore a firm must carefully define how it builds and maintains its relationships with (which) customers. This means that they have to define how to build and retain a relationship with their customers. Relationship-building may be done by offering additional products, services that are interrelated or not with their core products or services offered to the customers. This can be thought of as describing what things of value are offered (or used) to attract and retain the customers. Though we do not have a direct candidate to map it onto the Reference Ontology, we relate it to the Interface processes and the Competitive Value in the Reference Ontology.

In this case the Interface process and Competitive Values together describe what things are offered in what ways to attract and retain the customers. For example, in the music rights case there are three relationship mechanisms which are: active artist acquisition for famous artists; passive web sign up for unknown artists; and standard mailings for rights redistribution. All these can be thought of as transfer types belonging to one or more interface processes which specify the ways that the rights users and artists/producers collaborate with the RightsSociety SENA. The Competitive Values attached to an Interface process highlights certain properties of these transfer types to attract customers. For example web sign-up provides a convenient way to connect to the RightsSociety SENA.

(4) The Value Proposition in BMO describes how a company packages its products and services as well as other complementary objects of value and offers them to its customers to fulfill their needs. It provides an overall view of a company's bundle of products and services on offer to its Target Customers and also describes how these products and services differ from its competitors and why customers should be interested in buying them. The Value Proposition in the Reference Ontology also means the same and hence we map Value Proposition in the BMO to the Value Proposition in the Reference Ontology.

(5) In BMO, an Agreement specifies functions, terms and conditions of a partnership with the trading partners of a company. It describes the reasons for engaging partnerships with other companies, the strategic importance of them, such as how their business activities are relevant to eachother, what kind of competition there is between them and how closely they are linked together, for example, whether they are linked directly to eachother or linked through a third party.

An agreement in the Reference Ontology specifies the conditions agreed in advance with customers as well as trading partners of the modelling agent. Though the two concepts are not entirely similar to eachother they share similarities meaning that both are knowledge level concepts and an Agreement in the Reference Ontology corresponds to the negotiated terms and conditions with trading partners of a company in addition to that of its customers. Hence we map the Agreement in BMO to the Agreement in the Reference Ontology.

(6) An Activity in BMO is defined as actions performed by a company in its value creation, marketing and profit-generating process. It includes internal value creation activities of an actor as well as activities needed to transfer objects of value to its customers. In the Reference Ontology these aspects are managed by a set of conversion and transfer events. While the conversion events deal with activities related to a company's value creation process, the transfer events deal with exchanging them with its customers. Therefore we map the Activity in BMO to a set of conversion and transfer events in the Reference Ontology.

(7) The Value Configuration in BMO shows a set of activities of a company to create things of value that the customers are willing to pay for. It contains activities performed by the company itself and jointly with its trading partners, like for example, activities defined by the Porter Value Chain and also further extensions to it based on several

other research activities in that area. These extensions include activities with outside partners describing different service provisioning and also a company's involvement as an intermediary in linking various actors. By linking the inside and outside activities together, the Value Configuration describes how a company organises its value-creation process to meet customer needs.

The class Process in the Reference Ontology groups different activities that an actor performs in his/her value-creation process to meet its customer needs. The combination of Transformation, Interface, Exchange and Transaction in the Process describes how different conversion and transfer event types are arranged to create and deliver a company's products to its customers. They further specify the actors, activities performed by them and also the resources used by them. Therefore we map Value Configuration in the BMO to the class Process in the Reference Ontology.

(8) BMO defines the Capability as an ability to execute a repeatable pattern of actions. It describes whether a company has the ability to repeat its value-creation process to meet its customer needs. Repeatability of activities depends on the resources that a company has or the partnerships it holds with other companies capable of executing similar kinds of activities. The Reference Ontology has no immediate correspondent to the Capability in BMO. However it can be mapped to a combination of Resource Type and Transformation Type, concepts defined on the knowledge level. While the former describes the resources that a company has, the latter describes the types of internal activities of an actor to repeatedly create the things of value.

(9) The Partnership in BMO describes how several companies join together to provide a certain Value Proposition to customers by coordinating their capabilities towards achieving their common business goal(s). Hence the BMO Partnership is defined from provider perspective and not from a customer perspective. Therefore we can see this as an Agreement between certain actor types excluding the customers that it is aiming at providing a joint value proposition for. Hence we map the Partnership in BMO to a relationship between an Agreement and an Actor Type in the Reference Ontology.

4.2 Mapping e^3-*value* Ontology to the Reference Ontology

In this section, we present the proposed mappings between the principal concepts in e^3-*value* and the Reference Ontology.

e^3-value	Reference Ontology
Actor	Actor (1)
Market segment	Actor type (1)
Value object	Resource type and Right (2)
Value port	Transfer type (3)
Value exchange	Exchange (4)
Value offering	Set of Transfer types either all increment or decrement belonging to same Interface process(5)
Value interface	Interface (6)
Value activity	Transformation (7)
Value transaction	Transaction (8)

Table 4: e^3-*value* concepts and corresponding Reference Ontology concepts.

(1) An Actor in e^3-*value* is an independent economic entity involved in value exchanges. We map it to a similarly defined concept: an Actor in the Reference Ontology. A Market Segment in e^3-*value* is a collection of actors who share similar valuation properties. Since this segmentation is an abstraction for a number of actual actors who share similarities, we map it to the Actor type in the Reference Ontology.

(2) A value object in e^3-*value* is something that is valuable to at least one of the actors in a business model. It can be goods, service or a consumer experience. However in a value exchange between two or more business actors, it transfers not only resources but also some form of right on these resources. Since these rights can be of different forms, it may not be sufficient to mention the resource alone and may be important to highlight the rights transferred between agents. For example buying a car is different from renting a car. In the first case, the recipient gets an ownership right on the car, while in the second case, the recipient gets a time-limited use right on the car. Here we have two different value objects though there is only one Resource Type. Therefore, we map Value Object in e^3-*value* to the Resource Type and Right in the Reference Ontology.

(3) An actor in *e³-value* uses a Value Port to provide or request some Value Object. The direction of the value port, in or out, indicates whether an actor provides or requests, a value object respectively. In the Reference Ontology, increment and decrement Transfer types indicate whether an actor provides or receives a resource to or from other actors. Thus, a Value Port in *e³-value* is mapped to a Transfer Type in the Reference Ontology. The direction of the Value Port, in or out, is represented by means of the Transfer Type being an increment or decrement.

