Towards a Reference Ontology for Business Models

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Abstract. Ontologies are viewed as increasingly important tools for structuring domains of interests. In this paper we propose a reference ontology of business models using concepts from three established business model ontologies; the REA, BMO, and e3-value. The basic concepts in the reference ontology concern actors, resources, and the transfer of resources between actors. Most of the concepts in the reference ontology are taken from one of the original ontologies, but we have also introduced a number of additional concepts, primarily related to resource transfers between business actors. The purpose of the proposed ontology is to increase the understanding of the original ontologies as well as the relationships between them, and also to seek opportunities to complement and improve on them.

1 Introduction

It is increasingly recognized that when modelling enterprises and the ways they do business, a starting point could be to identify the main actors and the values transferred between them. This can be expressed in terms of business models. A business model is created in order to make clear who the actors are in a business case and explain their relations, which are formulated in terms of values exchanged between the actors.

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In this paper, we propose a reference ontology for business models. The purpose is not to present an all encompassing ontology of the business domain. Neither is the purpose to question the design of the ontologies that are analysed. The purpose is to identify, analyse, and compare the basic notions of business models by constructing a reference ontology based on three established business model ontologies: REA, e^3-value, and BMO.

A reference ontology will be richer and wider in scope than any of the ontologies it is based on. One benefit from widening the scope is the increased applicability of the reference ontology. Another benefit is that opportunities for extensions and revisions of the component ontologies are discovered and can be considered. Finally, the main benefit of the reference ontology is that it provides a clear understanding of the relationships between the original ontologies. A characteristic of business models is the focus on concepts related to value transfers between actors. This makes their scope different from enterprise model ontologies (e.g. TOVE [Fox92] or EO [Uschold96]) that are more focused on organisational activities, structures, and management.

The work presented in this paper represents a continuation of the effort reported in [Andersson06a] but has also a bearing on work presented in [Weigand06, Bergholtz05, Schmitt05, Andersson06b]. The main purpose of those works was to investigate methods for going from business models to process models in structured ways. Such methods need a clear understanding of the business domain, and ontologies are useful as tools for getting this understanding.

The paper is structured as follows. Section 2 provides a brief overview of the three ontologies used as a basis for the reference ontology. In section 3, the reference ontology is presented. Mappings between concepts in the original ontologies and the reference ontology are presented in section 4. Section 5 concludes the paper with a summary and directions for further work.

2 Features of REA, e^3-value and BMO

The reference ontology presented in this paper is based on three established business model ontologies: REA, e^3-value, and BMO. As these are the most comprehensive and well defined ontologies for business models, they provide an adequate basis for a reference ontology. These three ontologies were originally developed for different and specific purposes, but there has also been recent work on expanding their applicability. REA was originally intended as a basis for accounting information systems [McCarthy82] and focused on representing increases and decreases of value in an organisation. REA has been extended to form a foundation for enterprise information systems architectures [Hruby06], and it has also been applied to e-commerce frameworks [UMM03]. e^3-value focuses on modelling value networks of cooperating business partners and provides instruments for profitability analysis that help in determining whether a certain value network is sustainable [Gordijn04]. Extensions of e^3-value have been suggested that incorporate process related aspects as well as risk management [Bergholtz05] and [Weigand06]. BMO differs from the two other ontologies by being much wider in scope. In addition to modelling

exchanges of resources, BMO also addresses internal capabilities and resource planning. Furthermore, BMO incorporates marketing aspects describing value propositions as well as marketing channels [Osterwalder05].

2.1 The Resource-Event-Actor Ontology

The Resource-Event-Actor (REA) ontology was formulated originally in [McCarthy82] and has been developed further, e.g. [Geerts99, UMM03]. Its conceptual origins can be traced back to business accounting where the needs are to manage businesses through a technique called double-entry bookkeeping. This technique records every business transaction as a double entry (a credit and a debit) in a balanced ledger.