(4) A Value Exchange in *e³-value* represents the trade of value objects between pair of in and out Value Ports belonging to different actors or market segments. An Exchange process in the Reference Ontology represents the trade of resources between a pair of increment and decrement Transfer Event Types belonging to two different actors. Thus a Value Exchange in *e³-value* is mapped to an Exchange Process in the Reference Ontology.

(5) A Value Offering in *e³-value* is a set of Value Ports in an Interface with the same direction. It shows a bundle of the value objects provided or received by an actor. In the Reference Ontology, we map Transfer Event Types of increment and decrement with the value ports, out and in, to the *e³-value* Ontology. Thus, a Value Offering in *e³-value* is mapped to a set of Transfer Event Types belonging to the same interface process, that either all decrement or increment.

(6) In *e³-value*, a Value Interface groups individual value ports belonging to an Actor or a Market Segment. It is used to model economic reciprocity meaning that an Interface shows what Value Objects are offered and what is expected in return. It is also used to bundle Value Objects offered together to an actor, for example a product plus the delivery service. An Interface Process in the Reference Ontology group increment and decrement Transfer Event Types associated with the same actor type. It also shows is the things an actor offers and what he accepts as compensation for that. Therefore we map Value Interface in *e³-value* to the Interface Process in the Reference Ontology.

(7) A Value Activity in *e³-value* represents internal value-creating activities of an actor that produces value objects. They represent activities profitable to an actor. In the Reference Ontology, the Transformation Process collects several increment and decrement conversion types together to show the value-creating and value-adding activities of an actor that produces objects of value. Hence we map Value Activity in *e³-value* to the Transformation Process in the Reference Ontology.

(8) The Value Exchanges in *e^3-value* are performed according to semantics of a Value Interface. In a Value Interface, all ports should exchange value objects or none at all. As a result of these semantics, the value exchanges occur in combinations, for example, a fee and the goods represent such a combination. In *e^3-value* such a combination is defined as a Value Transaction. In the Reference Ontology a Transaction is defined as a process containing a set of related exchanges and represents economic reciprocity. These exchanges consist of transfer types of one interface of an actor and corresponding transfer types belonging to an interface of another actor. Therefore the Value Transaction in *e^3-value* is mapped to the Transaction in the Reference Ontology.

4.2 Mapping REA Ontology to the Reference Ontology

Our analysis of REA is based on UMM [UMM06] and Geerts [Geerts02]. This version of UMM [UMM06] does not explicitly distinguish between the notions of conversion and transfer described in [Hruby06] and only transfers of resources are modelled in UMM. However, recent developments in REA (e.g. [Geerts05]) discuss conversion and transfer events and many other adjustments to REA ontology. Below we list important REA concepts and their correspondences to the proposed Reference Ontology.

REA	**Reference Ontology**
Partner	Actor
Partner type	Actor type
Economic Event	Transfer Event of an Actor (1)
Economic Resource	Resource
Economic Event Type	Transfer Type of an Actor Type (2)
Economic Resource Type	Resource Type
Duality	Relationship between a pair of give and take Transfer Events of an Actor(3)
Economic Commitment	Commitment (4)
Economic Contract	Contract (5)
Agreement	Agreement (5)

Table 5: REA concepts and their corresponding Reference Ontology concepts.

(1) An Economic Event in REA represents a transfer of an Economic Resource from one agent to another. REA ontology looks at an event from the modelling actor's perspective. Geerts [Geerts02] describes an economic event in REA as:

> *"There is a transaction (an economic event) where an internal agent (an economic unit or agent) gives some thing of value (an economic resource) to an out side 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."*[Geerts02].

From the above it is obvious that an economic event (either increment or decrement) in REA represents an activity on the modelling actor's side related to a transfer of resource to the other actor (outside agent). The REA model in Figure 18 below models this situation from artist's perspective in the music rights case. Artists sell their music rights to the RightsSociety *SENA* and get cash in return. The events are two events as *music rights sale* (give) and *cash receipt* (take) in the figure represent the artist's view point.

In the Reference Ontology, we model things from a global actor's view meaning that a business model created includes events related to all the actors in the model. Transfers of resources on the operational level are represented by means of give and take Transfer Events in the Reference Ontology. Since REA models Events from a single actor perspective, we map it to Transfer Events belonging to an Actor in the Reference Ontology.

In addition to the transfer of a resource, a Transfer Event in the Reference Ontology models the transfer of right of the resource. However the REA Ontology does not model the right being transferred but only the Resource.

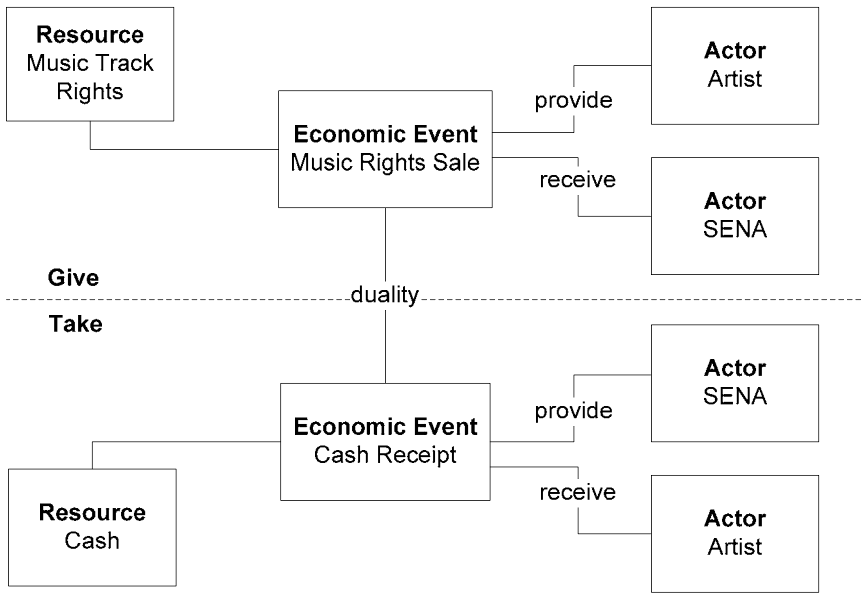

Figure 18: REA model for music rights case from an Artist's perspective.

(2) An Economic Event Type resides on the knowledge level in REA ontology. It links actual instance details to a more abstract level so that it provides information about past or future economic events. Economic Events in REA are mapped to the Transfer event of an actor in the Reference Ontology, and for the same reason, an Economic

Event Type in REA is mapped to a Transfer Type of an actor type in the Reference Ontology.

(3) In REA, a Duality relationship between two Economic Events means that one Event is carried out as compensation to the other.

> *"The connection between give events and take events is one of the central ideas of REA modeling, and it is called a* ***duality*** *relationship."* [Geerts97]

The above proves that the duality relationship in REA is a relationship between two economic events: give and take, of the modelling actor. Therefore we map it to a relationship between two Transfer events of an actor that corresponds to a *give* transfer and a *take* transfer where the *give* transfer signals the resource giving up and the *take* transfer shows that another resource receives in return.

(4) REA ontology defines an Economic Commitment as an obligation to perform an Economic Event in the future. An Economic Commitment is fulfilled by an Economic Event. Hence, an Economic Commitment in REA is mapped to a similarly defined concept: Commitment in the Reference Ontology.

(5) Economic Contract in REA is an aggregation of Economic Commitments and is a sub-type of an Economic Agreement. An Economic Agreement in REA does not characterise any specific economic contract. In the Reference Ontology, we have similar concepts defined in the same way. Therefore we map it to an Agreement in the Reference Ontology while the Economic Contract is mapped to a Contract.

5 Formalising Mappings between *e^3-value* Ontology and the Reference Ontology

This chapter describes the details related to the formalisation of the mappings between the *e^3-value* ontology and the Reference Ontology. As the concepts in the two ontologies are not identical to eachother, the mapping process essentially has two steps. In the first step, the *e^3-value* concepts are possible to directly map to the Reference Ontology concepts and are formalised. The second step interacts with the business modeller and gets the additional information required to completely define the Reference Ontology concepts and complete the mapping process. In the following sections, we present the details related to formalising the high-level mappings proposed in the previous chapter between *e^3-value* and the Reference Ontology.

5.1 Realisation of Mappings

The mapping process described below realises the mappings between *e^3-value* to Reference Ontology described in section 4.2. As described above this is a two-step process. In step one, the *e^3-value* concepts that have corresponding concepts in the Reference Ontology are directly mapped to eachother while in the second step the missing information about the additional concepts defined in the Reference Ontology attached to these mapped concepts is appended.

Figure 19 below illustrates the steps in the mapping process. The input in step one is the Resource Description Framework (RDF) version of the graphical representation of *e^3-value* business case described in section 2.3.2, which is generated by *e^3-value* modelling tool. We use a set of XQuery functions to extract information from this RDF input and generate an intermediate output in RDF/OWL (Web Ontology Language) format. This RDF/OWL intermediate output provides partially completed information related to concepts in the Reference Ontology and it lacks certain information related to the conversion types and transfer types of it. This missing information will then be furnished as a user input in RDF/OWL format. A set of Extensible Stylesheet Language Transformations (XSLT) template rules are then used to insert them into the intermediate output file to generate the final output as shown in step two in the figure.

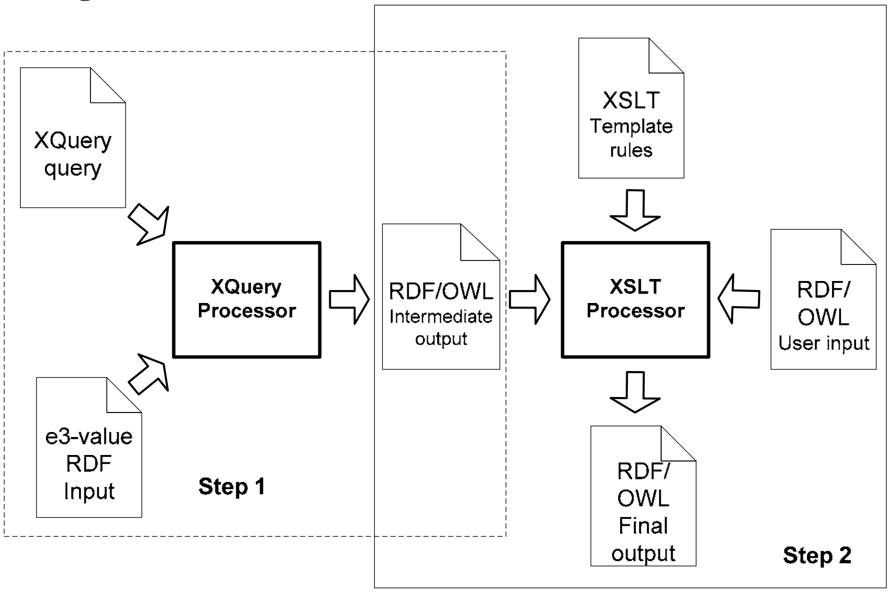

Figure 19: Two-step mapping process.

5.2 The XML Query Language - XQuery

Analogous to the use of Structured Query Language (SQL) for querying databases, XML Query Language (XQuery) is used to query Extensible Markup Language (XML) documents. XQuery is a platform-independent language that allows queries to be evaluated on any system with predictable results. It operates on the logical structure of the XML document which is known as the XQuery Data Model [Xquery06]. That is, in XQuery, every document is represented as a set of nodes which could be an element, document, attribute, name-space, etc.. XQuery uses path expressions to locate these nodes.

An XQuery query consists of an optional Prolog which can be used for declaring name spaces, functions, global variables, etc., and a query body. The prolog should appear before the query body. Figure below shows a simple XQuery query and different parts of it.

```
xquery version "1.0";
declare namespace rdf = "http://www.w3.org/1999/02/22-rdf-syntax-ns#";
declare namespace a = "http://www.cs.vu.nl/~gordijn/e3value#";

Declare function local:getTransferType () as xs:string {

(:function body goes here:)

};
```

Prolog

```
<transferType>{local:getTransferType ()}</transferType >
```

Query body

Figure 20: Simple XQuery query and different parts of it.

5.2.1 Use of XQuery over Programming Languages

The choice of XQuery over other languages has a couple of advantages. Its usage as a domain-specific language allows us to deal with domain concepts such as XML [Xquery06]. It further allows us to use simpler expressions in extracting information from XML documents. This means that if we were to use a general purpose programming language, it would have needed much more complex expressions to yield similar results. This leads to enhance the performance as well. There are other reasons for domain- specific languages to over perform the conventional programming languages. [Xquery06] describes them in three aspects. Firstly, the domain-specific languages are optimised for the tasks in a particular domain whereas general programming languages have to perform a wide range of tasks. Secondly these domain-specific languages such as XQuery allow queries to directly access the internal data structure. In contrast programming languages do not behave in this way and hide internal data structures from direct manipulation. Thirdly, programming languages usually require focusing on intermediate results as well, while languages such as XQuery focus on returning a correct final answer regardless of intermediate results. For example, it might be possible that XQuery looks in cache and benefits from the recent answer of the same query [Xquery06].