The core concepts in the REA ontology are Resource, Event, and Actor and the intuition behind the ontology is that every business transaction can be described as an event where two actors exchange resources. To get a resource, an agent has to give up some other resource. For example, in a purchase a buying agent has to give up money to receive some goods. The amount of money available to the agent is decreased, while the amount of goods is increased. There are two events taking place here: one where the amount of money is decreased and another where the amount of goods is increased. This combination of events is called a duality. A corresponding change of control of resources takes place at the seller's side. Here the amount of money is increased while the amount of goods is decreased. An exchange occurs when an agent receives economic resources from another agent and gives resources back to that agent; and vice versa. A conversion occurs when an agent consumes resources to produce other resources [Hruby06]. Events often occur as consequences of existing obligations of an actor; in other words, events fulfill the commitments of actors. A commitment is defined as being "an agreement to execute an event in a well-defined future that will result in either an increase or a decrease of resources" available to an agent. Thus, events "happen" because commitments exist between actors, and the duality relation between events exists because of a relation called reciprocity between commitments. Which commitment is related to which is established through an agreement.

2.2 The e^3-value Ontology

The e^3-value ontology [Gordijn00] aims at identifying exchanges of value objects between the actors in a business case. It also supports profitability analysis of business cases. The ontology was designed to contain a minimal set of concepts and relations to make it easy to grasp for the intended users. The basic concepts in e^3-value are actors, value objects, value ports, value interfaces, value activities and value exchanges. An actor is an economically independent entity. An actor is often, but not necessarily, a legal entity, such as enterprises and end-consumers. A value object is something that is of economic value for at least one actor, e.g. cars, Internet access, and stream of music. A value port is used by an actor to provide or receive value objects to or from other actors. A value port has a direction, in (e.g., receive goods)

or out (e.g., make a payment) indicating whether a value object flows into or out of the actor. A value interface consists of in and out ports that belong to the same actor. Value interfaces are used to model economic reciprocity. In the case of e^3-value models without actor compositions a value exchange is a pair of value ports of opposite directions belonging to different actors. It represents one or more potential trades of value objects between these value ports. A value activity is an operation that can be carried out in an economically profitable way for at least one actor.

2.3 The Business Model Ontology

The Business Model Ontology (BMO) as proposed in [Osterwalder04] provides an ontology that allows describing the business model of a firm accurately and in detail. The BMO takes the perspective of a single enterprise, highlighting its environment and concerns for facing a particular customer's demands. It consists of nine core concepts in four categories (or "pillars" as they are called). The categories are Product, Customer Interface, Infrastructure Management, and Financial Aspects.

The single concept in Product is 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 contains three concepts; Target Customer, Distribution Channel, and Relationship. A target customer is a segment of customers to which a company wants to offer value. A distribution channel is a means of getting in touch with the customer. A relationship is the kind of link a company establishes between itself and the customer.

Infrastructure Management contains three concepts; Value Configuration, Capability, and Partnership. A value configuration describes the arrangement of activities and resources that are necessary to create value for the customer. A capability is the ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer. A partnership is a voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.

Financial Aspects contains two concepts; Cost Structure and Revenue Model. Cost structure is the representation in money of all the means employed in the business model. Revenue Model describes the way a company makes money through a variety of revenue flows.

3 A Reference Ontology

In this section, we introduce the reference ontology for business models. It is constructed using the concepts of REA, e^3-value, and BMO as inputs to an analysis and subsequent synthesis. The approach used in constructing the reference ontology has been to survey all concepts from all the established ontologies and analyse similarities and differences.

As the three original ontologies include concepts on the operational level as well as the knowledge level, the reference ontology has to include both these levels. As

described in [Fowler97], the operational level models concrete, tangible individuals in a domain. The knowledge level, on the other hand, models information structures that characterise categories of individuals at the operational level. For example, the ontology distinguishes between Resource Types (categories of resources like car models) and Resources (specific, tangible things like concrete cars).

We have aimed at including all of the concepts in REA and e^3-value except for a small number of peripheral concepts, i.e. concepts that occur in only one of the ontologies and are not central for transfers of values. For BMO, we have not aimed at including all its concepts. In particular, some concepts from Customer Interface and all concepts from Financial Aspects are excluded from this work. The reasons are that the Distribution Channel and Link from Customer Interface concerns technical distribution issues. The reason for omitting the Financial Aspects category is that this category goes into issues of internal capabilities and resource planning, and has little to do with transfers of values between actors.