However it might be possible that depending on the implementation, a domain- specific language may perform more poorly than a programming language but it clearly has advantages over the latter.

5.3 Formalising Mappings using XQuery

As described in earlier sections, the formalisation of the proposed mappings between *e³-value* and the Reference Ontology is a lengthy one comprising two steps. Some of the transformations from RDF version of *e³-value* business model to OWL version of the Reference Ontology business model are very straightforward. However in certain cases like exchanges, transactions and transformations the formalisation process becomes a lengthy one. As a result the overall set of XQuery mappings in the first step became too large to be included in this dissertation. Here in this section we only present the details related to XQuery mappings between value exchanges and transactions in *e³-value* and the exchange and transaction process in the Reference Ontology.

5.3.1 Value Exchange in *e³-value* Ontology to Exchange Process in the Reference Ontology

As described in section 4.2 a value exchange in *e³-value* is mapped to an exchange process in the Reference Ontology. However, we highlight several points in relation to this mapping. In *e³-value* business model, a value exchange is used for three different purposes:

1. To represent transfer of resources between actors;
2. To represent transfer of resources between value activities;
3. To connect value ports of an interface in a value activity with value ports of an interface in an actor.

Figure 21 below depicts this situation. Numbers 1, 2 and 3, inside the circles, represent the above three bullets respectively.

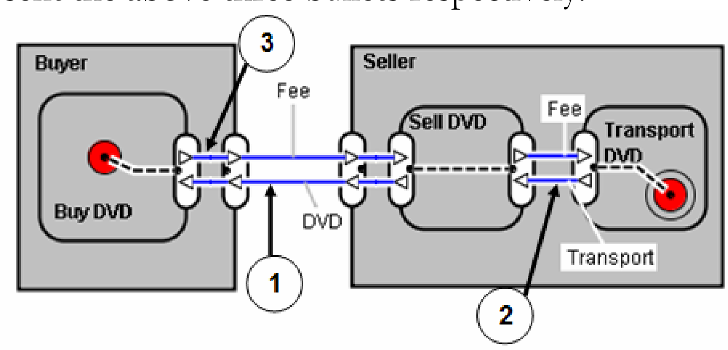

Figure 21: Different uses of the concept value exchange in *e³-value*.

Though *e³-value* uses the notion of value exchange in three different ways, only the first two signify transfer of value objects and the other is used as a way of connecting a value exchange between actors to a value activity of an actor. Therefore, in our transformation rules we overlooked them and only the first two are considered.

To map value exchanges in *e³-value* to the exchange process in the Reference Ontology, we used following algorithm:

```
let Rs be the source RDF
     for all instances of value_exchange in Rs do
     if does not belongs to 3rd category above then
          create an instance exchange process in RO
          for all value_ports in value_exchange do
            create one instance of increment or decrement
            transfer type in RO.
               for an actor possessing that value_port do
                 if actor is a market_segment then
                      create one instance actor type in RO
                 end if
      end if
```

In the mapping process, we use different XQuery functions to map value exchanges, value ports and actors in *e³-value* to exchange process, transfer types and actor types in the Reference Ontology. Below, we present these three functions:

```
declare function local:getRelatedActorType($i as xs:string,$p as
xs:string) as element()* {
let $docName := doc("musicRights.rdf"),
    $vi := $docName//a:value_interface,
    $ms := $docName//a:market_segment

for $vi1 in $vi//a:vi_consists_of_of return
 if (string($vi1/@rdf:resource) = $i) then
  for $ms1 in $ms return
   if($vi1/../a:vi_assigned_to_ms/@rdf:resource = $ms1/@rdf:about)
    then
     element{$p}{attribute
         rdf:resource{fn:concat("#",string($ms1/@a:e3_has_name))}}
    else()
  else()
};
```

The function above retrieves actors possessing a certain value port based on the relationship between a value port to and value interface and a value interface and an actor. We must recall that in *e³-value* value interface attached to an actor or a value activity and in the latter case value activity belongs to an actor.

```
declare function local:getExchangeRelatedValuePort($j as xs:string)
as element()* {
let $docName := doc("musicRights.rdf"),
    $ve := $docName//a:value_exchange,
    $vp := $docName//a:value_port

for $vp1 in $vp return
 if (exists($vp1/a:vp_out_connects_ve)) then
  for $vp2 in $vp return
   if (exists($vp2/a:vp_in_connects_ve)) then
    if (string($vp1/a:vp_out_connects_ve/@rdf:resource)=
        string($vp2/a:vp_in_connects_ve/@rdf:resource)) then
      for $ve1 in $ve return
       if (string($ve1/@a:e3_has_uid) = $j) then
        if (string($vp1/a:vp_out_connects_ve/@rdf:resource)=
                                   string($ve1/@rdf:about))then
           (for $k in ($vp1, $vp2) return
             element hasEventTypes {
              element TransferType {attribute rdf:about
                  {fn:concat("#TT",string($k/@a:e3_has_uid))},
                  local:getRelatedActorType
                  (string($k/a:vp_in_vo/@rdf:resource),
                                     "hasActorType"),
                 if (data($k/@a:vp_has_dir) = "true") then
                  (element isEventType {attribute rdf:datatype
                    {"http://www.w3.org/2001/XMLSchema#string"},
                                                  "decrement"})
                 else(element isEventType{attribute rdf:datatype
                    {"http://www.w3.org/2001/XMLSchema#string"},
                                                  "increment"})
                 }})
        else()
      else()
     else()
   else()
 else ()
};
```

The above function selects value ports based on its relationship to the value exchanges belonging to the first two categories described above. It then creates instances of transfer types of increment or decrement depending on the value port being in or out. Furthermore, it uses the function *getRelatedActorType* to retrieve the actors possessing these value ports and creates instances of actor type where ever applicable.

Finally, the following XQuery function traverses through all the value exchanges and retrieve exchanges related to first two categories mentioned at the beginning of this section and then uses function *getExchangeRelatedValuePort* above to complete the mapping.

```
declare function local:getExchangeTransferType($p as xs:string) as
element()* {
let $docName := doc("musicRights.rdf"),
    $ve := $docName//*[@a:e3_has_name]

for $ve1 at $j in $ve[position()<=last()] return
 if (string(node-name($ve1)) = "a:value_exchange") then
  if (not(exists($ve1/a:ve_has_second_vp))) then
   (element{$p}{attribute rdf:ID
    {fn:concat("E",data(remove($ve1/@a:e3_has_uid, $j)))},
     local:getExchangeRelatedValuePort(string($ve1/@a:e3_has_uid))}
    )
   else ()
  else()
};
```

5.3.2 Value Transaction in *e³-value* Ontology to Transaction Process in the Reference Ontology

Unlike value exchanges or value ports, the information about transaction is not directly available in the RDF version of *e³-value* business model. Therefore extracting such information about the transaction should be based on the value ports corresponding to value exchanges being on the same interface of an actor. Recall that the *e³-value* defines the value transaction as a set of related exchanges, for example right to make public and cash between the artists and SENA.

To get the information related to a transaction and map them to the transaction process in the Reference Ontology, we followed the following algorithm:

```
let Rs be the source RDF
for all instances of value_exchange in Rs do
  if value_exchangei does not belong to category 3 above
  then
    find two instances of value ports of value exchangei
      find two instances of value interfaces related to
      the above two value ports
       create an instance of Transaction process in RO
         for each instance of value exchange of one of
         the two interfaces above do
          create an instance of value exchange in RO
  end If
```

More precisely, first we searched for value exchanges of category one and two outlined at the beginning of this chapter and then collected the information related to the two value ports of such an exchange. This information is then used to retrieve the value interfaces that these value ports belong to. Finally we retrieved the information related to exchanges from value ports of one of these interfaces and completed the mapping.

The reason for retrieving information about value exchanges in two places is first to group value exchanges based on the value interfaces they belong to and then to create an instance of transaction process in the Reference Ontology. To our knowledge, XQuery 1.0 does not provide any functionality for grouping elements like in SQL. Therefore we had to rely on the relationship between value exchanges, value ports and value interfaces to get the related exchanges and group them under an instance of transaction in the Reference Ontology.

The above algorithm shows the main steps of retrieving this information and in the implementation we used several XQuery functions to do each of the tasks described there.

```
declare function local:getInterfaceOfPort($j as xs:string)as
xs:string*{
let $docName := doc("musicRights.rdf")
    $ve := $docName//a:value_exchange,
    $vp := $docName//a:value_port,
    $vi := $docName//a:value_interface,
    $vo := $docName//a:value_offering

for $vp1 in $vp return
if(exists(($vp1/a:vp_out_connects_ve)or($vp1/a:vp_in_connects_ve)))
then
  for $ve1 in $ve return
    if (string($ve1/@a:e3_has_uid)= $j) then
      if (string($vp1/a:vp_out_connects_ve/@rdf:resource)=
                                 string($ve1/@rdf:about)or
          string($vp1/a:vp_in_connects_ve/@rdf:resource=
                                 string($ve1/@rdf:about)) then
        for $vo1 in $vo return
          if ($vp1/a:vp_in_vo/@rdf:resource=$vo1/@rdf:about)then
           for $vi1 in $vi return
             if($vo1/a:vo_in_vi/@rdf:resource=$vi1/@rdf:about)then
                      string($vi1/@a:e3_has_uid)
             else()
          else()
       else()
    else()
 else()

};
```

The function above takes a value exchange as an input and outputs two value interfaces related to it as separate strings. These two strings are then merged by the following function to return a single string.

```
declare function local:mergeInterfaces() as xs:string* {
let $docName := doc("musicRights.rdf"),
    $ve := $docName//a:value_exchange

for $ve1 at $j in $ve[position()<=last()] return
 if (not(exists($ve1/a:ve_has_second_vp))) then
  for $k in
       (local:getInterfaceOfPort(string($ve1/@a:e3_has_uid))[1])
     for $h in
       (local:getInterfaceOfPort(string($ve1/@a:e3_has_uid))[2])
         let $x := xs:string($ve1/@a:e3_has_uid)
         let $y := fn:concat($k,fn:concat("_",$h))
     return $y
  else ()
};
```

Binding the two interfaces related to a value exchange helps to create an instance of transaction process in the Reference Ontology which contains a set of related exchanges.

```
declare function local:getExchnages($j as xs:string)as xs:string*{
let $docName := doc("musicRights.rdf"),
    $vi := $docName//a:value_interface,
    $vp := $docName//a:value_port,
    $ve := $docName//a:value_exchange

for $vi1 in $vi return
 if (string($vi1/@a:e3_has_uid) = $j ) then
  for $vp1 in $vp return
   if(exists($vp1/a:vp_in_connects_ve)or
                  exists($vp1/a:vp_out_connects_ve)) then
      if($vp1/a:vp_in_vo/@rdf:resource =
                  $vi1//a:vi_consists_of_of/@rdf:resource) then
      for $ve1 in $ve return
       if(string($vp1/a:vp_out_connects_ve/@rdf:resource)=
                                    string($ve1/@rdf:about)
        or
          string($vp1/a:vp_in_connects_ve/@rdf:resource)=
                                    string($ve1/@rdf:about))then
            string($ve1/@a:e3_has_uid)
       else()
      else()
    else()
 else()

};
```

Finally we create an instance of transaction process based on the distinct values of two interfaces merged together. It then splits the single string representing the merged interfaces and passes one of them to the above function to retrieve the set of value exchanges belonging to that interface.

```
declare function local:getTransactionProcess() as element()* {
let $docName := doc("musicRights.rdf"),
    $vi := $docName//a:value_interface

for $j in (distinct-values(local:mergeInterfaces()))
 let $q := fn:substring-before($j,"_")
 let $r := fn:substring-after($j,"_")
return
 element Transaction {attribute rdf:ID {fn:concat("TP",$j)},
   for $vi1 in $vi return
    for $t in $q return
     if (string($vi1/@a:e3_has_uid) = $t )then
      for $i in (local:getExchnages($t))return
       element hasExchanges {
        element Exchange{attribute rdf:about
            {fn:concat("#E",$i)}, local:getTransferType($i)}
       }
     else()
  }
};
```