We have also introduced a small number of concepts that do not have any direct correspondences in the original ontologies. This has been done mainly in order to facilitate the analysis of value transfers and resources. The introduction of those additional concepts represents an extension of the reference ontology with respect to the combination of the originals.

The concepts are described in the following paragraphs and the correspondences to an original ontology are discussed and motivated in section 4.

Actor

An *Actor* is someone who is able to participate in events (event defined below).

Resource, Feature, and Right

A *Resource* is an object that is regarded as valuable by some actors. An actor views a resource as valuable because she can use it for producing other resources, for trading it with other actors, or for deriving some consumer experience. Essentially any object can be a resource. However, it is possible to identify some typical categories of resources like goods, information, and services. A resource may have properties and associations to other objects, like the weight of a pizza or the number of shops accepting a credit card. Such properties and associations are modelled by means of the class *Feature*.

Resources are furthermore related to rights. A *Right* on a resource means that an actor is entitled to use that resource in some way. An example is the ownership of a book, which means that an actor is entitled to read the book, give it to someone else, or even destroy it. Another example of a right is borrowing a book, which gives the actor the right to read it, but not to give it away or destroy it or use it in any other way. Figure 1 shows the main concepts: Resource, Feature and Rights that are described in this section together with their relationships to other concepts.

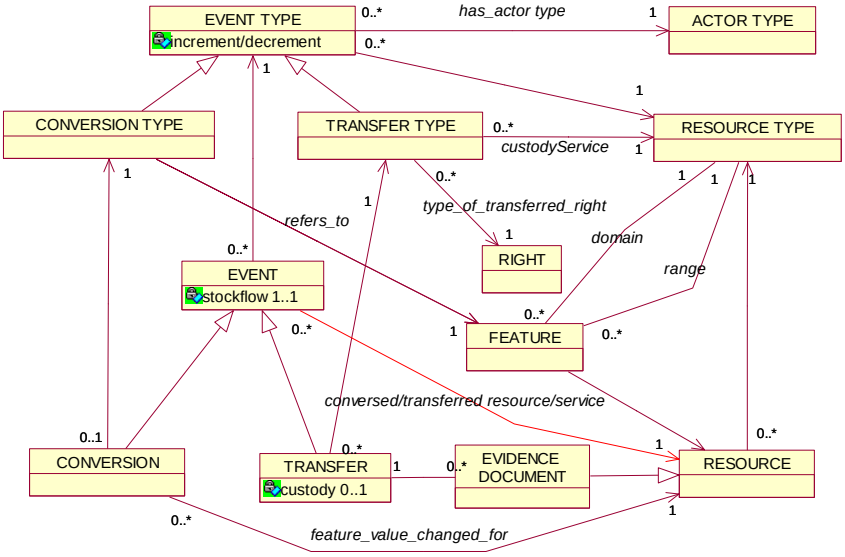

Figure 1 Resource, Feature, and Right, and their respective relationships

Event, Transfer, and Conversion

An *Event* changes a feature or a right of a resource. An event is associated to exactly one actor representing the perspective from which the event is viewed. This means that each event can be seen as either an increment or decrement event from that actor's perspective. An increment event changes a feature or a right of a resource in such a way that the resource becomes more valuable for the actor, while a decrement event causes a change that decreases the value of the resource. In order to model increments and decrements, an attribute *stockflow* of the class Event is introduced that can take one of the values in {use, consume, produce, give, take}. This corresponds to the stockflow relationship in REA [McCarthy82].