5.4 The Results of Mappings in Step One

At the end of step one, we get only a partially completed set of Reference Ontology concepts. Figure 22 below shows a part of an RDF/OWL intermediate output.

```
<owl:Class rdf:ID="Transaction">
      <rdfs:subClassOf rdf:resource="#Process"/>
      <rdfs:subClassOf>
         <owl:Restriction>
            <owl:onProperty>
               <owl:ObjectProperty rdf:resource="#hasExchanges"/>
            </owl:onProperty>
            <owl:allValuesFrom rdf:resource="#Exchange"/>
         </owl:Restriction>
      </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="hasExchanges">
      <rdfs:domain rdf:resource="#Transaction"/>
      <rdfs:range rdf:resource="#Exchange"/>
</owl:ObjectProperty>

<Transaction rdf:ID="TP109_81">
   <hasExchanges>
      <Exchange rdf:about="#E116">
         <hasEventTypes>
            <TransferType rdf:about="#TT84">
               <hasActorType rdf:resource="#Producers"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">decrement</isEventType>
            </TransferType>
         </hasEventTypes>
         <hasEventTypes>
            <TransferType rdf:about="#TT111">
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">increment</isEventType>
            </TransferType>
         </hasEventTypes>
      </Exchange>
   </hasExchanges>
   <hasExchanges>
      <Exchange rdf:about="#E115">
         <hasEventTypes>
            <TransferType rdf:about="#TT112">
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">decrement</isEventType>
            </TransferType>
         </hasEventTypes>
         <hasEventTypes>
            <TransferType rdf:about="#TT83">
               <hasActorType rdf:resource="#Producers"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">increment</isEventType>
            </TransferType>
         </hasEventTypes>
      </Exchange>
   </hasExchanges>
</Transaction>
```

Figure 22: Part of an RDF/OWL intermediate output.

The RDF/OWL output we get at the end of step one contains the information related to the concepts that can be directly mapped from *e*^{3}-*value* to the Reference Ontology. It lacks certain information (e.g. rights) about the transfer types and all the information relevant to the conversion types as this information is not available in the *e*^{3}-*value* ontology. In addition to these, it also requires information related to features of resources and second-order values as these concepts are not also present in the *e*^{3}-*value* ontology.

To bridge the difference between the two ontologies and complete the mapping process, we require human intervention. Therefore in the second step of the mapping process described in section 5.2, we request this additional information as a user input. An intermediate output in step one is used as the principal input to step two and the user input containing the missing information is used as the secondary input. Here we assume that the secondary input containing missing information is also in RDF/OWL format with a structure similar to the principal input. We then use a set of XSLT templates to append this extra information in the secondary input into the principal input and get the final output.

In the second step, it is hardly possible to use XQuery to append information from one file to the other since XQuery 1.0 does not support finding similar patterns and inserting the additional information into proper positions. This happens to be the main reason for using XSLT in here.

```
<TransferType rdf:ID="TT111">
    <hasTransferredRight rdf:resource="#RightToMakePublic"/>
    <hasTransferredOrConversedResourceType rdf:resource="#Song"/>
    <hasActorType rdf:resource="#RightsSociety"/>
</TransferType>
<TransferType rdf:ID="TT112">
    <hasTransferredRight rdf:resource="#Ownership"/>
    <hasTransferredOrConversedResourceType rdf:resource="#Money"/>
    <hasActorType rdf:resource="#RightsSociety"/>
</TransferType>
<TransferType rdf:ID="TT83">
    <hasTransferredRight rdf:resource="#Ownership"/>
    <hasTransferredOrConversedResourceType rdf:resource="#Money"/>
    </TransferType>
<TransferType rdf:ID="TT84">
    <hasTransferredRight rdf:resource="#RightToMakePublic"/>
    <hasTransferredOrConversedResourceType rdf:resource="#Song"/>
</TransferType>
```

Figure 23: Part of user input to the step two.

The XSLT we have implemented for appending information in the secondary input to the principal input contains a set of template rules. These rules match similar constructs in the secondary and the principal inputs and append the additional information contained in the former into the latter and generate the final output.

As it was explained in the above paragraphs, the additional information required in step two basically fall into six main concepts in the Reference Ontology. They are:

1. Event Type
    a. Transfer Type – information related to rights and resource type, and actor type;
    b. Conversion Type – information related to actor type, feature, and resource type.
2. Process
    a. Exchange – information related to transfer type;
    b. Transformation – information related to conversion type;
    c. Interface – information related to transfer type;
    d. Transaction – information related to transfer type.
3. Feature
4. Competitive Value
5. Right
6. Resource Type.

Among the above concepts the information related to the resource type is available in the *e^3-value* ontology. However, due to the differences in the definition of a resource in the two ontologies, we propose to get it as a user input to avoid any confusion with other concepts such as rights. Recall that a value object in *e^3-value* could be service, good, money or even a consumer experience and we map it to a resource and the right on that resource in the Reference Ontology.

Due to certain differences between the constructs in two inputs, different XSLT template rules are needed for appending the information. Therefore, the developed XSLT is too large to include in here.

Figure 24 below depicts a fragment of an OWL description related to the transaction process after step two.

```
<owl:Class rdf:ID="Transaction">
        <rdfs:subClassOf rdf:resource="#Process"/>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty>
                    <owl:ObjectProperty rdf:resource="#hasExchanges"/>
                </owl:onProperty>
                <owl:allValuesFrom rdf:resource="#Exchange"/>
            </owl:Restriction>
        </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="hasExchanges">
        <rdfs:domain rdf:resource="#Transaction"/>
        <rdfs:range rdf:resource="#Exchange"/>
</owl:ObjectProperty>

<Transaction rdf:ID="TP109_81">
   <hasExchanges>
      <Exchange rdf:about="#E116">
         <hasEventTypes>
            <TransferType rdf:about="#TT84">
               <hasTransferredRight rdf:resource="#RightToMakePublic"/>
               <hasTransferredOrConversedResourceType rdf:resource="#Song"/>
               <hasActorType rdf:resource="#Producers"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">decrement</isEventType>
            </TransferType>
         </hasEventTypes>
         <hasEventTypes>
            <TransferType rdf:about="#TT111">
               <hasTransferredRight rdf:resource="#RightToMakePublic"/>
               <hasTransferredOrConversedResourceType rdf:resource="#Song"/>
               <hasActorType rdf:resource="#RightsSociety"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">increment</isEventType>
            </TransferType>
        </hasEventTypes>
      </Exchange>
   </hasExchanges>
   <hasExchanges>
      <Exchange rdf:about="#E115">
         <hasEventTypes>
            <TransferType rdf:about="#TT112">
               <hasTransferredRight rdf:resource="#Ownership"/>
               <hasTransferredOrConversedResourceType rdf:resource="#Money"/>
               <hasActorType rdf:resource="#RightsSociety"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">decrement</isEventType>
            </TransferType>
         </hasEventTypes>
         <hasEventTypes>
            <TransferType rdf:about="#TT83">
               <hasTransferredRight rdf:resource="#Ownership"/>
               <hasTransferredOrConversedResourceType rdf:resource="#Money"/>
               <hasActorType rdf:resource="#Producers"/>
               <isEventType rdf:datatype="http://www.w3.org/2001/XMLSchema#string">increment</isEventType>
            </TransferType>
         </hasEventTypes>
      </Exchange>
   </hasExchanges>
</Transaction>
```

Figure 24: An OWL description with classes and object properties.

During the mapping process, we also defined the relevant OWL classes and their object and data type properties along with the set of actual transformations. This enables us to import the final output to an ontology development tool such as Protégé. Being able to use the final output with Protégé has advantages as it has more advanced features that can be used to further refine and improve the results.

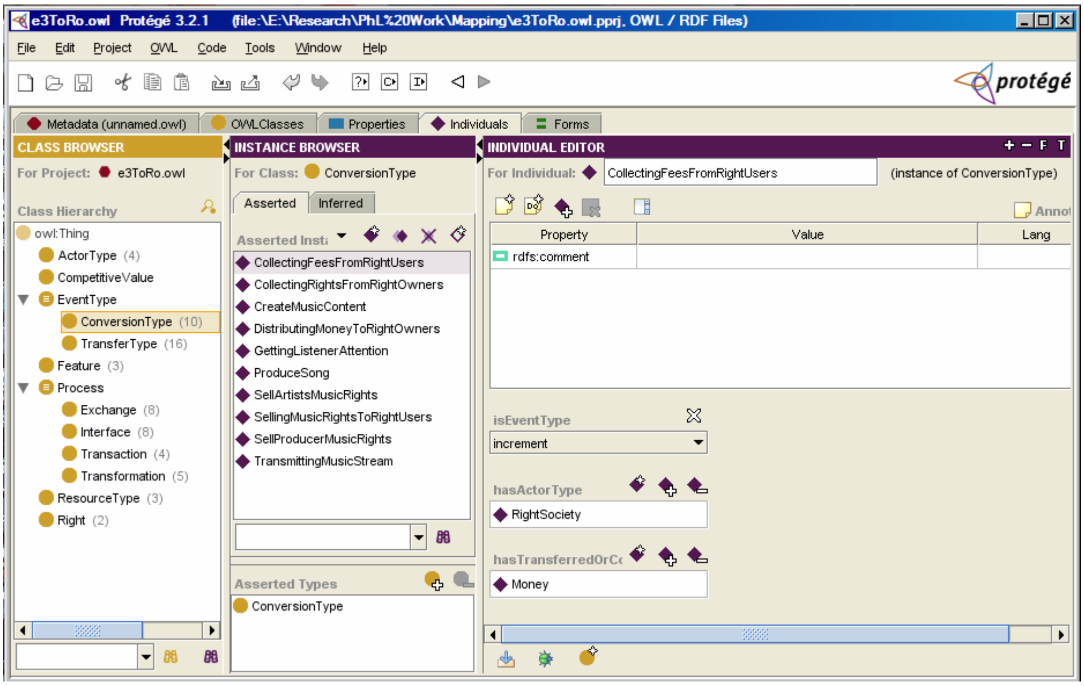

Figure 25: Reference Ontology imported into Protégé.

5.5 Observations

So far, we have explained the mapping process between the *e³-value* ontology and the Reference Ontology in detail. In this section, we discuss issues related to the formalisation of mappings between *e³-value* and the Reference Ontology suggested in Chapter 4.

The high-level mappings suggested in section 4.2, provide a basis for transformation from the *e³-value* business model to a Reference Ontology business model. It maps similar concepts to eachother and they may or may not be identical. Furthermore these high-level mappings do not specify how the mapped concepts correspond to eachother at the instance level. Therefore during the mapping process we also had to focus our attention to these details as well. However, in most cases the mapping process is not very complicated, but in certain cases like transactions, things get a little complicated. This is due to the fact that the RDF version of the *e³-value* business model does not support directly extracting information related to the transactions.

One of the main problems we encountered during the transformation process is mapping actors as a part of other mappings: for example, exchanges. In an actual implementation of this high-level mapping, we need to precisely identify the other associations that a value exchange has and to what concepts we map them in the Reference Ontology. An exchange process in the Reference Ontology is defined as set of transfer types of increment and decrement belonging to two actor types. In *e³-value*, a value exchange represents transfer of value objects between actors and these actors can either be an elementary actor or a market segment. Figure 26 below shows the exchange process and its relations to other concepts in the Reference Ontology.

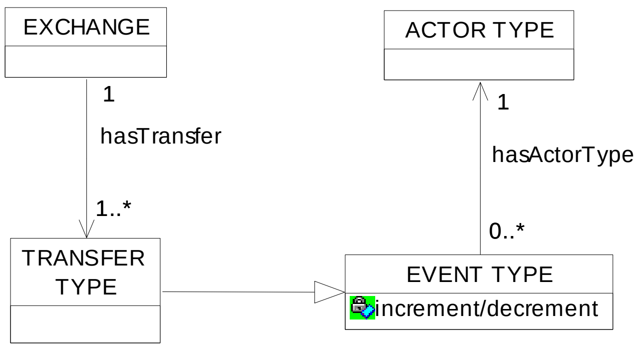

Figure 26: An Exchange Process and its relations to other concepts.

The above figure shows that an instance of exchange process in the Reference Ontology contains details of increment and decrement transfer types, and actor types. During the mapping process, we extract this information from the *e³-value* business model. The in and out value ports of a value exchange of both market segment and elementary actor are mapped to increment and decrement transfer types of an exchange process in the Reference Ontology. However a problem arises when mapping actors involved in a value exchange to an actor type in an exchange process. Since we define an exchange process as increment and decrement transfer types belonging to two different actor types in the Reference Ontology, both elementary actor and market segment associated with a value exchange in *e³-value* should be mapped to actor type in the Reference Ontology. In the case that a value exchange in *e³-value* has an elementary actor involved, the business modeller has to define its typification to map it to an actor type in an exchange process in the Reference Ontology, and because of that it might be difficult to correctly identify the relationship between value exchange in *e^3-value* business model and an exchange process in the Reference Ontology business model. This is due to the fact that several actors may be related to a single actor type at the knowledge level. In the present proposal we have not suggested a way to overcome this problem.