The class Event has two subclasses, *Transfer* and *Conversion* [Hruby06]. A transfer means that a right is transferred from one actor to another (for a more detailed analysis, see the next subsection). If the actor of the event receives the right to the resource, the event is a take event (represented by the stockflow attribute). If the actor gives up the right to the resource, the event is a give event. Similarly, a conversion event changes some feature of a resource. If this change means that a new resource is created or the value of an existing resource is increased, the event is a produce event. If the resource is completely consumed and no longer exists after the event, it is called a consume event. If the resource is used but continues to exist also after the event, it is called a use event. Use, consume, and give are decrement events, while produce and take are increment events. Figure 2 shows the events, transfers, conversions and their relationships to other concepts such as exchanges, interfaces, and transactions.

Rights, Custody and Evidence Documents - Three components of a transfer

A Transfer from A to B can be viewed as consisting of three components:

- transferring rights on a resource from A to B
- giving custody of the resource to B
- transferring an evidence document (documenting the transferred right) from A to B

The second component of a Transfer is transferring the custody of the resource being exchanged from one actor to another. An actor has the *Custody* of a resource if he has immediate charge and control of the resource, typically physical access of the resource. If an actor has the custody of a resource, this does not mean that she has any rights on the resource. For example, a distributor may have the custody of some goods, but he is not allowed to use the goods in any way. Providing custody of a resource is essential in a value exchange, as the buyer is typically unable to exercise the rights she gets unless she has custody of the resource. In the reference ontology, custody is modeled by means of the *Custody* attribute of a Transfer (Figure 1).

A Transfer may also include the transfer of some evidence document that certifies that the buyer has certain rights on a resource. A typical example of an evidence document is a movie ticket that certifies that its owner has the right to watch a movie. While the first component, the transfer of right, always is included in a Transfer, the last two components are optional. For example, when buying a piece of land, the buyer is typically not given the custody of that resource. Clearly, evidence documents are not always provided in a value exchange. Furthermore, the provision of custody and evidence documents may be so trivial that it is not of interest to make them explicit in a model.

Process, Interface, Exchange, Transaction, and Transformation

A *Process* is a set of Event types including increment as well as decrement event types, i.e. a process specifies how to group together a number of transfer and conversion events. This means that a process, as defined here, only describes the changes of rights and features of resources; it does not specify temporal or communicative aspects. These aspects are certainly relevant for processes in general, but they are outside the scope of business models. The notion of a process is quite general, as it may contain any event types. It is, therefore, useful to identify a number of specialised processes, and the ontology distinguishes between interfaces, exchanges, transactions, and transformations. An *Interface* is a process consisting of transfer event types all associated to the same actor type. An interface specifies that an actor (type) is prepared to trade according to the transfer event types of the interface. An *Exchange* is a process consisting of a pair of one give transfer event type and one take transfer event type associated to two different actor types. An exchange specifies that one actor (type) is prepared to give a resource to another actor (type) who takes it. A *Transaction* is a process consisting of a number of exchanges, or more precisely, the transfer event types included in the exchanges. A transaction specifies that two actor (types) are prepared to trade with each other according to the transfer event types of the exchange. A *Transformation* is a set of conversion event types all associated to the same actor type. A transformation specifies that some resource is produced while other resources are consumed or used.