6 Concluding Remarks and Future Research Directions

6.1 Concluding Remarks

In this research we proposed a Reference Ontology based on three well-established business modelling ontologies: REA; *e^3-value*; and BMO. On one hand the proposed Reference Ontology facilitates the common understanding between these three ontologies and on the other hand it extends them in analysis of value transfers by introducing rights, custody and evidence documents as three sub-concepts of it. With the aim of facilitating a better understanding between the three ontologies: REA; *e^3-value*; and BMO, we have also proposed a set of high-level mappings that relates concepts in the original ontologies to the concepts in the Reference Ontology. These concepts may not be identical to eachother and at the level of proposed mappings; we have only considered their overall meaning in the context of value transfers between various stakeholders of a business. The intention of proposed mappings is to facilitate the transformation from one formalism to another one. At this end we formalised the mappings between *e^3-value* and the Reference Ontology and the results show that the proposed mappings between *e^3-value* and the Reference Ontology are adequate. As it was stated in our goals, our intention is to facilitate deriving one type of business model from another, for example, deriving BMO business model from *e^3-value* business model. To achieve this, we need to propose mappings in both directions: from BMO, REA and *e^3-value* to the Reference Ontology and vice versa. However due to limitation of time, we could only propose mappings from the original ontologies to the Reference Ontology and left behind the mappings in the opposite direction for future research. Therefore to see an overall success, we need to formalise the mappings related to the other two ontologies as well as propose and formalise mappings from the Reference Ontology to the original ontologies.

The three ontologies in our analysis differ from eachother in their scope. While REA and *e^3-value* primarily focus on exchange of resources between actors, the BMO goes into broader scope and analyses things related to relationships of a firm and its infrastructure as well. In this work we tried to identify a borderline between these two scopes and hence put our emphasis on transfer of value between actors and how this value is created and presented to a customer.

One of the advantages of using the Reference Ontology to convert between different formalisms is in its ability to help the user to get a better understanding between different terminologies used to represent similar business knowledge. Also it could avoid repeating relatively difficult mappings between different formalisms. For example, mapping BMO concepts to REA or *e^3-value* and vice versa tend to be more difficult than mapping REA or *e^3-value* concepts to eachother. If we map these three ontologies directly to eachother, we have to undergo a painful process of mapping between BMO concepts and REA and also repeat the same process to *e^3-value* too.

Our analysis shows that there are considerable overlaps in the concepts of these three ontologies and at the same time have differences between them. We mainly focused on transfer of value between various business stakeholders. That is, we addressed the question *what is actually transferred between business partners*? The REA ontology answers this by means of an economic event and *e^3-value* answers it by means of a value exchange. While the former defines an economic event as an activity that transfers a resource from one agent to another, the latter defines a value exchange as an activity transferring a value object between different actors. In both cases, the REA and *e^3-value* ontologies use resource and value object respectively to refer to the thing of value that is transferred from one agent to another, but they are not identical to eachother, for example, a consumer experience could be a value object in *e^3-value* but for REA it cannot be. To reconcile these two views on what is transferred between the actors, we propose to decompose it into three sub-concepts: the transfer of rights; custody; and the documentary evidence. The motivation behind this proposal is that at the process level, we might need to distinguish transfer of different types of controls over the same resource. For example one economic event may transfer an ownership of a car while another would transfer right to use by lending it [Ansersson06]. In this case the economic event points out to the same resource but transfers different rights over it.

Our work differs from the Enterprise ontology [Uschold98] and Toronto Virtual Enterprise ontology (TOVE) [Fox92] that the goal of both these ontologies is to deal with internal activities of an enterprise. Primarily they are aiming at creating reusable representations of knowledge internal to an enterprise, for example activities related to organisation management, structure, etc., but not primarily focused in analysing the transfer of value between various business stakeholders. More precisely, they aim at describing how a business works and it is organised. In our work, we primarily focused on what things of value were transferred between a network of business actors, how they differentiate their products from their competitors and what activities there were to produce these values.

Among the three ontologies subjected in our analysis to build the Reference Ontology, the BMO has much a wider scope than the other two ontologies. Therefore we expect that the formalisation of mappings described in Chapter 4 could be more complex for the BMO. However since both REA and *e^3-value* share similarities, we assume that actual mapping process from REA model to the Reference Ontology model will be similar to the *e^3-value*.

6.2 Future Research Directions

In order to measure the effectiveness of the proposed ontology, there are future works needed to be done. In this section we briefly discuss a few possible directions of future research.

1. Validation of the Reference Ontology

   The ontology presented in this thesis needed to be validated to see its successes and failures as a business modelling ontology. One way to do this is to implement it in an ontology management tool such as Protégé. Though to some extent we have carried out this implementation, due to incompleteness of the work we have not included it in this thesis. A correct formalisation of the Reference Ontology in Protégé will lead us to further improve our conceptualisation in the UML class diagram.

2. Formalising mappings related to REA and BMO

   The high-level mappings outlined in Chapter 4 related to REA and BMO needed to be formalised to see how they perform. With our experience in formalising the mappings related to *e^3-value*, we strongly believe that formalisation of REA mappings would be greatly similar to the *e^3-value*. However, as BMO goes into more details than the above two ontologies, the formalisation of the mappings related to it will be much complex than them and will be a strong measurement for the applicability of the proposed Reference Ontology.

3. Mappings between the Reference Ontology and BMO, REA and *e^3-value*

   One of the main goals of this research is to facilitate communication between the ontologies, BMO, *e^3-value* and REA. As a part of this endeavour, we proposed a Reference Ontology and a set of mapping from these three ontologies to it. The idea is to let these ontologies communicate with eachother by mapping their concepts to the Reference Ontology and vice versa. However, the mappings proposed in this work include mappings from BMO, REA and *e^3-value* to the Reference Ontology and the mappings from Reference Ontology to these three ontologies need to be proposed.

Although the Reference Ontology is not completely validated along with the proposed set of high-level mapping between three ontologies: REA; BMO; and *e^3-value*, we believe that it has a potential in playing the role of facilitator in making the common understanding between them.

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