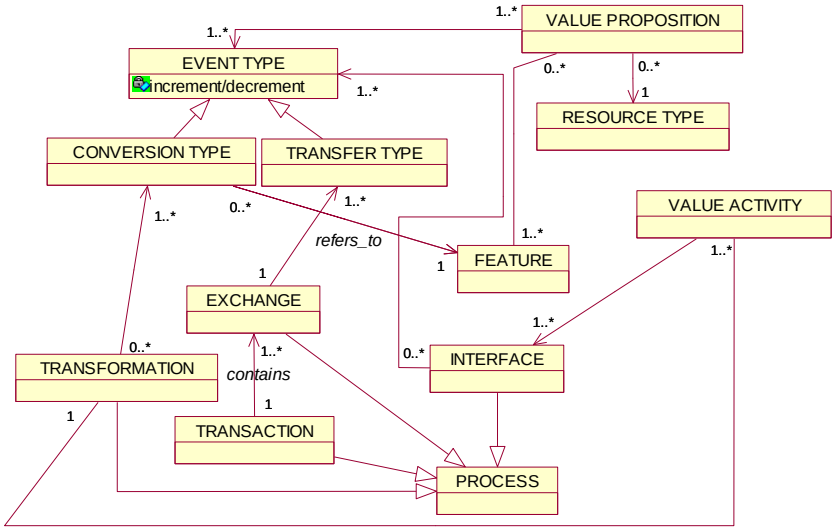

Figure 2 Events, Transfer, Conversion and their respective relationships

Commitment, Claim, Contract, and Agreement

A *Commitment* is an obligation to carry out a give Transfer within an Exchange in the future. A *Contract* is a collection of Commitments. An *Agreement* is an arrangement between two Actors that specifies in advance the conditions under which they will trade. A Claim comes into existence when one business partner has fulfilled an Economic Commitment while the other partner has yet to fulfill the reciprocal Economic Commitment.

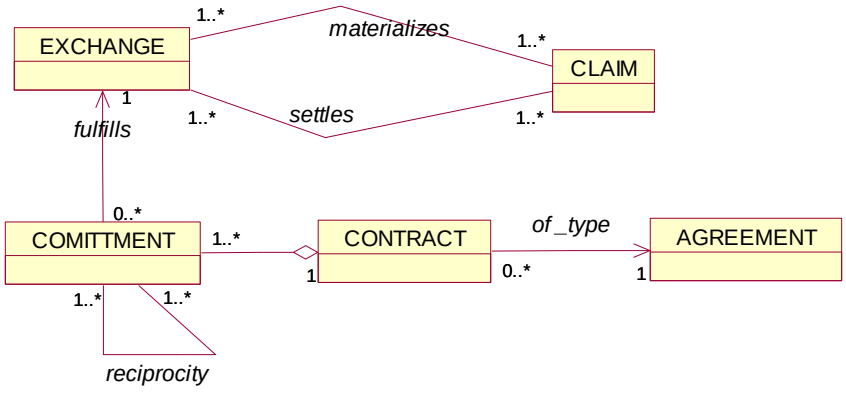

Figure 3. Commitment, Claim, Contract and Agreement and their respective relationships

Value Activity
A *Value Activity* consists of a number of interfaces associated to one actor. A value activity is a set of related processes carried out by one actor, but that could potentially be performed by another actor.

Value Proposition
A *Value proposition* consists of a resource type and a number of features and processes containing decrement event types associated to that resource type. Intuitively, a value proposition does not only specify a resource type offered by an organisation but also arguments why the customer should buy that resource type. These arguments could consist of references to features of the resource, such as the freshness or nutritional content of a pizza. Another kind of argument would be references to processes where the resource is used or consumed in order to produce or improve other resources. For example, an argument for buying a kitchen machine is that it can be used to produce freshly squeezed orange juice.

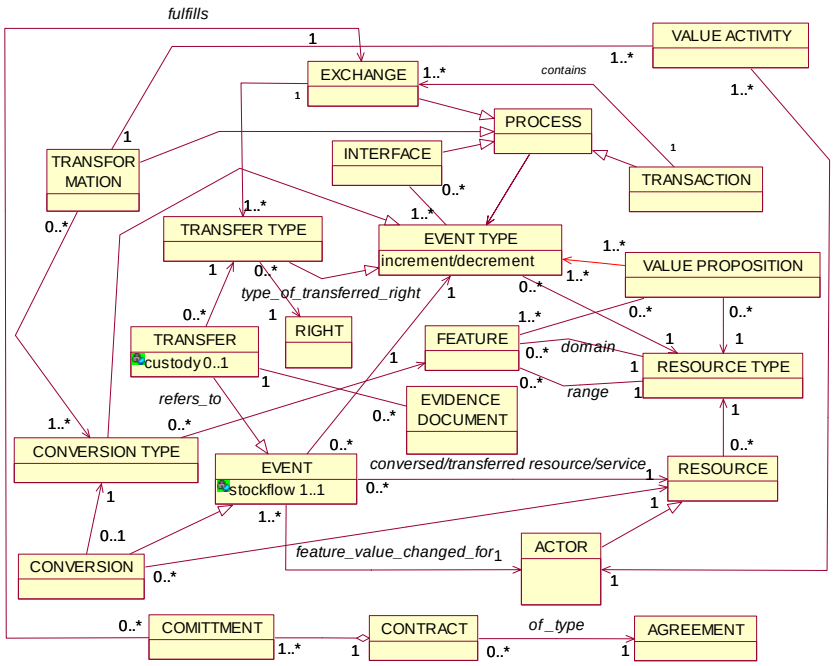

Figure 4. The Reference Ontology (some concepts omitted)

Figure 4 contains the entire reference ontology, in UML Class diagram notation, except for a few concepts that are excluded to reduce clutter. Figures 1-3 are views of this model.

4 Mappings of Business Model Ontologies to the Reference Ontology

In this section, we map each of the business model ontologies REA, e^3-value, and BMO to the Reference ontology. For reasons of space, the mappings are presented informally in tables as relationships between concepts of the ontologies.

4.1 REA-Reference Ontology mappings

The version of REA used in this analysis is based on UMM [UMM03]. This version does not explicitly distinguish between the notions of conversion and transfer described in [Hruby06], as it focuses on electronic commerce. In fact, only transfers of resources are modeled in UMM.

REA	Reference ontology
Partner	Actor
Partner type	Actor type
Economic Event	A pair of Transfers (1)
Economic Resource	Resource
Economic Event Type	Exchange (2)
Economic Resource Type	Resource Type
Duality	Transaction (3)
Economic Commitment	Commitment (4)
Claim	Claim (5)
Economic Contract	Contract (6)
Agreement	Agreement (6)
Reciprocity	Reciprocity (7)

(1) In REA, an Economic Event represents the transfer of an Economic Resource from one partner to another. In the reference ontology, this is mapped to two Transfers. One Transfer represents that one Actor gives up a Resource, while the other Transfer represents that the other Actor receives that Resource. It can be noted that REA does not model the right being transferred but only the Resource.

(2) In REA, an Economic Event Type resides on the knowledge level, while an Economic Event is on the operational level. As Economic Events are mapped to pairs of Transfers, an Economic Event Type will be mapped to a pair of Transfer Types – one give and one take Transfer Type. In other words, an Economic Event Type is mapped to an Exchange.

(3) In REA, Economic Events can be related to each other by means of the duality association, which means that one Economic Event is carried out as a compensation for another, see Section 2. In the reference ontology, a number of Economic Events that are related by duality will, therefore, belong to the same Transaction. Note that while the reference ontology differentiates between Economic Events in terms of Conversions and Transfers of Resources from one Actor to another, REA does not make this distinction.

(4) In REA, an Economic Commitment is an obligation to perform an Economic Event in the future. An Economic Commitment can be fulfilled by an Economic Event. Hence, in the reference ontology, an Economic Commitment is mapped to a Commitment.

(5) A Claim in REA materializes when one business partner has fulfilled an Economic Commitment, while the other partner has yet to fulfill the reciprocal Economic Commitment. Thus a Claim in REA is mapped to a Claim in the reference ontology.

(6) An REA Economic Contract is an aggregation of Economic Commitments. In REA, an Economic Contract is a subtype of an Economic Agreement. In the reference ontology, however, the concept of Agreement is an arrangement between two actors that specifies in advance the conditions under which they will trade, i.e. a concept defined on the knowledge level. Economic Contract is mapped to Contract in the reference ontology.

(7) Reciprocity is a relationship between two or more Economic Commitments that expresses that the corresponding Economic Events are related through one and the same duality. The REA Reciprocity relationship is mapped to the equally named relationship in the reference ontology.

4.2 e^3-value -Reference Ontology mappings

e3value	Reference ontology
Actor	Actor
Market segment	Actor type
Value object	Resource type and Right (1)
Value port	Transfer type (2)
Value exchange	Exchange (3)
Value offering	Set of Transfer types (4)
Value interface	Interface (5)
Value activity	Transformation (6)
Value transaction	Transaction (7)

(1) When a Value Exchange occurs in e^3-value, some (instance of a) Value Object is transferred from one agent to another. However, it is not sufficient to specify only which resource that is transferred; the right that the receiving actor obtains also has to be given. 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. Thus, there are two different value objects though only one Resource Type. For this reason, a Value Object is mapped to the combination of a Resource Type and a Right.

(2) A Value Port in e^3-value represents that an Actor Type is prepared to provide or receive some Value Object. Thus, a Value Port is mapped to a Transfer Type. The direction of the Value Port, in or out, is represented by means of the Transfer Type being an increase or a decrease of value for the actor.

(3) A Value Exchange in e^3-value is a pair of Value Ports belonging to different actors or market segments. It represents one or more potential trades of Value Objects

between these Value Ports. A Value Exchange is, therefore, mapped to two Transfer Types of different Actor Types, where one is an *increase* Event Type and the other a *decrease* Event Type. In other words, a Value Exchange in e^3-value is mapped to an Exchange.

(4) A Value Offering in e^3-value is a set of Value Ports with the same direction. Thus, it is mapped to a set of Transfer Types, either all decrease or increase.

(5) A Value Interface is either one Value Offering or one in-going and one out-going Value Offering that belong to the same Actor. Value Interfaces are used for modeling economic reciprocity and are hence mapped to Interface, i.e. a Process consisting of Transfer Event types all associated to the same Actor Type.

(6) A Value Activity in e^3-value corresponds closely to a Transformation. However, a Transformation tells what resources that are used or consumed in order to produce some other resource, while a Value Activity tells what activities carried out by an actor and what value objects are used as inputs to produce value objects that are tradable. In the reference ontology the Transformation specifies that some resource is produced while other resources are used or consumed. Therefore the Value Activity in e^3-value is mapped to the Transformation in the reference ontology.

(7) A Value Transaction in e^3-value is defined as a set of Value Exchanges. The Value Exchanges in a Value Transaction are performed according to the Value Interfaces connected to the Value Exchanges. This means that if a Value Object is exchanged through a particular port of a value interface, then Value Exchanges must occur via all the other ports of that value interface. In the reference ontology a Transaction is defined as process containing a set of Exchanges. We also mapped the Value Exchange in e^3-value to the Exchange in the reference ontology. Therefore the Value Transaction in e^3-value is mapped to the Transaction in the reference ontology.

As can be seen from the mappings above, there are close relationships between the concepts in REA and e^3-value, but also some differences:

Resource, Right, and Value Object

Economic Resource in REA and Value Object in e^3-value models similar, but not identical concepts. In an Economic Event, something is transferred from one agent to another agent, but what is transferred is not an only an Economic Resource, but the control of an Economic Resource and in some cases also the custody of the same resource. For example, one Economic Event may transfer the ownership of a car, while another Economic Event lends the car. These Economic Events concern the same Economic Resource but transfer different rights on that resource. This motivates the introduction of Rights in the reference ontology. In e^3-value, a Value Exchange transfers a Value Object from one agent to another. Therefore, Value Object can be mapped to both Right and Resource in the reference ontology.

A recent analysis on Value Objects, [Weigand06], points out that a Value Object has a dual character combining both a right and transformations, i.e. how the value object can be used to modify some object of interest to an actor. The reference ontology is able to capture this through Conversions that use or consume the Value Object.

4.3 BMO-Reference Ontology mappings

BMO	Reference ontology
Target Customer	Actor Type (1)
Value Proposition	A set of Value propositions (2)
Offering	Value Proposition (3)
Agreement	Agreement (4)
Actor	Actor OR Actor Type (1)
Activity	Value Activity (5)
Value Configuration	Process, in particular Transformation, and Transaction OR the corresponding classes defined on the knowledge level (6)
Resource	Resource
Capability	A relationship between Value Proposition, Resource and Value Configuration (7)

(1) A Target Customer is mapped to the class Actor of the reference ontology, while the class Actor is mapped to Actor or Actor type. In BMO actors are viewed from an internal perspective. This means that the ontology is designed from one particular actor's viewpoint making this actor implicit. In contrast, the reference ontology views actors from an external perspective. Therefore, an Actor in BMO does not exactly correspond to an Actor of the reference ontology. The class Actor in the reference ontology represents all actors, whereas the class Actor in BMO represents all actors except the one from whose perspective the ontology is constructed. Furthermore, an Actor in BMO (as opposed to a Target Customer) should be understood as being defined on the operational level, whereas a Target customer (segment) is defined as the type of customers a company intends to address, i.e. a definition on the knowledge level.

(2) In BMO, a Value Proposition represents value for one or several Target Customers, i.e. how a firm differentiates what it offers from its competitors. A Value Proposition may be decomposed into a set of Offerings (2), and hence is mapped to a set of reference ontology Value Propositions, see (3).

(3) An Offering in BMO is part of an overall Value Proposition (which in turn may be decomposed into a set of Offerings). Each BMO Offering describes an elementary product or service, offered (directed) towards the target customers. In the reference ontology it is mapped to a Value Proposition related to (set of) decrement Event type(s).

(4) In BMO an Agreement specifies functions, terms and conditions of a partnership with an (external) actor. It is mapped to the concept of Agreement in the reference ontology, where an agreement is an arrangement between two actors that specifies *in advance* the conditions under which they will trade, i.e. a concept defined on the knowledge level.

(5) An Activity in BMO is an action relative to one company, performed in order to do business and achieve the company goals. It is mapped to the concept of Value

Activity in the reference ontology, since value activities in the reference ontology are defined as activities that can be profitably performed by some Actor.

(6) BMO Value Configuration describes the arrangements of activities and resources that are necessary to create value for the customer (a Value proposition), which is mapped to the reference ontology class Process. In the reference ontology Process is a set of increment and decrement Event Types that have to happen in order to fulfill transfers of value. The reference ontology further distinguishes between a number of specializations of processes: Interfaces, Exchanges, Transactions and Transformations. In mapping Value Configuration to Processes it should be noted that the sub types Transformation and Transaction are probably most similar to Value configuration. A Transformation tells what resources are used or consumed in order to produce some other resource of value for some actor. A Transaction groups a number of Exchanges.

(7) A BMO Capability describes the ability to execute a repeatable pattern of actions. A Capability hence describes whether or not a particular needed Value Configuration can be applied by a particular company to provide the value proposition and if the appropriate resources (i.e. services and resources) are available. This concept of capability has no immediate correspondence in the reference ontology. Capability is mapped to a relationship between a particular Value Proposition, a Value Configuration and the needed services and resources, where the capability relationship signals that the offering partner can deliver its value proposition.

5 Concluding Remarks

In this paper we have presented a reference ontology based on three business ontologies – the REA, e^3-value, and BMO. We constructed the reference ontology primarily in order to gain a better understanding of the original ontologies. An additional use of such an ontology is that it may serve as a mapping tool where models can be transformed from one formalism to another.

The work has shown that there is a considerable overlap between the ontologies but that there are also differences, some obvious and some subtle. An example is that Economic resource in REA and Value object in e^3-value might seem identical to each other. However, they are different as can be seen by analysing what is happening in an Economic event. In an Economic event, something is transferred from one agent to another agent, but what is transferred is not an Economic resource, but the control of an Economic resource. For example, one Economic event may transfer the ownership of a car, while another Economic event lends the car. These Economic events concern the same Economic resource but transfer different rights on that resource. This motivates the introduction of Rights in the reference ontology – in a Transfer, the right to a resource is transferred from one agent to another. In e^3-value, a Value exchange transfers a Value object from one agent to another. Therefore, Value object is mapped to the combination of Right and Resource in the reference ontology Similarly, the concept of a Transfer gave rise to the issue of what is transferred. To address this question, i.e. what is actually transferred in a value transfer, we analysed

the concept into three sub-concepts; Custody, Documentary Evidence and Right transfer and thereby extended the reference ontology with concepts not present in the originals.

Future research includes validation of the reference ontology. One way of doing this is to implement the original ontologies as well as the reference ontology using an ontology management tool such as Protégé [Protégé06]. Formalized mappings between the ontologies could then be formulated using an ontology mapping language.

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